Riikka Reitzer

DIGITAL SUSTAINABILITY AND ACTOR ROLES

CASE LEADING COMPANY ECOSYSTEM

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Tämän pro gradu -tutkielman aiheena on tutkia Business Finlandin rahoittamia veturiekosysteemejä. Kestävän kehityksen vaatimukset sekä digitalisaatio edellyttävät teollisuudelta uusia ratkaisuja ja laaja-alaista yhteistyötä muuttuvassa liiketoimintaympäristössä. Tämän tutkielman tarkoitus on ymmärtää syvällisemmin digitalisaation merkitystä kestävässä kehityksessä, eri toimijoiden rooleja veturiekosysteemeissä sekä yhteiskehittämiseen vaikuttavia tekijöitä. Tutkimus toteutettiin laadullisena tapaustutkimuksena. Tutkimusaineisto kerättiin käyttämällä vetureiden julkisia tiekarttoja sekä puolistrukturoiduilla veturiekosysteemien edustajien, Business Finlandin ja ekosysteemien yhteistyökumppaneiden henkilöhaastatteluilla. Tutkimustulokset osoittavat, että veturiyrityksillä on useita avainalueita, jossa he panostavat innovatiivisten digitaalisten teknologioiden tutkimiseen ja kehittämiseen samalle edistäen vastuullisuustavoitteitaan. Veturiyrityksillä on voimakas rooli määrittäessään ekosysteemeiden tiekartat. Heidän odotetaan johtavan näitä ekosysteemejä kohti kunnianhimoisia missioita, jotka kuvastavat veturiyritysten omia strategisia tavoitteita. Toimijoiden väliset suhteet ja riippuvuudet tekevät ekosysteemin hallinnasta ja yhteistyöstä dynaamista ja monimutkaista. Tulokset viittaavat siihen, että veturiyritysekosysteemit ovat yhdistelmä osaamisen, innovaation, liiketoiminnan ja yrittäjyyden ekosysteemejä. Tutkimustulokset viittaavat siihen, että huolellinen hankevalmistelu, monipuolinen konsortio, selkeät ja realistiset tavoitteet sekä avointa viestintää ja selkeä hyödyntämissuunnitelma auttavat yhteistyöprojekteja saavuttamaan tavoitteensa ja edistämään merkittävää toimialojen kehitystä. Tutkimus korostaa selkeästi määriteltyjen roolien, vastuiden ja hyötyjen merkitystä ekosysteemin toimijoille, jotta vältetään epäselvyydet ja varmistetaan tehokas yhteistyö.

Asiasanat: digitalisaatio, kestävä kehitys, vastuullisuus, yhteiskehittäminen, ekosysteemi, veturi, roolit

ABSTRACT

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The purpose of this master's thesis is to study leading company ecosystems funded by Business Finland. Sustainable development and digitalization require from the industries new solutions and wide-ranging cooperation in a continually changing business environment. The purpose of this thesis is to gain understanding of digitalization's significance for sustainable development, the roles of different actors in these leading company ecosystems and factors impacting co-creation. The study was carried out as a qualitative case study. The research data was collected from the public roadmaps of leading companies and by semi-structured individual interviews of experts from the leading companies, Business Finland and ecosystem partners. The study results show that leading companies have several key areas where they rely on researching and developing innovative digital technologies to support also their sustainability objectives. The leading companies have a dominant role as they set the roadmaps and expected to steer these ecosystems toward achieving the ambitious missions which reflect their strategic goals. The relationships and dependences make the ecosystem management and collaboration dynamic and complex. The findings suggest that the leading company ecosystems are a combination of knowledge, innovation, business and entrepreneurship ecosystems. The research findings indicate that by ensuring thorough project preparation, forming a well-rounded consortium, setting clear and realistic objectives, maintaining open communication, and planning exploitation, the collaborative projects can achieve their goals and drive significant industry development. The study underscores the importance of clearly defined roles, responsibilities and benefits for all ecosystem actors to prevent ambiguity and ensure effective collaboration.

Keywords: digitalization, sustainability, co-creation, ecosystem, leading company, role

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1 INTRODUCTION

This chapter includes an introduction to the background and motivation of the study, as well as key concepts and terms. In this chapter also the structure and the outline of the study are introduced to the readers.

The objective is to study what role digitalization, sustainability and co-creation play in the leading company ecosystems. The emphasis is on understanding digital sustainability, the roles, motivation, and relations of the different actors in ecosystems developing new digital solution which promote sustainability and economic growth of the companies. Factors contributing to success or failure of co-creation in joint research and development projects are explored.

1.1 Background of the study

Sustainability has been discussed for decades and it has become part of the strategic management of companies across industries (Saeed & Kersten, 2019). The study from Saeed and Kersten noted that specially when talking about sustainable development and company strategy, taking stakeholders and the operating environment into account have become essential themes for companies today. Governments have an important role by providing supportive policies and initiatives that facilitate the adoption and implementation of sustainable solution including technological transformation of industries towards digital sustainability and ecological-economic-social sustainability (Luthra et al., 2020).

The Finnish Government Programme has set as one of its targets to strengthen long-term growth and capacity for renewal by increasing the funding for research and innovation. The target is 4% of GDP in 2030 (Länsipuro, n.d.). Business Finland, the Finnish Funding Agency for Innovation, contributes to achieving this goal. One way is to finance companies with funding instrument named Funding for leading Companies and Ecosystems (*Funding for Leading Companies and Ecosystems - Business Finland*, 2023). The aim of the funding is to

create significant export business potential for Finland through increased research, development and innovation activities and new business. These leading company projects are also expected to bring big investments, increase in turnover of the companies, tax income, new working places and positive environmental impacts. A company granted the status of leading company starts building an ecosystem and working with partners to achieve the set goals. Business Finland has set key performance indicators for the leading companies and follows the progression on regular basis. Figure 1 shows the eighteen leading company ecosystems that were running January 2024. On the green background are the five ecosystems which are funded from the European Union's (EU) temporary NextGenerationEU instrument of the Recovery and Resilience Facility (RRF) (*Recovery and Resilience Facility - European Commission*, n.d.). EU's goal is to support the economic recovery from the coronavirus pandemic. The funding's aim is to build a greener, more digital and more resilient EU. Leading companies on white background are the seven ecosystems funded by Business Finland without EU funding. On the yellow background are six challenger ecosystems which have a smaller funding and no EU funding. The differences between leading company and challenger company funding are explain in more detail under 5.2 Case Leading Company ecosystem.

Figure 1 Ecosystems running in January 2024.

1.2 Motivation of the study

This study is motivated by gaining deeper understanding the key characteristics of these leading company ecosystems, the digitalization and sustainability elements, actor relationships and motivations in these ecosystems. The study focuses on the characteristics of these ecosystems and key themes of digitalization and sustainability within the context of leading companies' roadmaps for research and development (R&D). One of the goals is to identify in which areas digital technologies are applied and how companies prioritize digitalization their R&D efforts. Sustainability objectives are analyzed to gain understanding how digitalization efforts are linked to sustainability goals. The relationship or impact the digital strategies on the realization of sustainability objective are studied.

The leading company roadmaps, ecosystems and joint R&D projects are studied to learn about actor roles in these ecosystems and factors contributing for success or failure of the joint R&D projects. A specific aspect chosen for the study of co-creation are the collaborative, Business Finland funded R&D projects within these leading company ecosystems.

1.3 Structure of the research

The purpose of the qualitative research is to study how sustainable development and digitalization come into view in the roadmaps, what are the roles of ecosystem actors and which factors impact the co-creation in the leading company ecosystems. The research problem is to identify how leading company ecosystems work and which roles different actors have in developing sustainable and digital solutions. The research questions encourage an examination of the strategies, processes, and outcomes of integrating digital technologies into leading companies' sustainability efforts. The research consists of the research problem and following sub-questions:

RQ1 How digitalization and sustainability are linked in these ecosystems?

RQ2 What are the roles of different actors in the leading company ecosystem?

RQ3 Which factors contribute to the success or failure of joint R&D projects?

RQ4 What are the characteristics and structure of the leading company ecosystems?

The study focuses on dual transition, the relationship between digitalization and sustainability. Beyond the scope of the study are the individual transitions. The research topic for co-creation is outlined to Business Finland funded joint R&D

projects in the leading company ecosystems evolving companies and public research organizations. Out of the scope of the study are single company projects, joint projects with private partners only or joint project funded by other research funders.

The thesis is divided into eight chapters. First chapter covers the background and motivation of the study, key concepts and terms, the structure and the outline of the study. The chapters two and three introduce the theory background, chapter two focusing on literature review of digital sustainability and chapter three on literature review on ecosystems. The fourth chapter summarized the connection between digital sustainability and ecosystem. The fifth chapter introduces the research design including research and data collection methods as well as data analysis used. Study results are presented in the chapter six. Chapters seven cover the discussion including findings, considerations regarding theoretical contribution, practical relevance, and study limitations. The eight and last chapter discusses the conclusions of the study and gives suggestions for further research.

1.4 Key concepts and terms

The theoretical background of the research is formed by literature related to digital sustainability and ecosystems. Due to the study's context of digital sustainability and co-creation in the leading company ecosystems, the focus is on ecosystem characteristics, stakeholders and their roles in the collaboration.

In this chapter only short definitions of the key terms are given. For the convenience of the reader, a more detailed descriptions of the terms and concepts are given under related chapters.

Scientific definitions for the key terms, such as digitalization and sustainability, are not clearly defined. Although it is mainly understandable what is meant by these terms, their definitions cannot be unambiguously locked. Digitalization is defined as a socio-technological process in which the techniques of digitization, process of converting analog signals into binary digits, are applied to a wider social and institutional context (Tilson et al., 2010). Digital sustainability refers to using digital technologies and innovations to support sustainable development goals (Sparviero & Ragnedda, 2021). By integrating digital solutions into various aspects of business and society, digital sustainability aims to create a more resilient and sustainable world.

The term "ecosystem" is adopted from biology to economy (Pilinkienė & Mačiulis, 2014). According to the study, in the field of business, an ecosystem refers to a network of organizations and resources, working together in a coordinated manner to achieve mutual benefits. This collaborative environment fosters innovation, knowledge sharing, and co-creation of value among participants. Different types of ecosystems are viewed based on literature. Collaboration in joint research and development projects are studied in the

context of these leading company ecosystems and from the perspective of the ecosystem framework.

The leading company ecosystems and joint R&D projects are analyzed using the semiotic and narrative actantial model from Greimas (1983). Greimas developed the actantial model as part of his narrative semiotics theory, which identifies the key roles or actants: subject, object, sender, receiver, helper and opponent. This model is fundamentally about the dynamics of action and interaction among these roles within stories. The model is grounded in the idea that narratives can be broken down into a series of relationships among roles or functions of these actants, that interact within the story. In this study the stories are the leading company roadmaps and the interviewees' narrations.

Combining the ecosystem framework and joint R&D projects with Greimas' actantial model is an innovative interdisciplinary approach, exploring semiotic analysis when studying interconnections and interdependencies within ecosystem. The are some previous studies using Greimas' actantial model in information technology studies, for example research from Barricelli et al. (2016) studying semiotics of virtual reality.

The chosen theoretical framework of the study is presented in Figure 2. Based on earlier literature development of digital sustainability is a collective effort requiring complementary expertise from partners (George et al., 2021). Ecosystems are an example of such collaborative environments (Khan et al., 2022; Paasi et al., 2023). Earlier research shows a theoretical framework for successful ecosystem work where ecosystem type, structure, actor roles impact the value creation and capture (Khademi, 2020). Following the previous literature this study suggests that the ecosystems work and collaboration in digital sustainability development leads to achieving the goal. The next two chapters introduce digital sustainability and ecosystem research topics.

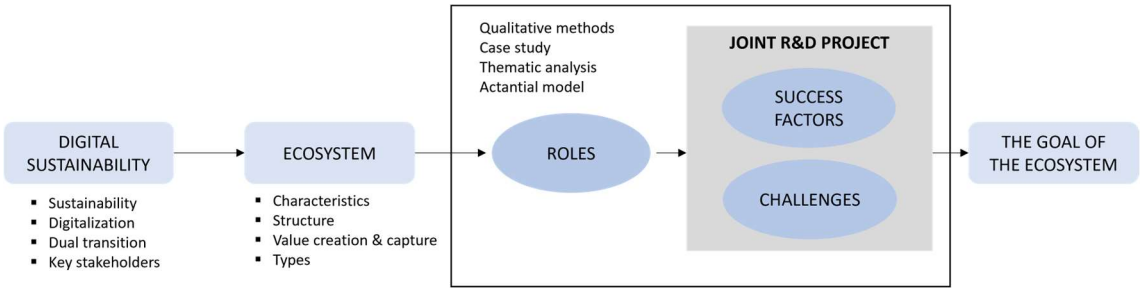

Figure 2 Theoretical framework of the study.

2 DIGITAL SUSTAINABILITY

This chapter provides definitions for sustainability, sustainability transformation, digitalization, digital transformation and digital sustainability. The fundamentals of these concepts are explained. Also, key stakeholders in developing digital sustainability are introduces to the readers.

2.1 Sustainability

Hartman et al. (1999) laid the groundwork for the today widely accepted three-pillar conception of sustainability with the environmental, social and economic dimensions. Environmental sustainability focuses on maintaining and balancing natural resources consumption with replenishment and preserving ecological integrity (Ghobakhloo, 2020). Economic sustainability's focus in on achieving long-term economic growth without depleting environmental and social resources, ensuring that economic development does not come at the expense of natural or social capital (Ghobakhloo, 2020). Social sustainability's focus in on managing both positive and negative impacts of business, environmental, economic, and technological activities on people. The goal is to create healthy and livable communities that protect individuals from discrimination and ensure access to universal human rights and basic amenities (Ghobakhloo, 2020).

The definition for sustainable development is not unambiguous but there are there are multiple definitions for it (Salomaa & Juhola, 2020), one of which is sustainable transformation. It is acknowledged that sustainability cannot be solved by one government or organization alone, it is understood that collaboration among the stakeholders is needed to achieve sustainability (Vurro et al., 2024). The article from Vurro et al. emphasizes that the collaboration aiming at solving sustainable challenges require assorted group of partners while at the same time managing these partners and multiple collaborations adds complexity. This cooperation aiming at sustainability requires collaboration capabilities such as understanding the different perspectives, openness, trust and exchange of knowledge (de Almeida et al., 2021). Year 2015 United Nations member states

described in "The 2030 Agenda for Sustainable Development" the seventeen sustainable development goals (SDGs, Figure 3) which were adopted by all of the member states (*THE 17 GOALS | Sustainable Development*, n.d.). These STGs are calls for action for all countries.

Figure 3 United Nations sustainable development goals.

Each of these goals is detailed with specific targets to be achieve by 2030, intended to guide global efforts towards sustainable development. Achieving the SDGs is a global, collective responsibility that involves governments, the private sector, civil society, and individuals. The global challenges in achieving the SDGs are not isolated issue but systemic threats which require transformation of the global economy (Ripple et al., 2023). The seventeen SDGs can be categorized under the three pillars of sustainability: environmental, social, and economic (Kleespies & Dierkes, 2022; Purvis et al., 2019).

2.2 Digitalization and digital transformation

In this section terminology related to digitalization is covered. Then properties that highlight the innovative potential of digital technologies are described. Lastly this section providers readers a short overview of the impact of digital transformation on businesses and capabilities required for coordinating co-creation and business-oriented ecosystems.

Although digital technologies have been around for decades, there remains ambiguity in the related terminology (Ritter & Pedersen, 2020). Some authors use terms "digitization" and "digitalization" interchangeable. Ritter and Pedersen define digitization as the transformation from analog to digital data having digit values of 0 or 1 and digitalization as utilization of digitization and the application of digital technologies. Legner et al. (2017) describes digitization and digitalization in a similar way. Digitization refers to the technical process of converting analog signals into digital form and focuses on the digital technologies themselves and their ability to store, transmit, and process information more efficiently. Legner et al. (2017) defines digitalization as a broader sociotechnical phenomenon, involving the adoption and integration of digital technologies in various individual, organizational, and societal contexts. Digitalization encompasses the transformation brought about by digital technologies, which extend beyond mere technical conversion to impact business models, organizational structures, and societal norms. Digital transformation is defined as systemic change and a process of organizational chance to incorporate innovative use of digital technologies for value creation (Pauliuk et al., 2022; Riasanow et al., 2021).

Digitalization has enabled a modular architecture by combining layers of devices, networks, services and contents created by digital technology (Yoo et al., 2010). These layers enable the creation of new digital products and distributed networks with coupling across devices, networks, services and contents. In addition to the layered architecture of digital technology, digital innovations bring advantages such as reprogrammability, data homogenization and self-referentiality. According to Yoo et al. these three properties, the capability of digital technologies to be easily modified or programmed for different functions or tasks after their initial deployment, the process of standardizing data formats, making diverse data sources compatible and easier to integrate and analyze and using digital technologies to create, modify, and improve other digital technologies, underline the innovative potential of digital technologies.

Digital transformation involves leveraging digital technologies to fundamentally change how businesses operate and deliver value to customers (Mann et al., 2022). Organizations struggle to adapt to technological innovations and the changes in the business environment that digital transformation requires (Pappas et al., 2018). The transformational challenges it brings, both in business and societal contexts, require understanding and new capabilities. Digital transformation does not concern only companies with software products but also

companies with physical products (Porter & Heppelmann, 2014). New types of smart products combining physical parts with information technology require companies to integrate external capabilities to create and capture value from digital transition (Porter & Heppelmann, 2014; Vial, 2019).

Orchestrating digital transformation in a business-oriented ecosystem requires developing a future vision, assessing internal capabilities, and a change of perspective in the organization's mindset towards digital transformation (Mann et al., 2022). According to Porter & Heppelmann (2014) companies need to be outward-focused, willing to leverage external knowledge, skills, and resources that are not available internally. The authors further emphasize that digital transformation requires engaging new actors, forms of working and sources of value into the ecosystem. This does not take place without complications; digitalization may bring both new opportunities but also threats. Co-creation of digital solution and creation of smart products may bring challenges such as disruption of the value chain and changes in the share of value capture.

2.3 Digital sustainability, a dual transition

The two current movements, digitalization and sustainability have been mainly studied as two separate phenomena (Pauliuk et al., 2022). An article from the nineties describes how information technology can advance sustainable development and sustainable societies (Tonn & White, 1996). Since then, digital transformation has slowly started to take place (Hilali et al., 2020). Although sustainable development and digital transformation are two global processes taking simultaneously place, they also interact (Pauliuk et al., 2022). Sustainable development is understood as the long-term global environmental, social and economic stability (*THE 17 GOALS | Sustainable Development*, n.d.) and digital transformation is defined as the process of organizational chance to incorporate innovative use of digital technologies for value creation (Riasanow et al., 2021). Digital sustainability, the dual transition of digitalization and sustainability is defined as a set of values that, when implemented, guide the development and utilization of digital technologies in a way that ensures a sustainable future (Astuty et al., 2024; Sparviero & Ragnedda, 2021). The values are the same as for sustainability set by the United Nations Sustainable Development Goals. Digitalization has an essential role in enhancing sustainability and solving the grand challenges in making the world more sustainable (George et al., 2021; Ghobakhloo, 2020; Ha et al., 2022)

Digitalization offers opportunities to make positive impact on sustainability (Santarius & Wagner, 2023). The authors describe digitalization's potential to optimize resource usage, reduce emissions, and improve energy efficiency. According to Santarius and Wagner digital technologies such as internet of things (IoT), artificial intelligence (AI), blockchain, mobile technologies, sensors and big data analytics are essential in creating sustainable

business by enabling more informed decision-making and enhancing innovations that contribute to environmental, economic, and social sustainability. Digitalization is critical for achieving sustainability goals, as it enables sustainable solutions through smarter, more efficient, and inclusive approaches. Digital technologies also enable better monitoring and management of environmental impacts, optimize resource use, and support the development of circular economies (Klymenko et al., 2021; Santarius & Wagner, 2023).

It is argued that digitalization may bring environmental risks as it produces emissions and demand of resources and energy (Santarius & Wagner, 2023). Santarius and Wagner further elaborate that digital technology itself has also the environmental impact as it produces electronic waste. Digitalization brings other potential disadvantages, such as increased cybersecurity risks, potential job displacement due to automation, and the digital divide that may aggravate social inequalities (Ghobakhloo, 2020). According to Ghobakhloo these challenges call for a balanced approach to digitalization, emphasizing the benefits for sustainability and the need for measures to mitigate the negative impacts.

Today the concept of Industry 4.0, called the fourth industrial revolution, facilitates the industrial digitalization and contributes to sustainability (Cricelli & Strazzullo, 2021; Ghobakhloo, 2020). Industry 4.0 refers to the integration of advanced digital technologies into conventional manufacturing and production settings, where technological, social, and organizational elements converge and influence each other (Beier et al., 2020). It covers wide range of information technologies, such as sensors, data, cloud computing, augmented and virtual reality, robots, internet of things and artificial intelligence (Fraga-Lamas et al., 2021; Ghobakhloo, 2020). Although part of these technologies has been available already for a long time, now the progress and technological development allows the interoperability and integration needed for digitalization (Nascimento et al., 2019). Digitalization plays also essential role in economic sustainability (Cricelli & Strazzullo, 2021). Profitability and shareholder value are primary drivers for business decisions. Therefore, companies are more likely to promote sustainability if it aligns with their economic interests (Orzes et al., 2020). Industry 4.0 and digital innovations improve companies' long-term efficiency, competitiveness, innovation and market share while addressing sustainability goals. Without these economic incentives and potential, motivation of companies to make investments and develop new technologies and business models may be weaker (Beier et al., 2020; Orzes et al., 2020).

2.4 Key stakeholders

This section first highlights the key reason and challenge for collaborative approach for digital sustainability development. Then the multiple stakeholder groups needed for digital sustainability development are introduced to the readers: industry, governments, academia and research organizations, entrepreneurs and civil society.

Development of digital sustainability solutions frequently utilize collaborative ecosystem to strengthen their impact, therefore joint activities are often utilized to increase efforts to address complex global challenges (George et al., 2021). On the other hand, digitalization requires reorganizing collaboration (Kolloch & Dellermann, 2018) and profound changes in the business models (Hilali et al., 2020). Kolloch and Dellermann further state that especially industry with traditional physical products must collaborate with new partners from digital industry and combine their knowledge base for innovation effort.

The industry plays a critical role in digitalization and sustainability, both historically and currently (Leal Filho et al., 2020). In the previous decades industrial activities have significantly contributed to environmental degradation, resource depletion, and social inequalities. However, Leal Filho et al. highlight that the industry has the potential to drive positive change towards sustainability by adopting innovative technologies, sustainable practices, and corporate social responsibility. According to the authors to achieve sustainable development goals, collaborative efforts, innovative solutions, and strong governance frameworks are important to overcome the barriers to sustainable development goals and to realize a sustainable future. Updating industrial practices to be more sustainable is crucial in this transition. Industries are responsible for integrating digital technologies into their operations to enhance e.g. efficiency, reduce waste, and develop sustainable business models (Ha et al., 2022). The study by Ha et al. show that the adoption of digital technologies in industrial operations can lead to reducing environmental footprints and enhance efficiency. Companies are expected to invest in research and development to innovate new solutions that contribute to sustainability. While increasing economic efficiency and effectiveness is traditionally the main driver for companies, integrating digital strategies in business models for sustainability can also yield economic advantages (Bencsik et al., 2023). Economic success and sustainability can coexist, and digitalization offers companies new ways to create and capture value in sustainable manners. Innovativeness and new business models integrating sustainability goals are required value creation and delivery (George et al., 2021).

In addition to industrial activities, governments play a key role in creating enabling environments for sustainable development (Ghobakhloo, 2020). Ghobakhloo states that governments play a key role in providing the framework within which industries and businesses can operate sustainably. This is achieved by implementing policies and regulations that promote sustainable practices, investing in sustainable infrastructure, and fostering partnerships between the public and private sectors. Strong governance, policy coherence, and political commitment of national and local governments is needed to overcome sustainability development barriers and ensure a sustainable future. Regarding digital sustainability, governments' role is central in creating supportive policies, regulations, and frameworks which encourage the development and adoption of sustainable practices and digital technologies, while also ensuring that the negative impacts of digitalization are minimized (Ghobakhloo, 2020).

Academia plays an important role in advancing research on sustainable technologies and digitalization, providing the scientific basis for innovation and training the future workforce (Ghobakhloo, 2020). Universities and research institutions are important in fostering the necessary knowledge and capabilities for digital sustainability (Trevisan et al., 2023). The authors state that universities are expected to support digital sustainability with their infrastructure, education, research, campus operations, community outreach, and assessment and reporting. They serve as hubs for interdisciplinary research on digital sustainability, foster multidisciplinary collaborations across and address complex challenges of digital sustainability. Important research topics to foster digital sustainability include sustainable digital infrastructures, the creation of energy-efficient technologies, software and algorithms that minimize carbon footprint and the formulation of strategies for reducing the environmental impact of digital services and products (Nadkarni et al., 2021). The study from Nadkarni et al. state that an important aspect is the integration of ecological considerations into the design, operation, and disposal of digital technologies.

In the domain of digital sustainability entrepreneurs, startups and new ventures are expected to have a pioneering role in developing business models that address and integrate sustainability into the global industrial complex (George et al., 2021). The authors say that startups are seen important developers of disruptive digital technologies and testbeds for new sustainable solutions.

Also, civil society has a role, although not much attention has been given to it (Del Río Castro et al., 2021). According to the study by Del Río Castro et al. civil society and individuals play a significant role e.g. as consumers as consumption denote 60 % of the global wealth. Their engagement is important for creating demand for sustainable solutions, yet it remains to be researched how to evolve civil society in promoting the required chances.

3 ECOSYSTEM

This chapter describes the fundamentals of ecosystems, what ecosystems are, which type of ecosystems exits and why they are considered beneficial. Key concepts and terms related to ecosystem are defined. Recent theories regarding the ecosystem types and characteristics are reviewed to provide insight. Based on literature, the value creation and capture in ecosystems is introduced to the readers.

3.1 Ecosystem definition

The term "ecosystem" is adopted from biology to economy (Pilinkienė & Mačiulis, 2014). Analog to its biological counterpart, also in the economy context ecosystem has effects on its elements and surrounding and there are factors, actions and actors that may affect the functionality and performance of the ecosystem as whole. It was Moore in 1993 that initially proposed the concept of business ecosystem where a company should be viewed as part of a business ecosystem cross industries rather than a member of a single industry. For an individual participant, joining this type of an inter-organizational collaboration is beneficial when they lack the capability to commercialize a product or service on their own (Lin et al., 2010).

Despite the interest of both practitioners and scholars as well as vast number of publications on economy related ecosystems where companies and other entities cocreate solutions, there still is no precise definition for ecosystem (Jacobides et al., 2018). Also, the concepts and terminologies in ecosystems studies are fluid and ambiguous (Paasi et al., 2023). A recent study searched for a consensus definition of business ecosystems where Felch and Sucky (2023) underline the differences between biological and business ecosystems, particularly in terms of the actors' capabilities and goals. After comprehensive study of academic literature and consultancy firms, they propose an ecosystem definition that emphasizes the collaborative, cross-industry character of

ecosystems and ecosystem's focus on value-creation. Regardless of the differences in some aspects and emphasis of man-made ecosystem types, a common nominator is the requirement for collaboration in order to develop innovative solutions and solve grand challenged which provide customers value (Khan et al., 2022; Paasi et al., 2023). Despite the distinct goals and emphasis of different ecosystem types, the survival and growth of the ecosystems partners is a common aim of ecosystems (Cobben et al., 2022). Ecosystems are dynamic structures characterized by renewal, adaption to new market and technology conditions and evolving relationships among the ecosystem actors (Williamson & De Meyer, 2012).

3.2 Key characteristics of ecosystems

Based on literature, this section describes to the readers the ecosystem's key attributes are the goal, strategy & governance, stakeholders, their roles and relationships.

The goal of ecosystem is defined as shared objectives of the ecosystem actors to create value, where the desired value depends on the interest of the ecosystem actors (Felch & Sucky, 2023; Kapoor & Lee, 2013; Ketonen-Oksi & Valkokari, 2019). It involves the integration and co-development of various components, including skills and ideas provided by the actors within an ecosystem, where each participant contributes towards shared objectives (Cobben et al., 2022). Distinctiveness and clear positioning of an ecosystem can benefit the ecosystem's performance by encouraging unique and innovative development (Inoue, 2021). However, the literature suggest that distinctiveness has a complex impact (Cennamo & Santalo, 2013). According to Cennamo and Santalo it can have a negative effect on performance at moderate level, but distinct and unique positioning can be beneficial if a platform distinguishes from competitors. The alignment of common, shared goals among the ecosystem actors is a prerequisite for innovative outcomes that benefit the actors.

Ecosystem strategy relates to all ecosystem actors and defines potential benefits, sources of opportunities, engagement models and required capabilities, design and launch, competition and strategy's adjustment and expansion (Krome & Pidun, 2023). According to the authors the strategy involves understanding how to engage with other stakeholders within the ecosystem, designing and evolving strategic actions to build and sustain competitive advantage, and managing relationships and collaborations to create value for the ecosystem partners. It emphasizes the strategic alignment and governance to enhance ecosystem performance, including adaptive strategies to respond to changing business environment, such as changing market conditions and technological advancements. Further Krome and Pidun state that ecosystem strategy also involves managing the interdependencies within an ecosystem to optimize the collaboration and results. Strategy includes choices made to influence the

ecosystem's structure, the roles and interactions among its participants, and the creation and capture of value. It aims for relationships where mutual benefits drive the collaboration within the ecosystem. According to Krome and Pidun strategy recognizes the evolving nature of ecosystems and the need for continuous adaptation and co-evolution among the stakeholders involved. Governance is a mechanism to promote joint goal, it aligns, guides and controls the structures, processes, and practices of the ecosystem (Cobben et al., 2022; Lechner et al., 2023). It is very important as it impacts the motivation and behavior of the participants (Lechner et al., 2023). The study from Lechner at al. state that the governance and regulation define how and if new partners can join the ecosystem. These rules defining who may join the ecosystem can be tightly regulated or very flexible. According to Lechner et al. orchestrators, entities or organizations that manage and control the strategic direction of the ecosystem, aim to maintain the ecosystem's overall direction and coherence while balancing between control and autonomy. From the perspective of orchestrators there are four major aspects which need to be considered in governance: granting access, scaling-up, measurement and reward allocation, managing conflicts and membership. Williamson & De Meyer (2012) stress the importance of creating a structure and incentives to attract and manage partners with differentiating roles, managing overlaps and possible conflicts, and stimulating. For the long-term sustainability of an ecosystem balanced value capture mechanism must be ensured where stakeholders both contribute and derive value. Ecosystems can be open, closed or hybrid (Jacobides et al., 2018). Openness can lead to increased collaboration and innovations but at the same time it makes governing the diverse interest more difficult and potentially complicates ensuring the ecosystem’s unity.

Stakeholders vary in the different ecosystem types (Cobben et al., 2022). Valkokari (2015) identified several ecosystem actors such as suppliers, customers, focal companies, innovation policymakers, local intermediators, innovation brokers, funding organizations, research institutes, innovators and technology entrepreneurs. A versatile assembly of stakeholders provides the complementary input needed for the shared objectives to create value (Y. Li et al., 2022). Strong connection between stakeholders can also improve risk prevention performance. Effective stakeholder collaboration, characterized by open communication and mutual trust, leads to enhanced innovation capabilities and a more resilient ecosystem.

A role refers to the specific function or position an actor e.g. organization, institution, or individual plays within the ecosystem (Jacobides et al., 2018). These roles are characterized by their contributions to the creation, delivery and capture of value within the ecosystem. Often the role of an actor is complementary to the roles of other actors and supports the fundamental idea of an ecosystem that each participant brings in unique capabilities or resources. Achieving the overall goal of the ecosystem is supported when these capabilities or resources are combined with those of others. Roles in ecosystems are not fixed but can evolve over time as the ecosystem itself evolves, new technologies

emerge, regulatory landscapes change, or market demands shift. Clear roles are crucial for coordinating the activities of the participants and ensuring that their interdependencies can be managed. This coordination is often supported by a combination of formal and informal mechanisms (e.g. standards, governance structures) and shared norms or values, which help align the interests and actions of ecosystem participants. By defining and understanding the roles within an ecosystem, actors can define their position and interactions within the ecosystem, identify potential partners or complementors. This way actors may optimize their contributions to and benefits from the ecosystem. Roles also help in identifying gaps or opportunities within the ecosystem that new or existing participants can fill, thereby driving the goal of the ecosystem.

Relationships refer to the nature and dynamics of interactions between different actors within an ecosystem (Jacobides et al., 2018). These relationships are characterized by the way these actors such as companies, research institutes and other organizations are interconnected through their roles, dependencies, and the complementarities that exist between them. According to Jacobides at al. relationships in ecosystems are essential for understanding how value is created, delivered, and captured within the ecosystem, and how these processes are managed and coordinated. Relationships in ecosystems can vary in strength, formality, and directionality. They can be formalized through contracts and agreements. Relationships can be also informal, based on mutual understanding and shared goals. They can also be unidirectional, where one actor depends on another, or bidirectional, specifying a mutual dependency. Jacobides et al. state that the nature of these relationships is influenced by the ecosystem's structure, the roles of the actors within it, and the governance mechanisms that guide interaction and coordination.

Ecosystem's key attributes, goal, strategy & governance, stakeholders, roles and relationships, are summarized in (Table 1).

Table 1 Key attributes of ecosystems

Attribute	**Description**
Goal of the ecosystem	The shared and desired value proposition set by the ecosystem (Felch & Sucky, 2023; Kapoor & Lee, 2013; Ketonen-Oksi & Valkokari, 2019).
Strategy and governance	Strategy involves the planning and execution of actions aimed at achieving ecosystem's goals (Krome & Pidun, 2023). Governance refers to the structures, processes, and practices that guide and control the management the ecosystem (Cobben et al., 2022).
Stakeholders	Any entity participating in the ecosystem whether a direct ecosystem partner (e.g. companies, research institutes, customers) and an external stakeholder (e.g., government, funding organizations, regulatory bodies) (Valkokari, 2015). Also, term actor (Cobben et al., 2022) or participant (Adner, 2017) is used.
Roles	The specific function or position a participant plays within the ecosystem. The roles may adapt over time due to shifts in e.g. technology, regulation, and market demand (Jacobides et al., 2018).
Relationship	A relationship refers to the nature and dynamics of interactions and connections between different actors within the ecosystem (Jacobides et al., 2018).

3.3 Ecosystem as a structure

In addition to regarding an ecosystem as a network of organizations collaborating for mutual benefit and value creation, an ecosystem can also be seens as a structure (Adner, 2017). Adner's ecosystem structure is defined as a concept based on alignment of activities, actors, position and links which form the foundation for value creation. This approach emphasizes the importance of multilateral coordination among various partners, each contributing through distinct roles and interconnected activities:

> **Activities**: Discrete actions are need for the value creation to take place. Activities highlight the process-oriented nature of ecosystem functionality, focusing on the tasks or operations that contribute directly to the end goal.
>
> **Actors**: Different organizations or individuals that perform the activities. An actor can be involved in multiple activities or a single activity may require the involvement of multiple actors. For the ecosystem to be successful, multiplicity and diversity of partners are necessary.
>
> **Positions**: Actors location in the flow of activities across the system is relevant for the collaboration. Positions characterize the sequence of actions and defines who hands off to whom, providing a map of the operational structure of the ecosystem.
>
> **Links**: Transfers of e.g. material or information across the actors' positions. Importantly, these links are not confined to direct connections with the focal actor but can span across the ecosystem, illustrating the complex web of interdependencies.

Adner's framework implies that understanding an ecosystem requires an analysis of how these elements (activities, actors, positions, and links) interact and align with each other. A successful ecosystem strategy must understand and manage these interdependencies to ensure that the collective efforts of all actors join around the shared value proposition. Adner argues that in the modern, interconnected business environment, firms must look beyond direct interactions such as collaboration with the supply chain and instead consider their role within a broader ecosystem of value creation.

3.4 Value creation and capture

Value creation and innovating requires partners to share knowledge, resources, responsibilities and to promote positive and supportive environment (Khademi, 2020). The literature review from Khademi further states that the mechanisms for value creation and capture within ecosystems are complex due to varying structures of ecosystems and diverse interactions among the stakeholders. Managing relationships and resources within ecosystems and applying strategies to foster collaboration and enhance innovations are important for creating and capturing value. Ecosystems and the role of co-creation are also dynamically evolving through interactions between ecosystem actors (Khan et al., 2022). Previous literature recognizes strategies which promote value creation and capture in the complex, dynamic ecosystem setting (Table 2).

Table 2 Strategies promoting value creation and capture.

Complementary partners and assets	Including complementary partners and assets to enrich the ecosystem (Helfat & Raubitschek, 2018; Van der Borgh et al., 2012). The ecosystem leader must manage the incentives for complementors to encourage their participation and ensure value creation and a fair value capture within the ecosystem.
Universities and research centers joining the ecosystem	Ensuring universities and research centers join ecosystem. Their role is essential for the integration and dissemination of knowledge (Spena et al., 2016).
Common goals and shared vision	Aligning stakeholders towards common goals and focus on shared vision, which is formed collectively and acknowledges technology, science and social aspects (Bhalla, 2014; Hooge & Le Du, 2016).
Identifying opportunities	Identifying opportunities by understanding the interactions of the ecosystem actors and by forming a jointed ecosystem enhancing collaboration and innovation (Y.-R. Li, 2009)
Dynamic capabilities	Dynamic capabilities are essential for all actors and especially for the leader of the ecosystem (Helfat & Raubitschek, 2018). Three critical capabilities are emphasized in particular: 1) Innovation capabilities for developing new products or services to meet the changing market demand or technological advancements, 2) Scanning and sensing capabilities for identifying and responding to opportunities and threats in the market potentially helping companies also to identify competitive solutions, 3) integrative capabilities important for leading an ecosystem, including aligning the interests and activities of the stakeholders and managing the ecosystem's governance structure.
Facilitating the innovation process	Facilitating the innovation process of the individual companies as well as the innovation process of the ecosystem (Van der Borgh et al., 2012). The ecosystem environment supports companies with the engagement in innovative activities more effectively by providing facilities, resources and potential collaborators. The ecosystem enhances the value-creation potential by shared knowledge, resources, and a culture of collaboration.

3.5 Different types of ecosystems

In this paragraph first ecosystem literature from the last ten years is introduced to the readers. Several different types of ecosystems are gathered from the literature and shortly presented. Then a recently published literature review (Cobben et al., 2022) is covered to perceive a more focused view of four main ecosystem types based on the nature of the ecosystems' goals, characteristics and purposes. Since the first introduction of business ecosystem by Moore (1993), different types of man-made ecosystems have been introduced and the ecosystem concept evolves constantly (Arenal et al., 2020; Ketonen-Oksi & Valkokari, 2019). Ecosystem scientist have studied the typical characteristics of ecosystems and brought understanding of the boundaries and attributes of ecosystems (Cobben et al., 2022; Jacobides et al., 2018; Valkokari, 2015). These studies provide several alternative perspectives to define and categorize ecosystems, for example, based on their goal and function. Scholars have reported and studied a number of different types of ecosystems, such as industrial, innovation, business, digital business, service, entrepreneurship, knowledge and data ecosystems (Table 3).

Table 3 Examples of ecosystem types

Article	Ecosystem name	Definition of the ecosystem
Li et al., 2022	Digital innovation ecosystem	Complex system of stakeholders and collaborative relationships focusing on digital innovations.
Rosa et al., 2023	Green innovation ecosystem	Various stakeholders collaborate to achieve sustainable outcomes.
Arenal et al., 2020; Gomes et al., 2018a; Ketonen-Oksi & Valkokari, 2019; Pilinkienė & Mačiulis, 2014	Innovation ecosystem	System focusing on value creation through research, development and innovation activities between industry and research-based actors.
Clarysse et al., 2014; Felch & Sucky, 2023; Pilinkienė & Mačiulis, 2014	Business ecosystem	Group of companies combining their resources and skills to create value which no one could achieve alone. The focus is on customer value creation.
Öberg & Lundberg, 2022; Rådberg & Löfsten, 2023	Knowledge ecosystem	Participants focus on knowledge development and knowledge sharing.
Mele et al., 2018; Vargo & Lusch, 2016	Service ecosystem	A dynamic network of participants who interact with each other to integrate various resources to create mutual value through service exchange.
Audretsch et al., 2019; Pilinkienė & Mačiulis, 2014	Entrepreneurial ecosystem	Stakeholders interest is to organize an environment promoting establishing successful new ventures.
Pilinkienė & Mačiulis, 2014	Industrial ecosystem	Objective is to minimize the input of energy and use of virgin materials. The focus is on sustainability.
Pilinkienė & Mačiulis, 2014	Digital business ecosystem	Information and communication technologies are utilized to create value and support participants business community.
D'Hauwers et al., 2022	Data ecosystem	Actors use, exchange and re-use data to create value.

A systematic review of ecosystem types (Cobben et al., 2022) differentiates four main types of man-made ecosystems based on their goals, characteristics and purposes: business ecosystems, innovation ecosystems, knowledge ecosystems and entrepreneurial ecosystems. The definitions of these four types of ecosystems provide concepts based on their characteristics, goals, and their operational mechanisms without significant overlap. They were analyzed based on their competitive advantage, geographical and temporal scope, orchestration, actors, structure, value creation and capture. Their main differences were found in competitive advantage, geographical scope, orchestration, structure, value creation and capture. These characteristics enable the ecosystems to realize their specific goals (Valkokari, 2015). Previous studies have pointed out that ecosystems are dynamic and may chance their type (Clarysse et al., 2014; Valkokari, 2015) and the goals of an ecosystem are often manifold (Cobben et al.,

2022). Clarysse et al. (2014) highlight in their study that the value creation phases are very different in knowledge and business ecosystems. Ecosystem types have varying goals and logic of action (Clarysse et al., 2014; Cobben et al., 2022). They further observed that transition from knowledge to business ecosystem does not take place spontaneously and naturally. The same actor can participate and assume various roles within each ecosystem (Valkokari, 2015). In the following paragraphs the four archetypes of ecosystems recognized by Cobben et al. (2022) are introduced.

3.5.1 Business ecosystem

Moore (1993) defined the business ecosystem as system where "companies coevolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovation." At the center of a business ecosystem is a focal company and its environment (Jacobides et al., 2018). The focus is on business relationships and economic outcome is driver of the ecosystem (Cobben et al., 2022; Valkokari, 2015). Both competition and collaboration exist in the ecosystem, but actors pursue innovation, growth and sustainability. Actors underline common benefit, and the role of the ecosystem is to facilitate response to market demand and technological changes. The partners are often chosen from the business perspective and include e.g. customers, distributors, and other business network actors.

3.5.2 Knowledge ecosystem

A knowledge ecosystem is a network of knowledge-intensive organizations that interact closely to develop, transfer, and integrate knowledge (Öberg & Lundberg, 2022; Rådberg & Löfsten, 2023; Valkokari, 2015). Knowledge ecosystem emphasizes collaboration among participants to enhance creation of new knowledge, often involving universities, research organizations and industry. As industrial stakeholders, technology entrepreneurs or high-tech companies are emphasized (Rådberg & Löfsten, 2023; Valkokari, 2015). Although new knowledge enhances innovation, brings competitive advantage and helps companies to adapt to the changes in the business environment (Rådberg & Löfsten, 2023), knowledge ecosystem emphasizes exploration over exploitation, dissemination of the new knowledge and open exchange of ideas (Valkokari, 2015).

3.5.3 Innovation ecosystem

The literature does not provide unambiguous definition for innovation ecosystem (Gomes et al., 2018b). However, the emphasis of innovation ecosystem is on supporting innovation processes and outcomes. Innovation ecosystem is complex and has a versatile stakeholder group and typically the ecosystem consists of business, academia and government and is complemented by non-

governmental organizations (NGOs), universities, research organizations, communities and end-users (Cobben et al., 2022). Valkokari (2015) defines innovation ecosystem as a fusion of business and knowledge ecosystems, integrating exploration of knowledge with the focus on creating customer value.

3.5.4 Entrepreneurship ecosystem

Entrepreneurship ecosystems are environments with the shared goal to increase the creation and success for newly established ventures (Audretsch et al., 2019). Where the focus on business ecosystems is on company or companies, the emphasize of entrepreneurship ecosystems is on individual entrepreneurs or venture teams. The ecosystem creates competitive advantages for these new ventures and their stakeholders. These ecosystems aim at disruptive innovations which change the existing markets and creating new opportunities for growth and development. Although central actors, entrepreneurs are seen not only as beneficiaries of the ecosystem (Stam, 2015). The ecosystem prioritizes ambitious goals and new ventures with potential for high growth. Stakeholders include governmental organizations, venture capitalists, investors, research organizations, universities, and high-tech companies (Cobben et al., 2022; Stam & Van De Ven, 2021). Entrepreneurship ecosystem emphasizes the importance of a supportive environment including financial resources and a culture that values innovation and risk-taking.

4 SUMMARY

The purpose of this short paragraph is to outline for the readers the connection between the themes of the two previous chapters, digital sustainability and ecosystem.

The evolution of ecosystems towards digital transformation is an unavoidable trend in the digital economy (Yang et al., 2021). In ecosystem developing digital solutions, companies can create new industrial environments and leverage digital technologies to solve problems, create new products, new business models and enter new markets (Li, 2018; Riasanow et al., 2021). From ecosystemic point of view, traditional and digital innovation share the underlying principle of creating value through new combinations of resources and capabilities (Vargo et al., 2023). According to Vargo et al. both traditional and digital innovation types require collective effort. They both are dynamic and interactive processes and require coordination of multiple actors as the value is co-created through interactions between the stakeholders. However, the development of digital innovation does differ from traditional innovations in some respects. Vargo et al. further elaborate that digital innovation emphasizes the decoupling of information from physical means, while traditional innovation often involves tangible goods or physical interactions. Digital technologies enable the innovations larger geographical reach. Digitalization also enhances the ability to combine and mobilize resources more efficiently and makes resources more accessible and usable in the creation of value.

While digital transformation can enhance competitiveness and foster sustainable growth, ecosystems need to adapt their strategies, cultures, and operations to foster digital transformation (Pappas et al., 2018). Digital transformation typically include change across technology, human actors and organizations (Mann et al., 2022). It may fundamentally reshape how businesses operate and deliver value (Riasanow et al., 2021). Ecosystem stakeholders must adapt their individual practices and also contribute to and benefit from the collective capabilities and innovations of the ecosystem, fostering a more resilient and adaptable network of interdependent entities. There is a need to enhance connectivity and collaboration among ecosystem participants and create

ecosystem-wide strategies to leverage collective strengths and co-create value (Mann et al., 2022). Digital transformation requires capabilities that may be easier or faster to obtain from others in the ecosystem rather than trying to tackle intra-organizational (Williamson & De Meyer, 2012). According to Williamson and De Meyer ecosystemic approach helps to acquire digital capabilities, resources and knowhow needed for successful digital transformation.

Del Río Castro et al. (2021) connects digitalization as tool for aiming for sustainability and enhancing value creation in collaborative ecosystems. Cobben et al. (2022) describe the focus of different ecosystem types as indicated by value creation and capture Figure 4.

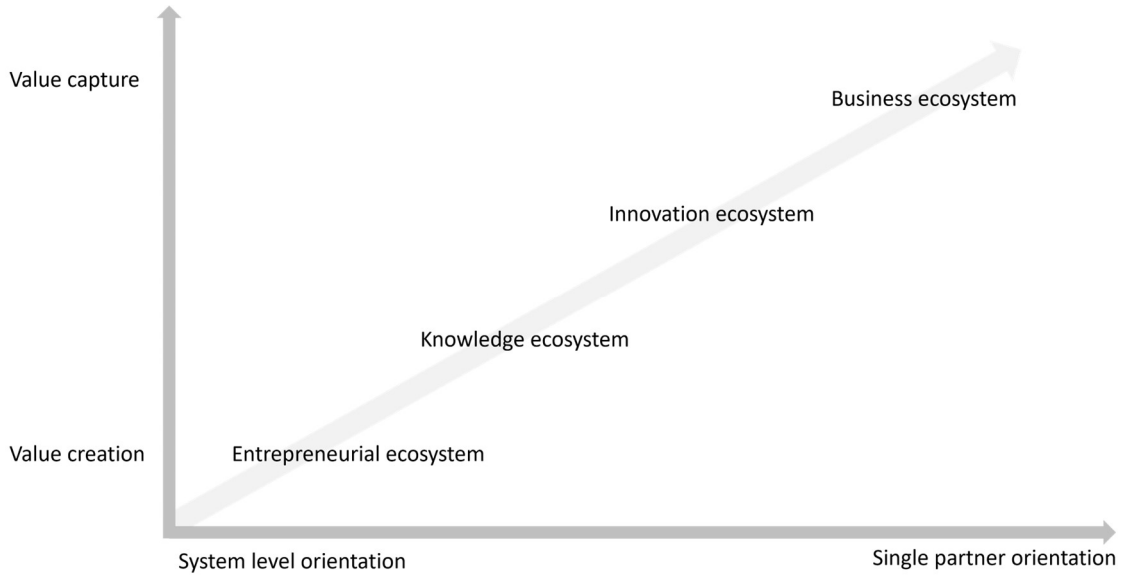

Figure 4 Value creation and capture focus by ecosystem type, modified from (Cobben et al., 2022 p. 144).

An entrepreneurial ecosystem aims at fostering a supportive environment for both start-ups and larger organizations. It emphasizes the importance of each partner taking responsibility for capturing value, with research primarily focused on establishing the necessary conditions for this value creation. Key elements include designing a collaborative business environment and cultivating an entrepreneurial climate. Knowledge ecosystem's efforts are focused on capturing value from jointly developed knowledge at system level. Innovation ecosystem is concentrated on realization of shared value, how both the individual actors and the ecosystem can create and capture value. A business ecosystem is focused on how individual ecosystem actors can capture value.

5 RESEARCH DESIGN

This section introduces the research design to the readers. First, the literature review process of the theory part of the study is presented. In the flowing section the research case of the leading company ecosystem is explained. The leading company ecosystem concept and funding are introduced and ecosystems' objectives and stakeholders are made known for the readers. Also, the leading company ecosystem joint R&D project concept is presented and explained. The section 5.3 introduces the methods used for the research as well as for collecting and analyzing the data of the master thesis study. The choices regarding chosen methods are explained and reasoned. To conclude this section, validity of the research is discussed.

An overview of research process is presented in the Figure 5. Two-way arrows in the figure reflect an iterative process. The data analysis, results, discussion and conclusion parts of the study formed an iterative cycle where the data analysis is linked to description and interpretation of the data (Dierckx de Casterle et al., 2012).

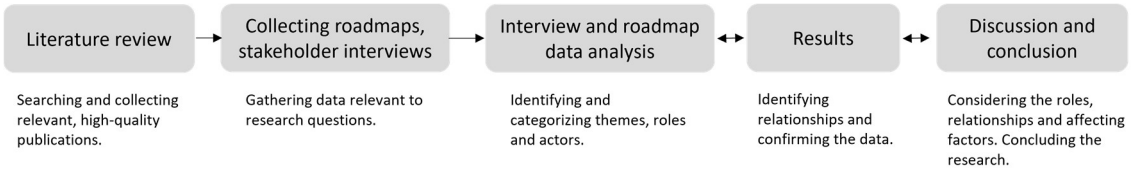

Figure 5 Simplified research process overview.

5.1 Literature review

For the literature review of the chapters 2, 3 and 4 search of articles from the databases was done to learn about the field of research, drivers and roles of the stakeholders. All in this study cited peer-reviewed articles were selected based on quality and relevance to the research and the research questions. Only articles with JUFO rating (*JUFO Portal*, n.d.) of 1 or higher the year of the scientific

publication were cited. Recent articles were included to reflect latest research findings. The Figure 6 shows the literature review process. The two-way arrows reflects iterative steps.

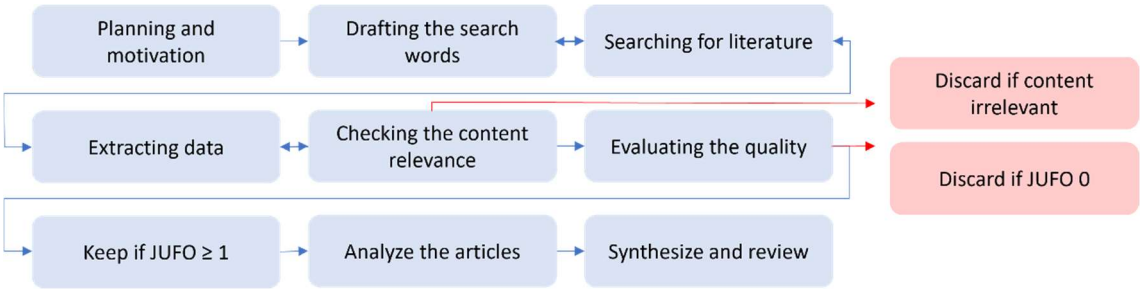

Figure 6 The literature review process.

The earlier literature was reviewed to get insight and deeper understanding of the status of the relevant research topics. The gained knowledge helper formulating appropriate and accurate research questions for the research study.

5.2 Case Leading Company ecosystem

This study considers the leading company ecosystems funded by Business Finland (status 8.1.2024), including the five ecosystems funded with EU Recovery funding (Figure 1, p. 8). In this section, first the requirements for leading company ecosystem are presented. Then the basic ecosystem structure and joint R&D project concept is introduced to the readers.

5.2.1 Leading company ecosystem requirements

Key criteria for Business Finland's evaluation of the leading company ecosystem funding include (*Vuoden 2023 Haastekilpailu Vetureille Ja Haastajayrityksille Sisällysluettelo*, 2023):

- Increase in research, development and innovation (RDI) investments.
- Clarity of the mission and goals.
- The need of the ecosystem to solve the mission and export potential for Finland (combining the leading company + ecosystem).
- The leading company project must be in the core of the company's strategy and the executive leadership must be committed to this leading company project.
- The added value from the Business Finland's funding
- The quality and concreteness of company's own project plan. The company must be able to show that it has adequate resources and committed team to lead the project.

- Action plan and commitment to develop the ecosystem (so called roadmap). Description how the company will lead the ecosystem and the millions of euros allocated to the ecosystem partnership.
- Availability of experts and identification of partner companies
- Exploitation plan for other funding sources (European Union, Research Council of Finland)

Companies applying for the leading company funding are also required to describe in their application the potential impact on green transition and digitalization.

Business Finland has two competition categories for the leading company ecosystem funding:

1. Leading Company (in Finnish veturi) competition: For leading companies that operate globally and can make significant increase in RDI investments in Finland. The funding is at most 20 M€ for the leading company and at most 50 M€ for the ecosystem.
2. Challenger (in Finnish haastajaveturi) competition: For companies that aims to grow to be global players or for companies that solve smaller or more focused challenge or develop totally new business venture or strengthen the role of a global player in Finland. RDI investment increase is not as big as those of a leading company. The funding is at most 10 M€ for the Challenger and at most 20 M€ for the ecosystem.

For the sake of convenience, the term leading company is used in this study when it is not required to emphasize the specific role of a challenger company. In other words, in this study, the leading company term is used for both leading company and challenger company.

Leading company ecosystems are funded for fix-term, maximum of five years. Companies can also collaborate and apply a joint leading company funding forming a shared ecosystem and roadmap. Business Finland two key performance indicators for the leading companies are the increase in RDI and ecosystem work. Business Finland follows also other positive national economy effects such as increased export, green transition, digitalization, job creation and tax income.

Leading companies are obligated to build an ecosystem around the mission and themes of their roadmap. Each leading company's roadmap describes the research and development (R&D) areas that the company has chosen and wants to develop in cooperation with others. Both private and public actors have a role in these leading company ecosystems. The way to join a leading company ecosystem varies. Some of the ecosystems are open to all willing to participate and other ecosystems may require a written agreement to join the ecosystem.

5.2.2 Ecosystem structure and joint R&D projects

Business Finland requires the leading companies to build an ecosystem around their mission and to promote collaboration with other companies and research organizations in resolving this mission. The leading companies have divided their mission into sub areas, which some companies refer as work packages, streams or focus areas. Figure 7 depicts an imaginary leading company ecosystem with six submission areas. Business Finland's funding to the leading company's own project is typically in the order of 10 to 20 M€ depending on the leading company's own investment which is typically something in the region of 25 to 50 M€. The total investment around a leading company ecosystem is in the range of 100 to 225 M€ depending among other things on whether the ecosystem a leading company or challenger company ecosystem. The ecosystem actors form partnerships and projects to support the implementation of the mission and the ecosystem research and development. These projects typically apply funding from Business Finland or European Union. The projects can be private-public partnerships or solely private partnerships.

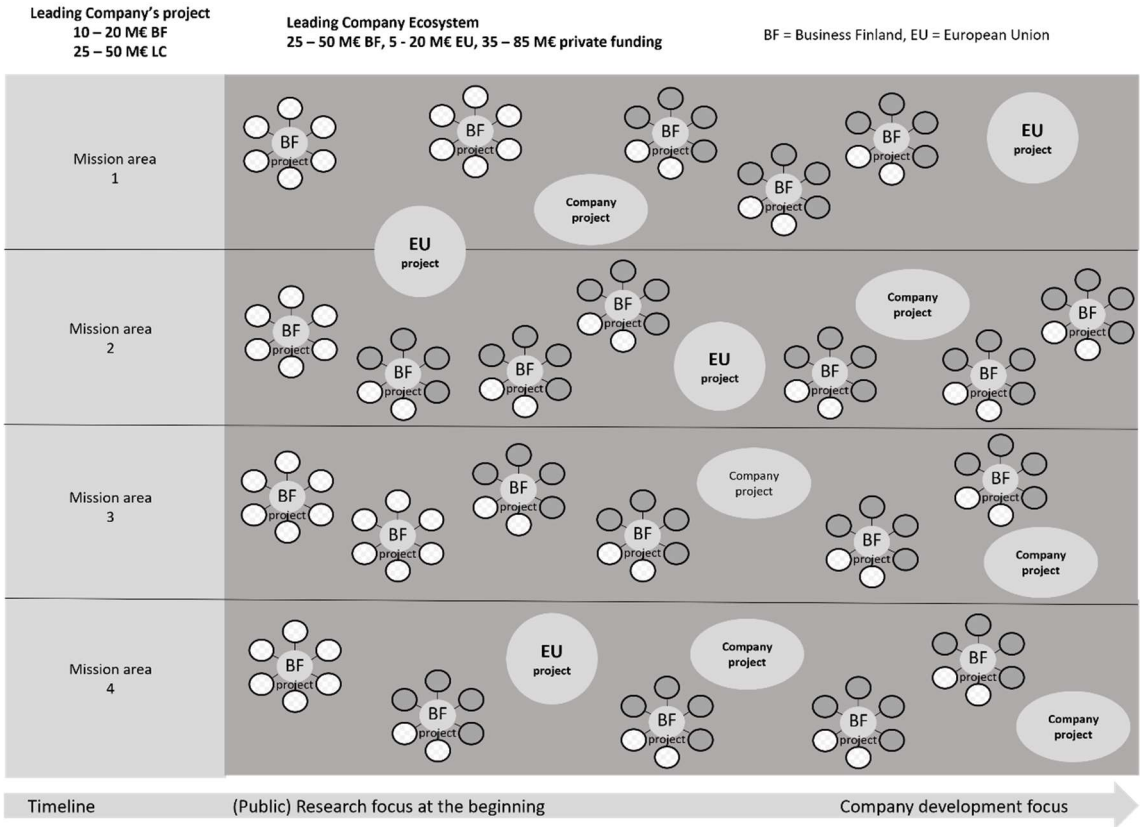

Figure 7 Outline of a leading company ecosystem structure.

Ecosystem projects' main funding instrument of is Business Finland partnership model funding (Innovation Funding Agency Business Finland PARTNERSHIP

MODEL FUNDING CALL Contents, 2024). The partnership model funding has two funding types: Co-Innovation projects and Co-Research projects (Figure 8).

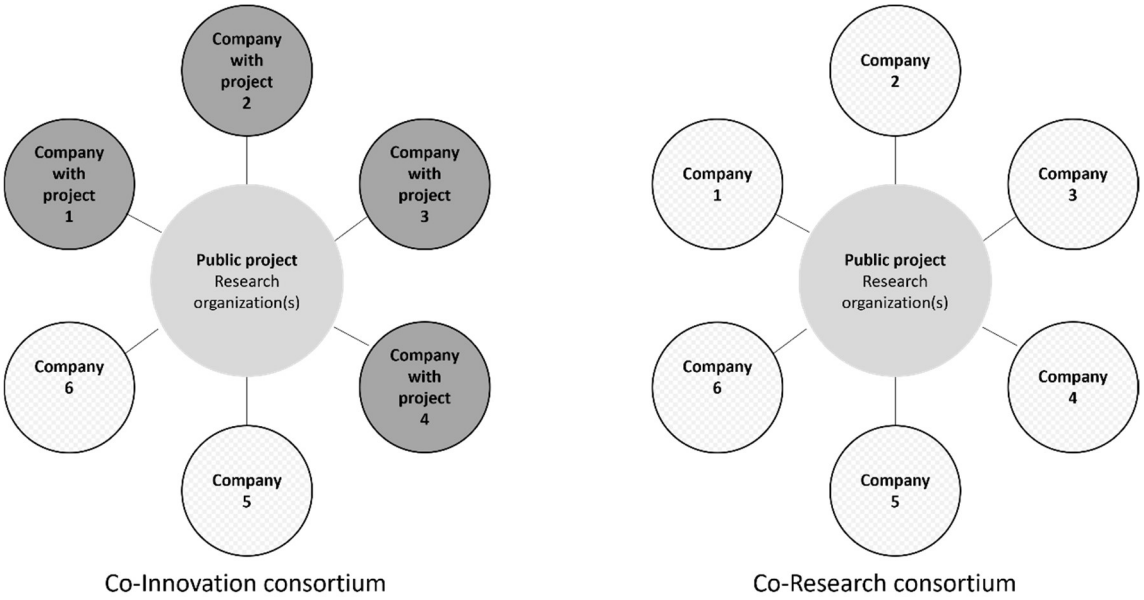

Figure 8 Co-Innovation and Co-Research funding models.

The Co-Innovation project involving research organizations must connects at least three companies and one research organization. It has a public project and confidential parallel company projects. The research organization(s) and the companies form a consortium. One of these companies can be a leading company. Companies without their own parallel project may also join the consortium and have a representative in the steering group of the public Co-Innovation project. The public research project is linked to the companies' parallel project and the consortium companies influence the content of the public research project which must support the development efforts of the companies. A partnership model Co-Innovation joint project may also consist of only confidential company projects, or a company may apply for their own confidential individual project, if that is the case, deviating from the Figure 8 the project does not have a public research part. Co-Innovation projects have higher technology readiness level and are closer to market than Co-Research funded projects which can be applied by research organizations only. However, companies are required to be in the steering group of the public Co-Research project and impact the content of the research project. Companies also part finance the Co-Research project with at least 10 % funding share. Co-Research projects focus on creating new knowledge and expertise which support the Finnish industry in the long run.

Leading company ecosystem project consortiums are built around specific research and development actions linked to the leading company's roadmap and mission. Partners in these projects are typically leading companies, other companies, universities and research organizations. The evolvement of the leading company has three different levels of commitment. The strongest

commitment is when the leading company allocates from its leading company funding a certain amount of resources for its own parallel R&D project. Second strongest level of commitment is that the leading company joins the steering group of a joint project but doesn't have its own R&D project. The weakest level of commitment is that the leading company provides a support letter stating that the R&D project is linked to its roadmap, but it does not allocate own R&D project, nor takes part in the steering group of the joint project.

This study focuses on Business Finland's Partnership model Co-Innovation projects evolving multiple partners, the so called joint R&D project with at least one university or research organization participating with public funded project and at least three confidential parallel company projects. Special attention is given to projects connected to digital sustainability.

5.3 Research methods

This section describes the overview of the research methods and process. The reasoning for the selected research methods for this study are given. The Figure 9 below summarizes the methods used and the process of conducting the empirical part of the study.

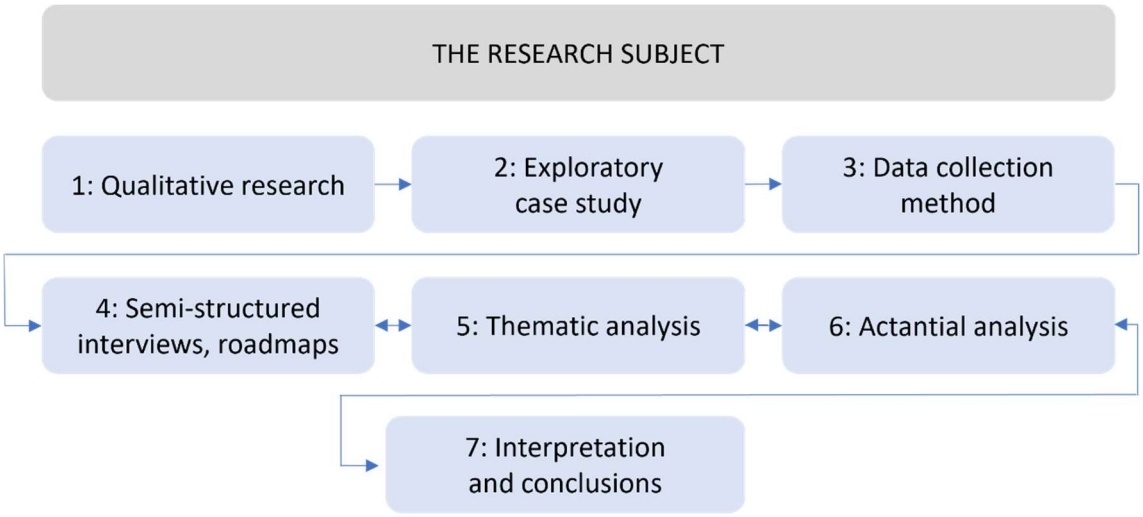

Figure 9 Research process and methods of the empirical part of the study.

The chosen research subject directed the choice of the research design. The first step was to select the qualitative research approach as the method for analyzing the concept of leading company ecosystem and digital sustainability in the collaborative value creation in these ecosystems. The second step was to choose case study with exploratory approach. The following step was to decide on the data collection method. The data was collected from the public leading company ecosystem roadmaps and by semi-structured expert interviews (fourth step). The thematic analysis of the roadmaps was conducted first. The analysis results of the

roadmaps affected the interview questions, thus the two-way arrow in between the steps 4 and 5 in the Figure 9. After thematic analysis of the roadmaps and interviews was done, the data was pooled together of the actantial analysis (step 6). The last step of the study was to interpretate the results and draw conclusions. The data analysis and iteration between steps 5, 6 and 7 are explained in more detail under section 5.5. In the following paragraphs the reasoning for the chosen research methods is explained.

Qualitative research methods (Myers, 1997, 2020) were chosen for this study based on the selected research topic and the research questions. The quantitative research methods were preferred because the goal of using qualitative research methods is to emphasize open approach and trying to find new insight and deeper understanding of the study object (Myers, 2020). The qualitative methods provide answers to questions starting often with "how" and "why"(Kaplan & Duchon, 1988; Myers, 2020). Qualitative research methods are appropriate as the purpose of this study was to understand these leading company ecosystems and explore the roles of the ecosystem actors and collaboration in the joint research project framework.

Case study approach with leading company ecosystems as research objects is used in this study. Yin (2003) defines case study as an empirical research strategy aiming to understand something taking place in the real world, especially when it is difficult to separate the study object from its surroundings. According to Yin case study strategy is particularly advisable when "how" or "why" questions are asked. Case study strategy with several leading company ecosystems as subject was used as the intent of this research was descriptive and it aimed at gaining insight and more general research results (Benbasat et al., 1987). Explorative case study (Yin, 2003) approach was used. Exploratory approach was chosen for the study due to the nature of the research questions. According to Yin exploratory approach it is suited to for explaining a present-day phenomenon emerging from the research data and when the researcher does not have influence on events.

Generative AI-based application ChatGPT was used to reflect themes and topics for the master thesis chapters and to create an overall picture of selected study topics. These initial raw ideas suggested by the ChatGPT were then evaluated and further developed based on cited literature and critical evaluation by the thesis author.

5.4 Data collection methods

Data collection included use of previously published secondary data and unpublished primary data. The published data was collected from the roadmaps of the leading company ecosystems. These roadmaps are available on the internet (*Funding for Leading Companies and Ecosystems - Business Finland*, 2023). The new unpublished data was collected through semi-structured interviews. According to Myers (2020) primary data increases the trustworthiness and quality of the

secondary written documents. Multiple sources of data also enrich the data and the underpin the research findings (Benbasat et al., 1987). The public leading company roadmaps alone do not disclose comprehensively the digital sustainability's relevance, nor do they tell about co-creation or the roles of different actors in these ecosystems. Therefore, complementary interview data is needed for better insight and deeper understanding. To further improve the reliability of the results, the study includes alternative perspectives by collecting data from several leading companies and few other stakeholders. According to Myers (2020) different perspectives support research findings and potential disagreements among the subjects reflect the complexity of real-life situations.

5.4.1 Leading company ecosystem roadmaps

The starting point of the empirical study was the roadmap analysis. The data was collected from the public descriptions of leading company ecosystems' roadmaps (*Leverage from Leading Companies - Business Finland*, n.d.). These roadmaps typically include the leading company's vision and mission, key research and development topics, rough schedule and desired roles of partners. Eighteen leading company ecosystems, which were running in January 2024 were included in this study (Table 4). The ended project from Nokia (Unlocking industrial 5G beyond connectivity) and the four new leading company ecosystems announced on 16th of February 2024 are not included in this study. Those four new leading company ecosystems are Kempower (Heavy electric traffic ecosystem), Valio (Food 2.0), Wärstilä (Wide & Intelligent Sustainable Energy) and Patria (eALLIANCE).

Table 4 The running leading company ecosystems (status 1.1.2024)

Name of the company	**Name of the ecosystem**
ABB	Green Electrification 2035
Bittium	Seamless and Secure Connectivity
Borealis	SPIRIT -Sustainable plastics Industry Transformation
Danfoss	Fossil Free Future
Fortum and Metsä Group	ExpandFibre
Kone	The Flow of Urban Life
Konecranes	Zero4
Meyer Turku	Necoleap – Climate-neutral cruise Ship
Mirka	SHAPE, Shaping the Green Transition – with net Carbon Negative Surfaces
Neste	Novel Sustainable & Scalable Solutions for Transportation and Chemicals
Nokia	Competitive Edge
Orion	A Digital Boost for the Pharmaceutical R&D
Picosun	Chip Zero
Ponsse & EPEC	Forward'27
Sandvik	SHIFT '25
Tietoevry	Building Trusted Digital Societies
Valmet	Beyond Circularity
Wärtsilä	Zero Emission Marine

5.4.2 Semi-structured interviews

Nine experts were interviewed. The five interviewees from the leading companies were selected based on their knowledge of the research topic and their leading positions in their company's leading company ecosystem. One presentative of a leading company ecosystem was interviewed as key informant responsible for a work package especially dedicated to digitalization related themes. These semi-structured individual in-depth interviews of the leading company representatives were complemented by interviewing three other actors of the ecosystems; one startup company representative, one research organization representative and one presentative from Business Finland, which is the funder of the leading companies and their ecosystems. These three other informants were chosen based on their profound practical experience of the research topic, especially concerning the roles of the ecosystem actors and the joint R&D projects.

The interviews were conducted in Finnish and were arranged in advance to take place in Teams (Table 5). The interviewees were assigned randomly the codes EXP1 to EXP9. Semi-structured interviews were chosen to allow the research process some flexibility, the predetermined interview questions were complimented by new questions rising from the interview situations (Myers, 2020; Yin, 2003). The predetermined open-ended questions combined with questions merging from the discussion allowed submerging into personal experiences of the interviewees (DiCicco-Bloom & Crabtree, 2006). The interview question frame remained the same and the questions were dictated by the three research questions of the study (Appendix 1). Altering of some of the questions took place in the process of the qualitative research process as preliminary data analysis took place simultaneously with data collection. All the interviews were recorded and transcribed. The transcripts were pseudonymized.

Table 5 Interviewees' positions and duration of the interview

Position	**Codes**	**Length (min)**
Director	EXP9	34
Manager	EXP8	48
Director	EXP7	35
Director	EXP6	55
Director	EXP5	41
Manager	EXP4	22
Manager	EXP3	49
Director	EXP2	48
Director	EXP1	25

Narrative approach was applied to motivate the interview participants to share their experiences, conception of digital sustainability, the cocreation process and how they perceive the leading company ecosystems and the stakeholder roles. The narratives are interviewees' descriptions of relevant events and a valuable tool in understanding (Liu et al., 2022) these leading company ecosystems. The goal of the interviews was to encourage the interviewees to share abundant descriptions and narratives about digital sustainability, the cocreation in the

leading company ecosystem and the roles of actors in these ecosystems. The aim was to encourage the interviewees to disclose information which would allow identifying how these ecosystems work and what potentially causes conflict and synergies in value creation and capture.

5.5 Data analysis

The data was analyzed by qualitative methods using theme and narrative approaches (Myers, 2020; Yin, 2003). The chosen approached are beneficial and flexible methods enabling summarizing key characteristics of the data, emphasizing similarities and differences in the data, and generating insights (Braun & Clarke, 2006). The roadmaps and the interviews gave altogether well over hundred pages of data. Qualitative data analysis methods were useful in reducing the data and in focusing on most relevant parts of information (Myers, 2020). Inductive reasoning was applied to gain insights from the data and observations made during the study phases (Eisenhardt, 1989). According to Dierckx de Casterle et al. (2012) qualitative data analysis is an intricate part of research process. To create transparency in the data analysis process and to support the reliability, the steps of the process must be documented (Noble & Smith, 2014, 2015). Therefore, the used analytical tools, thematic analysis and the actantial model are described in more detail in the following sections 5.5.1 and 5.5.2. In the following paragraph the high-level overview of the data analysis is described.

In this study, the thematic analysis of the roadmaps was done first. The results supported the formulation of the interview questions. After thematic analysis of the interview data, the results of the thematic analysis of both the interview and roadmaps were used for the actantial model analysis according to Greimas (1983). This way the results from the thematic analysis of the research data are linked to the concept of actantial model. The analysis process frequently revisited the data and the abstracted perceptions from the thematic and actantial analysis to generate more reliable interpretations from the qualitative data (Noble & Smith, 2015). The analysis process was iterative, bound to empirical evidence and exploited the two data sets (roadmaps and interviews) collected and analyzed. Deeper understanding was reached by iterating between analysis, results and discussion stages of the research process (Dierckx de Casterle et al., 2012). Dierckx de Casterle et al. emphasize the iterative principle as critical in interpretive research because it emphasizes the evolving nature of understanding, where insights gained at one stage of analysis inform and refine analysis at the next stage. Therefore, it is important to remain open to revisit and question the interpretations as new data or insight is uncovered.

5.5.1 Thematic analysis

Thematic analysis is chosen for this study because it emphasizes more the context and quality, differentiating from the related content analysis approach which is more quantifying process (Vaismoradi et al., 2013). According to Vaismoradi et al. thematic analysis uses a rather low degree of interpretation. During the analysis process the data undergoes relatively low rate of transformation from data description to interpretation. It is used to find and identify similarities and common schemes. Thematic analysis is extensively used qualitative research method in psychology (Braun & Clarke, 2006). It is an interpretive approach that searches for themes or repeating motifs in the data. The method is flexible allowing a broad applicability (Clarke & Braun, 2017) which makes it interesting approach to analyze the leading company ecosystem roadmaps and gaining deeper understand the role of digital sustainability in these value creating environments. Roberts et al. (2019) describe a framework of thematic analysis in qualitative research for rigor and reproducible process. The article emphasis the role of codes, synonym for themes or motifs by Braun & Clarke (2006), as fundamental elements in thematic analysis for organizing and interpreting qualitative data. Codes are used to systematically categorize data in a way that emphasizes their core meaning or significance, assisting a structured approach to analyzing qualitative datasets. In this study the framework of Braun & Clarke (2006) was used for the thematic analysis of the ecosystem roadmaps to ensure consistency and rigor (Figure 10).

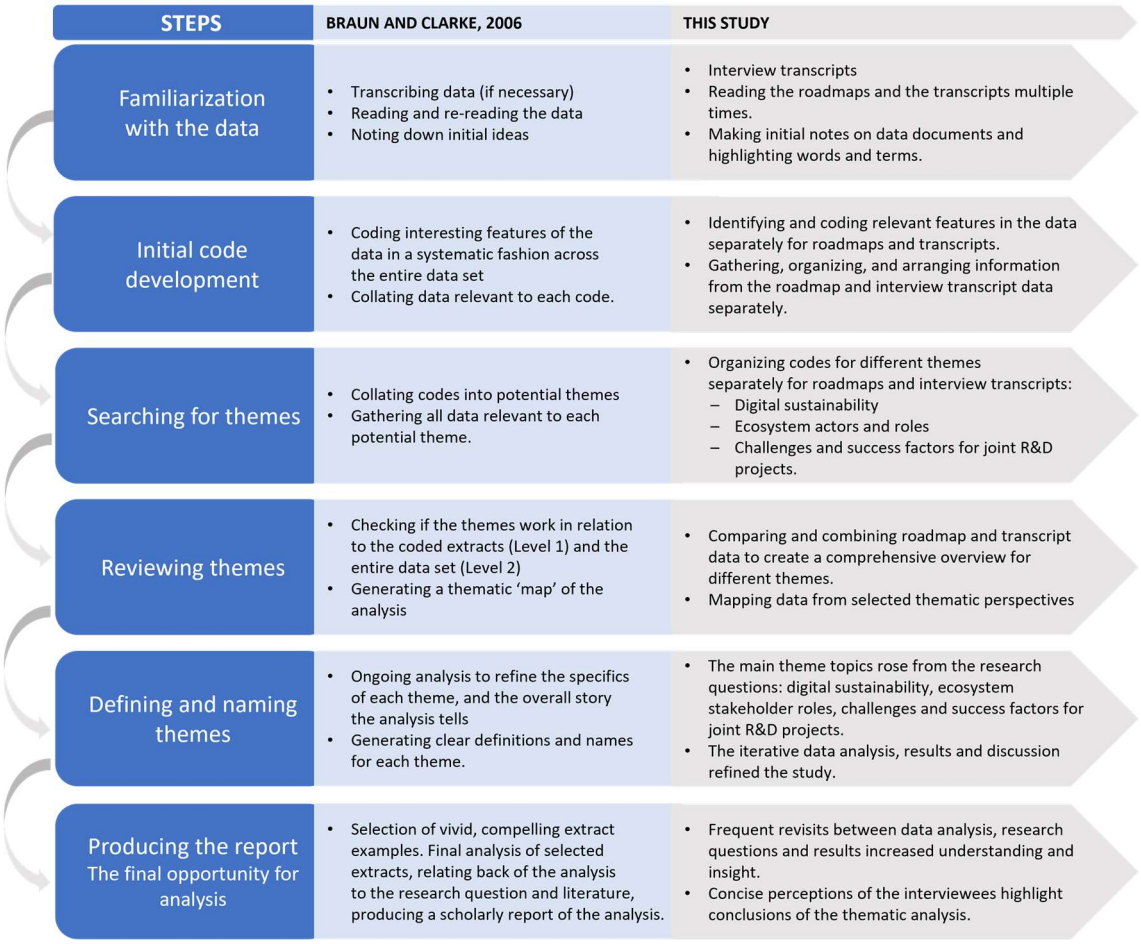

Figure 10 Thematic analysis process, adopted from Braun & Clarke p. 87 (2006).

Thematic analysis has also possible disadvantages, one being its broad applicability which can lead to indecisiveness of the researcher to restrict the focus of the analysis to limited aspects of the data (Braun & Clarke, 2006). Other potential disadvantages are ill handled analyses and unsuitable research questions. For these reasons particular care was taken to apply a systematic and documented approach for the thematic analysis to enhance as far as possible consistency and objectivity in the coding process. However, it is recognized that qualitative analysis often involves interpretation, and some variability between coders is natural (O'Connor & Joffe, 2020).

Thematic analysis was used for both the roadmap and interview analysis. First each individual roadmap was read through several times, key words such as digitalization, sustainability, green transition, and information technology related words were highlighted, coded and themes were developed. Roadmaps were analyzed individually and then compared. Roadmaps were revisited when interview transcripts were analyzed. The interview transcripts were read several times. Key words and sentences were highlighted and coded. Interview data was collected and grouped under themes. Three main themes were 1) digitalization and sustainability concepts, 2) Actors and their roles in the ecosystems and 3) Challenges and success factors for joint R&D projects. Cross-data analysis was

conducted to identify common and generalizable results (Eisenhardt, 1989). Interpretation was applied, analyzing the meaning of the roadmaps and interview transcripts first separately and then together. The goal of the thematic analysis of the roadmaps and the narratives of the interviews was to obtain meaningful results when interpreting the collected data while allowing flexibility without losing the focus.

Multiple revisits between the thematic analysis, actantial model analysis (introduced in the following chapter) and research questions took place to refine the study and increase insight.

5.5.2 Actantial model

Narrative analysis was used to gain missing and complementary information and deeper understanding of the study topic. For this purpose, the ecosystems' actor roles were studied using the actantial model (Greimas & Perron, 2017). Greimas's actantial model provides a framework for understanding the functions of different characters or elements in a narrative. The actantial model from Greimas can be linked to Adner's construct of ecosystem as structure introduced in the chapter 3.3. Greimas' model is actor centric while Adner's construct is activity focused. They both emphasis interdependence and relationships. The understanding of roles and relationships among ecosystem can provide valuable insights. The model from Greimas is a structural approach and a tool to analyze narratives by dissecting the roles and relationships within narratives. It is based on the idea that narratives can be broken down into a series of relationships among abstract roles or functions, known as actants, that interact within a narrative. These actants are also known as actors (Fowler, 2020; Webb, 2022). An actor is any entity, whether human or non-human, that may provoke an action in others (de Vries, 2020). Actors are categorized in six actant classes based on their function in the narrative: sender, subject, object, receiver, helpers and opponents (Figure 11). The subject is appointed by a sender to achieve a desired object which will benefit a receiver. Helper is an actor who supports the subject in gaining the desired goal. Opponent is an actor or force which prevents or makes it more difficult to achieve the goal.

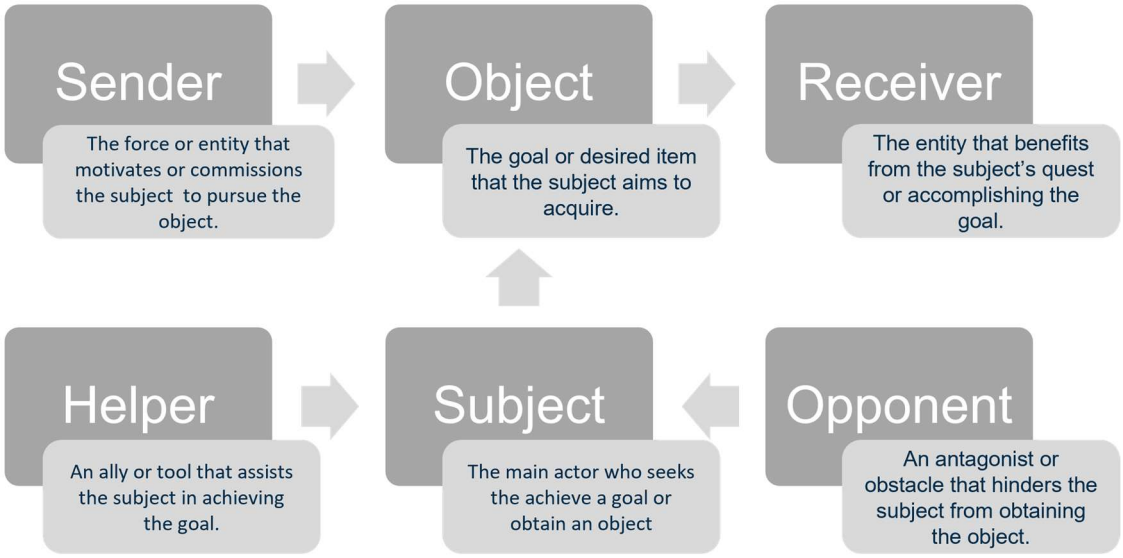

Figure 11 Greimas' Actantial model of the six actant classes.

The analysis emphasizes the leading companies' point of view. The purpose of using Geimas' actantial model as the method for the analysis of leading company ecosystems is to better understand and translate interviewees' thoughts regarding the ecosystem actors, their roles and relationships. Greimas' actant model is also used to analyze cocreation in joint R&D projects, which are tools in solving the missions set by the leading companies. The first step of the analysis is to identify and assign the actors to appropriate actantial type (Webb, 2022). Next the relationships between the actants are studied to gain better understanding of the interactions between them and to obtain insight of factors contributing to the ecosystem and the cocreation performance in the joint R&D projects. Due to the characteristics of actant being human or non-human makes actantial model particularly suitable for this study (de Vries, 2020).

The Greimas actantial model has three axes, which help to identify dynamics of the roles, relations and motivations of the actants (Fowler, 2020). These axes are the axis of desire, knowledge and power (Figure 12).

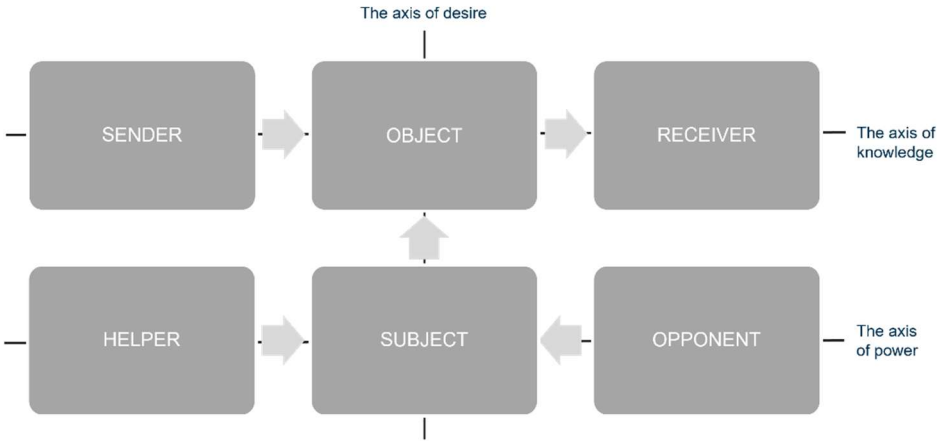

Figure 12. Greimas' three axes of desire, knowledge and power.

The axis of desire represents the motivation and goals of the actors. The axis of knowledge refers to the understanding and awareness of the actor. Knowledge often influences the actor's decisions and behavior. The axis of power signifies the actor's ability to influence or control other actors of the narrative. These three axes provide a framework for analyzing the dynamics of the actors and their interactions within narrative.

5.6 Evaluation of the research

The quality of the study was established by following peer-reviewed methods, triangulation, validity and thoroughness at the different stages of the study. Crucial aspects contributing to reliability and validity of the research finding are multiple sources of data and clear description of data analysis process which leads to the findings (Benbasat et al., 1987). Two methods were used for the data collection and for the data analysis, both which are typical triangulation methods in qualitative research (Carter et al., 2014).

To underpin reliability and validity of the study:

- Data and methodological triangulation were used:
  - Primary interview data (interviews) and secondary roadmap documents (roadmaps) were used. For the interviews different perspectives were included in the data collection by interviewing six leading company representatives, Business Finland's representative and two representatives of the ecosystem partners.
  - The analytical methods were used, thematic analysis and the Greimas' actantial model.
- The data analysis process followed a process disclosed in a peer-reviewed article (Braun & Clarke, 2006) and was described step by step. Attention was given to ensure that it is possible to follow the interpretation from the original data and conclusions made.
- The leading company ecosystem concept is described thoroughly, and the interviewed experts were well-acquainted with the research topic.
- Different facts rising from the data are openly presented, also contradicting ones.

6 STUDY RESULTS

This section describes the findings of the study based on the data collected and analyzed. The results are presented in four paragraphs. The first three paragraphs focus on the results of the data analysis covering digitalization and sustainability in the leading company ecosystems (6.1), the roles of the actors (6.2) and factors affecting the co-creation (6.3) in the joint R&D projects. The final subsection (6.4) summarizes the results of the study.

Selected quotations are used to give a specific example of an individual perspective and a key observation from the interviewees. The purpose of the quotations is to show examples of data used to derive study's conclusions (Corden & Sainsbury, 2006).

6.1 Digitalization and sustainability

The leading companies' roadmaps and expert interviews were used to study the relevance of digitalization and sustainability in the missions of the leading companies. The expert interviews showed that the terms digitalization and sustainability were understood similarly but the definitions were not unambiguous.

> Sustainability and digitalization are everywhere. Everyone defines what they mean in a slightly different way. Still, we are talking about the same thing. EXP4.

The interviews helped to discover how the meanings of these two terms are interpretated. Digital solutions are seen as means to follow processes or devices, their use, collect and analyze data to develop process, product or service based on the data. The concept of digitalization has not changed but the focus has shifted. Earlier much of general research and development focus was e.g. on internet of things and today the focus is more on data and data economy. Data is seen as the new manifestation of digitalization. Appears that a new name has been given to the same phenomena.

> Digitalization means that we can manage, process, find what is relevant and we can visualize it. EXP4.

Yet, at the same time the expert interviews raised the question of genuine business potential of data.

> I criticized the data economy in the sense that it is not the data that is important, but the insight created from the data. In data economy, we talk about sharing data, but data is still just data. How does it create value? What is the economy created from data? EXP2

The leading companies' roadmaps complemented the interview data and provided more insight regarding digitalization and sustainability in these ecosystems. The initial code development of the roadmaps using terms digital, digitalization, information management, information technology, data, sustainability and green transition resulted in collating the data and the eighteen leading companies in four categories Figure 13.

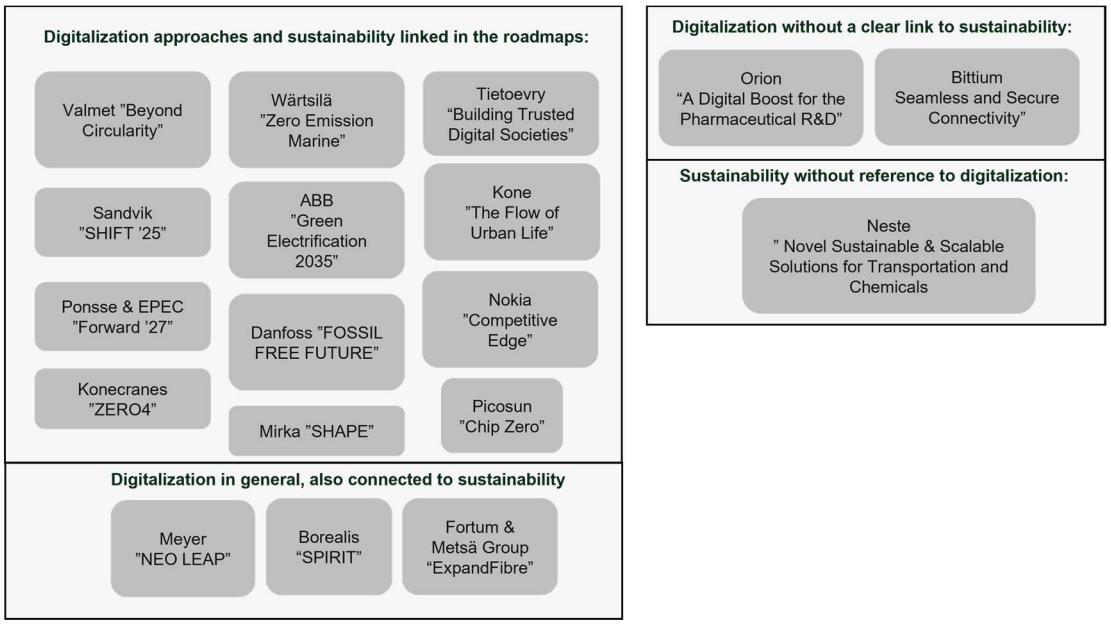

Figure 13 Leading companies categorized based on code development.

Fifteen leading company ecosystem roadmaps link digitalization and sustainability. Twelve of these roadmaps mention digital technologies linked to sustainability objectives (Valmet, Wärtsilä, Tietoevry, Sandvik, ABB, Kone, Ponsse & EPEC, Danfoss, Nokia, Konecranes, Mirka and Picosun). Three companies mention digitalization either as a general theme or a cross cutting topic (Meyer Turku, Borealis, Fortum & Metsä Group). Two of the eighteen leading companies refer to digitalization but without a clear link to their sustainability target (Orion and Bittium). One of leading companies does not have any clear reference to digitalization, although sustainability is a clear objective (Neste). However, based on the Neste's website, digitalization solutions are part of its business thinking (*Liikenteen Murros Tapahtuu Tässä Ja Nyt – Neste Ja Telia Rakentavat Yhdessä Älykkäämpää Liikkumista | Neste*, n.d.). The roadmaps of Orion and Bittium are the only ones not mentioning sustainability as objective, yet both companies clearly state on their company websites their commitment to sustainability (*Sustainability - Bittium*, n.d.; *Sustainability - Orion*, n.d.).

The initial coding was revisited to collect and identify from the roadmaps sustainability related terms which the leading companies use (Table 6).

Table 6 Sustainability related terms in the leading company roadmaps.

Leading company	Sustainability related terms in the roadmap
ABB	green electrification, carbon-neutral, sustainable, climate neutral
Borealis	Sustainable, renewable, recycled, eco-efficiency, carbon neutral, circular, green transition, CO_2 capture, CO_2-footprint
Danfoss	fossil free, carbon-neutral, climate solutions, sustainable, sustainability, green hydrogen, circularity
Fortum & Metsä Group	sustainability, sustainable, biocomposites, bioproducts, low emission, lower carbon footprint
Kone	sustainable, climate change, sustainability, green field services, social impact, ecological impact, economical impact
Konecranes	sustainable, decarbonized, circular, social impact, ecological impact, economical impact, zero-emission, decrease greenhouse gas emissions, decrease energy waste
Meyer Turku	sustainability, climate neutral, green transformation
Mirka	green transition, net carbon negative, circular, sustainable, ecodesign, biobased, biocomposites, non-fossil, recyclability
Nokia	climate sensing, environmental sensing, sustainable,
Ponsse & Epec	sustainable, environment, zero-emission, circular
Sandvik	sustainable, sustainability, societal, environmental, financial
Tietoevry	green cities, green energy transition in cities, decarbonization of energy use in municipal infrastructures
Valmet	circularity, sustainable, green transformation, carbon neutral, climate, resource efficient, fossil free, bio-refining, recycling
Wärtsilä	zero emission, sustainable, GHG reduction, green transition, bio fuels, bio & synthetic blends
Orion	-
Bittium	-
Picosun	chip with zero-lifetime emissions, resource efficient, energy efficiency, efficiency of power electronics, circularity, recycling
Neste	tackling climate crisis, renewable and circular solutions, biofuels, sustainable, reduce GHG*, recycle, efficiency, green hydrogen

* GHG = greenhouse gas

Those fifteen leading company ecosystems which mention both digitalization and sustainability in the roadmap were studied further to search digitalization themes. The initial code development identified IT-related solutions and technologies across the roadmap data. The Figure 14 shows the word cloud of extensive information technology related words identified in the initial coding phase.

Figure 14 Word cloud of IT related words in the roadmaps.

The word cloud and the IT-related words in the roadmaps concretize the broad applicability and relevance of information technology. Different smart technologies and topics emerge in the roadmap data. The raw data shows that smartness relates to artificial and edge intelligence, energy, electronics, energy storage solutions, infrastructure, building, cities, maintenance services, factories and life cycle solutions. One of the aims is to develop solutions to manage, purchase, analyze and exploit data. For those purposes leading companies want to co-develop data models and data marketplaces as well as use data for prediction and management of other resources, such as energy. The roadmaps suggest that data is needed to foster sustainability and sustainable development. Digitalization makes itself apparent also in many other ways. From the roadmaps arise topics such as modelling, simulation, optimization, sensors, algorithms, virtualization, metaverse (XR, AR, MR, virtualization), automation, analytics, edge computing, integration and many other technologies related to digitalization. All these topics were mentioned in the roadmaps as enablers or promoters of solutions fostering sustainability.

In the following phase of searching themes, the codes from the data were further developed. Inductive reasoning was used to divide the words into thematic groups. The purpose was to capture the commonalities across the main

key themes of digitalization and sustainability and subcategorize them into meaningful entities and patterns which are found in the roadmaps.

At the next roadmap analysis stage, the roadmap study focused on those twelve leading companies which link digitalization and sustainability. Out of the analysis was left the three companies mentioning digitalization as cross cutting topic (Meyer Turku, Borealis, Fortum & Metsä Group) and the companies not linking digitalization and sustainability in their roadmaps (Orion and Bittium). Each of the twelve roadmaps were studies and then compared to the other ones to identify themes under which the digitalization elements could be grouped. These digitalization related elements were then categorized into six themes to form the codebook. Twelve leading companies and their digitalization objective linked to these six key digitalization themes are described in the Figure 15.

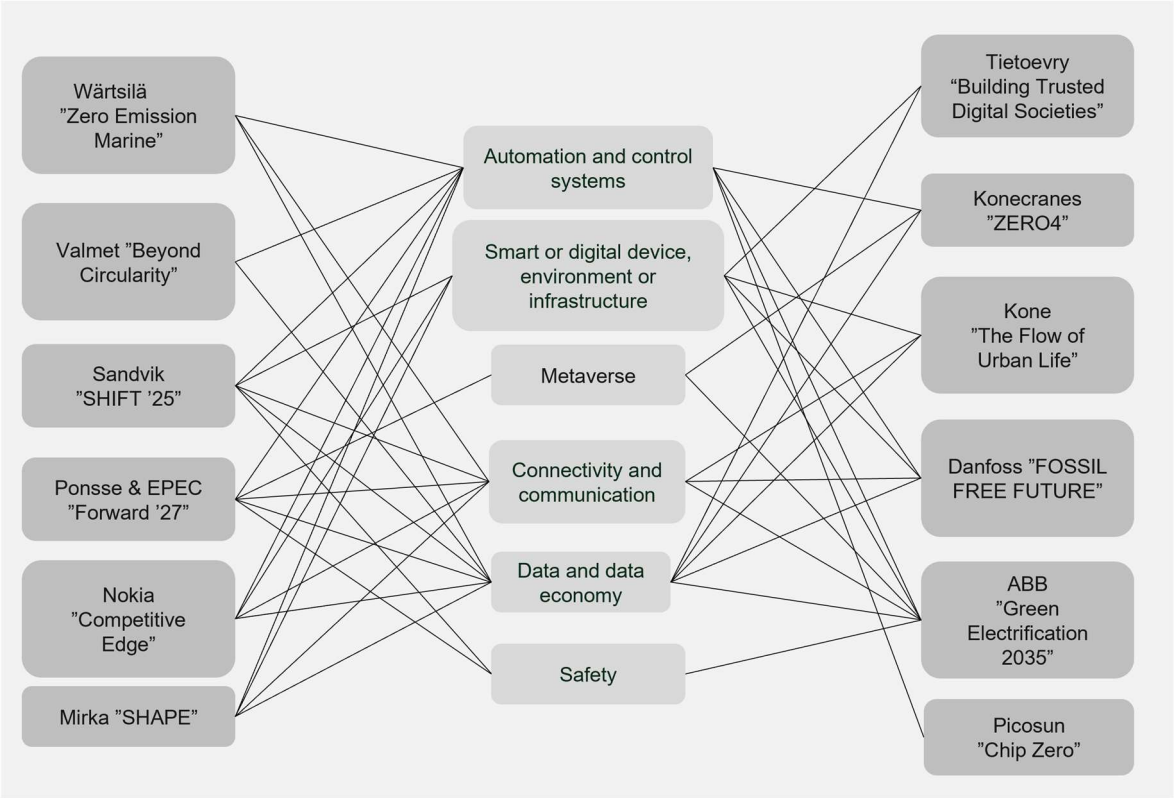

Figure 15 Overview of the key digitalization themes.

This key digitalization theme groups collate and simplify the extensive number of technologies named in the roadmaps into the themes automation and control systems, smart or digital device, environment or infrastructure, metaverse, connectivity and communication, data and data economy and safety. The thematic groups capture the essence and objectives of the original raw data related to information technologies. The grouping of the terms under broader themes aims for clarity and comprehensiveness admitting that there remains some overlapping in these thematic groups.

The interview data brought complementary insight to the digitalization data of the roadmaps. Interviews showed that digitalization is seen a supporting

tool. According to the interviewees complex data-based models cannot be operated without digital solutions or manual processes replaced and extended to large scale without it. Digital solutions improve the management of production processes, enable better products and comparison of alternatives, e.g. choosing a more carbon neutral process. For sustainability, the role of digitalization rises from data management where the emphasis is on the insight the data provides. Without digitalization it is not possible to fulfill the requirements set by sustainability such as calculation of carbon footprint. For the data management over the life cycle of products and services digital solutions are a must. Digitalization is also needed for the transformation from linear economy to circular economy. The twin transition combining digitalization and green transition is present in nearly all the leading company ecosystems, especially when talking about environmental and economy perspective.

> Digitalization functions as an enabler. At the best it is a supporting functionality that is not seen, heard, or smelled. It just takes place. EXP2.

Based on the roadmap data the digitalization efforts of the leading companies are linked to all three pillars of sustainability: social, environmental and economic impacts (Figure 16).

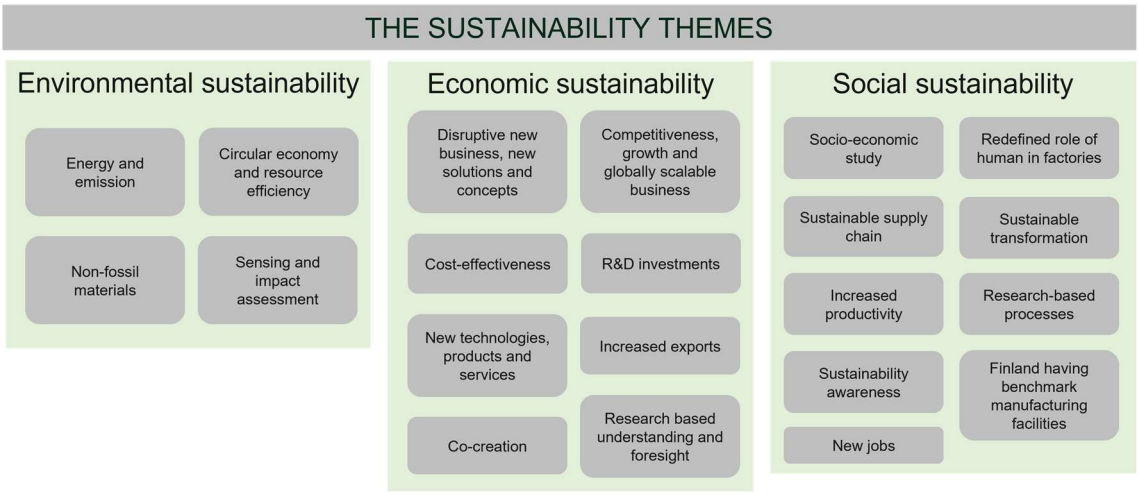

Figure 16 The sustainability themes.

The environmental sustainability themes are the most shared and frequent topic by the leading companies. The objectives to develop sustainable energy sources, reduce harmful emissions, replace fossil with non-fossil and bio-based materials, promote resource efficiency and circular solutions are shared cross the industries. Also developing solutions for sensing and impact assessment, e.g. through data, is a central objective of most of the leading companies.

Economic sustainability is less frequently emphasized but latent or indirect content of the roadmaps. However, those who do describe the economic sustainability targets, give various perspectives. Key indicators fall into the

category of financial gain and growth: new business, products and services, competitiveness, growth, cost-effectiveness, investments and increased export. Softer values include co-creation and research-based understanding and foresight.

Social sustainability is explicitly mentioned in three roadmaps (Sandvik, Konecranes and Kone) and social or socio-economic themes are referred by two (Wärstilä and Meyer Turku). Multiple targets for social sustainability are mentioned, including human role in work environment, Finland as model for socially sustainable work environment and sustainability awareness.

The interview data provided deeper insight to the link between the leading company programs and the three central pillars of sustainability, environment, economy and social sustainability. Companies emphasize the economic and environmental sustainability while in the science community currently social sustainability seems to gain more attention. In general, the concept of sustainability has broadened and deepened, partly because regulations and new directives demand it. Earlier sustainability was partly greenwashing or on agenda of few forerunner companies. Today sustainability is increasingly part of the everyday work and companies want to express how they have perceived sustainability and how they promote it. Companies have recognized that the sustainability goals cannot be reached alone. It is a long-term process which requires commitment from the whole value chain.

> Sustainability is no longer something where we can joyfully hide in a corner and claim that we are sustainable. We must tell outwards in real time how sustainable we are. EXP6.

The leading company roadmaps address ten of the United Nations 17 sustainable development goals (highlighted in Figure 17). In the Figure 17 the seven UN's SDGs not directly addressed by the leading company ecosystems are faded.

Figure 17 Sustainability goals of the ecosystems. Modified from (*THE 17 GOALS | Sustainable Development*, n.d.)

According to the interviews sustainability is good and market-determined business. Ignoring sustainability aspects is seen as risk which is recognized also by investors. In the future green transition is seen as an opportunity for technology business for Finland. Some of the leading companies want to have a forerunner position in green transition and circular economy. They see that this way they can enable new markets and international growth also for their partners. Other leading companies develop new sustainability associated service concepts and life cycle services which have very strong linkage to digitalization.

6.2 Roles of the ecosystem actors

All eighteen roadmaps communicate topics for research and development, which form the basis for the ecosystem work. In the Figure 18 the leading companies are groups in three groups (gray color scheme) based on how detailed they disclose the timeline and type of collaboration. Three companies describe the research and development topics (group 1). Nine of the roadmaps describe the also timeline for the R&D topics (group 2). The most descriptive roadmaps include also either the work and effort balance or the emphasis on research-oriented collaboration and industrial development focused collaboration (group 3). Three leading companies include additionally spinoff and startup efforts. Those three companies are additionally highlighted with the blue color scheme.

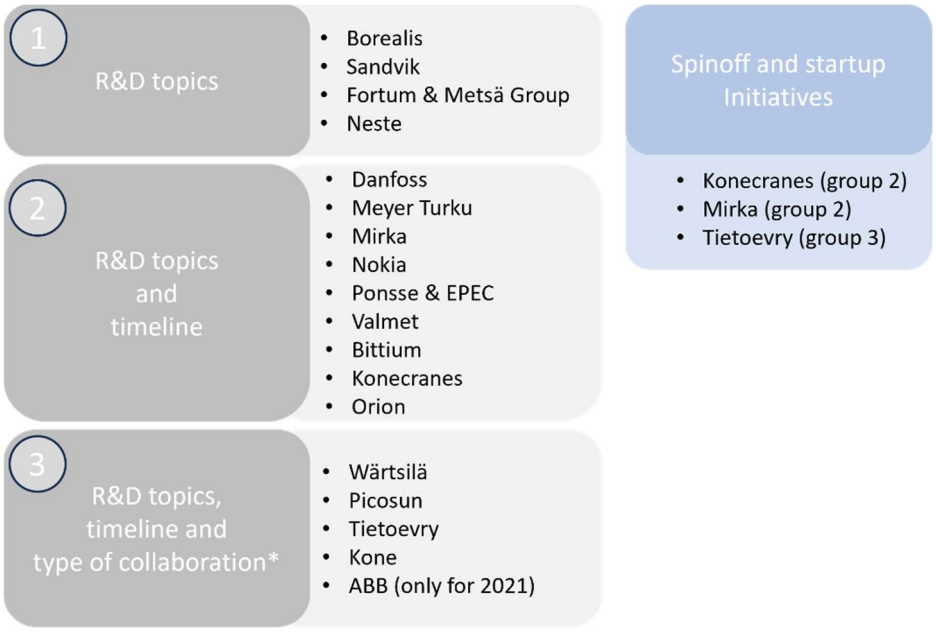

Figure 18 Roadmap descriptions.

The actors, their roles and relationships at the leading company ecosystem level were studied applying the Greimas' actantial model classifying the actors into six categories (Figure 19) using the data from the expert interviews. Considering the actant roles permit studying the complex dependencies and relationships. The roles were studied from the leading company's perspective.

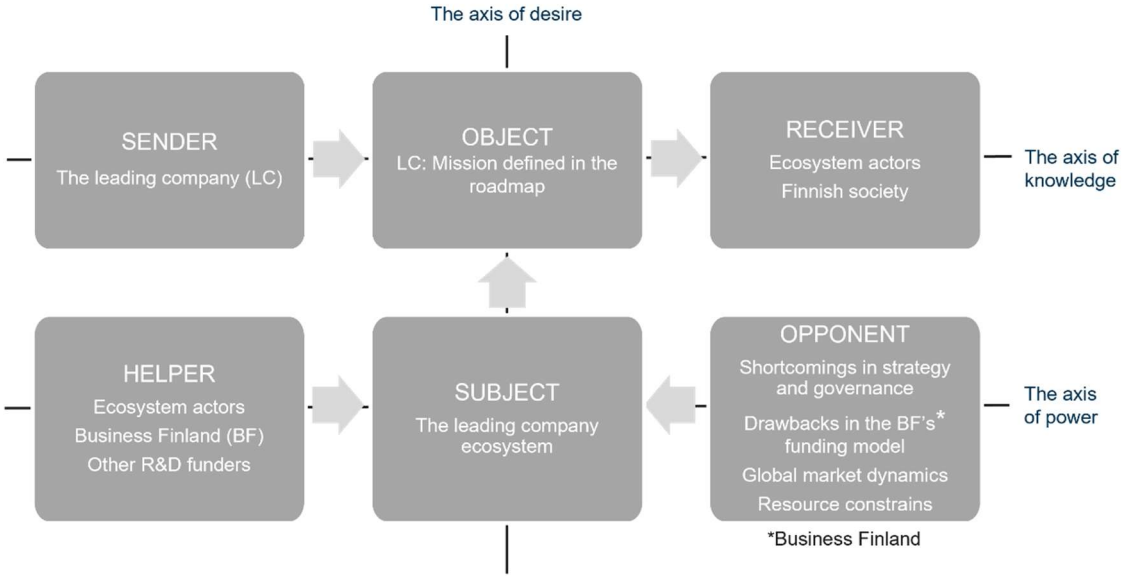

Figure 19 Actantial model of leading company ecosystem.

The leading company is the sender in this consideration. The mission described in the leading company roadmap defines the object. The subject, in this case the

leading company ecosystem with all its partners is the subject, which aims at achieving the object, to fulfill the goal set in the leading company roadmap. Receivers are ecosystem actors and the Finnish society. Ecosystem actors expect foremost to enhance their business. Finnish society benefits from increased export, investments & RDI, jobs, tax income and sustainability. The means supporting the ecosystem (subject) in achieving its goal are the ecosystem actors (helper), Business Finland (helper) and other R&D funders (helper). The motivations of the leading company and Business Finland are strongly dependent and intertwined. Business Finland's key motivation to support the leading company is to increase RDI investments and ecosystem work in Finland so that the Finnish society can benefit from the ecosystem results. Opponents which hinder the ecosystem from obtaining the object are related to shortcomings in the ecosystem strategy and governance, drawbacks in the Business Finland's funding model as well as global market dynamics and resource constrains.

According to the interview data, the strong and guiding role of the leading companies is an important strength of the leading company ecosystem and for many leading companies a natural continuum to their role as a partner enabling growth and internationalization of other actors. The leading companies' peer-group (in Finnish veturivarikko) facilitated by Business Finland supports the discussions and collaboration between the leading companies. The leading company program with the roadmap and mission gives the company the mandate to steer the activities of the ecosystem. The leading company must have a significant mission (object), which they want to solve and which they clearly communicate. Themes and challenges to be solved are therefore those of these leading companies. Their activities are business-driven and likely to attract also private funding on top of the public funding. Interviewed experts' emphasis that an advantage of the ecosystem funding is that it is not only funding for the leading company. Due to Business Finland's role and financial support, it is an even larger funding opportunity to the partners. The core idea of the leading company ecosystem funding is that the leading company's role is to support partners to look outside the ecosystem and gain access to international business environment via new growth paths and new partners. For small companies the leading companies may open door and markets otherwise difficult to get in.

The interview data gave also deeper insight about the partners and means (helpers) that assists achieving the goal of the ecosystem. Besides providing the funding and setting the key performance indicators, the role of Business Finland as helper is to mentor the leading companies and their partners. The collaboration between Business Finland and the leading company is significant and important for the success of the ecosystem. Ecosystem actors form the ecosystem (subject) and the critical partnerships that assists achieving the goal (object). Helpers include a diverse group of technology or service providers, developers, customers, universities and research organizations and other leading companies. Based on the expert interviews the core competency of the leading company is in their own industry and complementary expertise must be found from the partners which help to achieve the mission. An example of expertise

looked for from partners is know-how in digitalization when leading company's expertise lay elsewhere. Intermediary organizations of the Finnish innovation systems like consulting companies and open innovation platforms such as CLIC and DIMECC belong to the group of ecosystem actors. To the group of helpers belong also other R&D funders such as Academy of Finland and European Union. According to interview data, currently somewhat outside are left regulation and legislation, where companies typically are not active but are more often presented by representative organizations such as the Technology Industry.

SMEs are important partners of the ecosystems. The advantage of SMEs and especially startups is their agility and fresh, new ideas. Research-based spinouts bring totally new, out of the box views to do things differently. At the same time, in a deeply technology orientated, expensive machinery or factory operated industry it is more difficult and costly to chance processes when compared to information technology and software-based businesses. The strength of the small companies is especially in practical things and quick demos. According to the interviews startups are needed to bring the green transition forward more quickly. They are pioneers, agile and have innovative ideas.

> When we are developing something totally new, often spinouts from universities or small startups bring completely new ideas and approaches to achieve objectives. EXP8

A role of SMEs is also in the implementation of work, especially in some specific areas which are not expertise of the leading company. For example, in digitalization, data security and user experience. The ecosystem treats its partners equally in the sense that small companies can have visibility beyond their size. SMEs benefit from joining ecosystem projects which are a good opportunity for cocreating and networking. Getting on board gives the SME an opportunity to create trust and business together with partners that might otherwise be out if its reach. However, a commonly shared challenge is the lacking model to involve small companies and startups as applicants for the ecosystem funding. Currently they are not applicable for Business Finland Co-Innovation funding. Some leading companies solve this by engaging startups or SMEs as subcontractors or suppliers.

The role of universities and research organizations as another category of helper is to bring deep research-based expertise and theoretical basic research to the ecosystem. Their role is strongly in the generation of new knowhow. They are also expected to carry out applied research and complement the companies' facilities with their R&D infrastructure. Companies expect universities and research organization to be able to do initial scale-up from laboratory scale. The role of universities and research organizations alone is not sufficient for creating solid basis for market-determined solutions. They must be complemented by adequate number of companies from the value chain. For the companies, universities and research organization are also a pool of potential future employees.

Other helper organizations such as innovation consulting companies (e.g. Spinverse, AFRY) and open innovation platforms like CLIC and DIMECC coordinate some of the ecosystem or ecosystem projects.

Based on the interviews, the forces hindering (opponents) the leading company ecosystem from achieving the object are mainly formed by global market dynamics, shortcomings in the ecosystem strategy and governance, drawbacks in the funding model and resource constrains.

> Linear economy has come to an end, and it is a big change for the industry. EXP9

> Systemic changes make innovating and collaborating in ecosystems more challenging. EXP8

> Business Finland's ecosystem funding supports research and development but at the same time companies need to strictly consider how they use the money and resources. EXP7

The fluctuation in global market and economic lead to uncertainties in business environments, increased competitive pressure and demand for significant systemic changes. These uncertainties and demands can complicate collaboration in the ecosystem due to potential changes in actor roles and limited resources that companies are able to allocate to ecosystem work. Companies must consider more carefully where they invest money and resources.

The interview data revealed some weaknesses in the ecosystem strategy and governance. The results indicate that all partners do not understand, or the leading companies fail to communicate the leading company ecosystem concept.

> We expected that the leading company takes us to a new market or offers a solid technology platform but neither of those was realized. We did not internalize the role of the leading company. EXP5

> Most of the companies involved in the leading company ecosystems are primarily aiming for a business relationship with the leading company, and do not so much see the ecosystem as a springboard to the international market. EXP3

A missing feature in the leading company ecosystems seems to be a true linkage and interaction between the ecosystem R&D projects. There are examples of seminars, workshops and communications platforms for discussion, but all leading companies have not communicated and implemented approaches for information exchange between ecosystem actor and the individual ecosystem projects.

> In my opinion, what is often still missing from these ecosystems is that there would genuinely be more interaction between the projects than the fact that they are formally linked to that leading company ecosystem. EXP3

> Ecosystems are about open innovation, meaning that we create together and share together. Are we genuinely ready for this? EXP7

Also, it is not clear what are the rights, benefits and responsibilities of collaborators. From the leading companies' side there is little information about actor descriptions which would reflect the input and output an actor can have in the ecosystem. It is not communicated what specific role different actor groups have in the ecosystem. This seems to be an issue, categorized as opponent in the actantial model, that prevents getting out all the potential of the ecosystem. Currently in many leading company ecosystems all actors have similar role as general collaboration partners.

> The roles have not been described, but according to my understanding, the leading companies currently collect all the actors in a similar role. What is the collaborators' interest in bringing their expertise to the ecosystem, and on the other hand, what are its rights to use the results generated in the ecosystem? EXP3

The interview narratives indicated that some of the ecosystem challenges were related to the ecosystem funding model. Depending on when the leading company has got the Business Finland's ecosystem funding decision, the detailed terms of payment and expectations are slightly different and some of the rules and expectations of are still refining. This can partly explain the challenges related to ecosystem strategy and governance. The interviewed experts focus attention on the challenge to find a way to get small companies, especially spinouts and startups on board. Business Finland's current funding model doesn't allow small companies and startups to be funding applicants in the ecosystem's Co-Innovation projects.

> Business Finland expects that the leading companies take under their wings these smaller companies but the funding instrument for them is lacking. EXP7

After the initial actant analysis, the actants and their relations were further studied. Based on data analysis of the narratives three subgroups corresponding to three axes (Fowler, 2020) were formed:

> **Axis of desire**: The leading company ecosystem – Mission defined in the leading company roadmap.
>
> **Axis of knowledge**: The leading company – Mission defined in the roadmap – The ecosystems actors & Finnish society.
>
> **Axis of power**: Ecosystem actors, Business Finland and other R&D funders - The leading company ecosystem – Shortcomings in strategy and governance, drawbacks in BF's funding model, global market dynamics and resource constrains.

The position of these axes in relation to the actants is illustrated in the Figure 20. At the power axis, ecosystem actors, the joint R&D projects and their funders are a positive force and the subject's means of implementation to achieve the object.

On the other hand, the opponent's power and negative forces can disrupt the ecosystem from reaching the goal. In the axis of desire, the ecosystem (subject) aims to accomplish the mission (object) set by the leading company. The knowledge axis is linked to the power axis through the object. The sender wants that the object is accomplished and must understand the receiver's need to benefit.

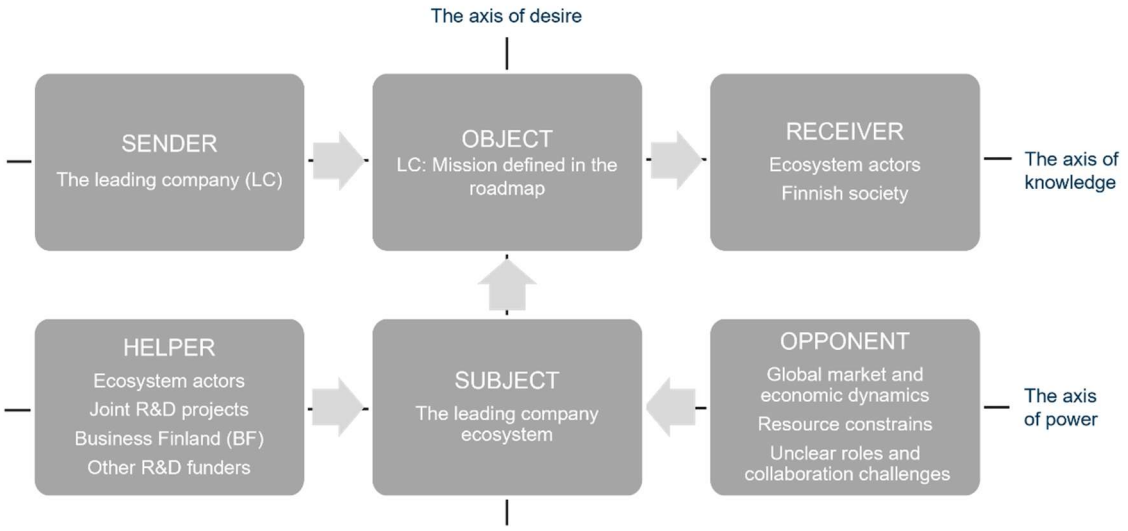

Figure 20 The axes of desire, knowledge and power.

The relationships are complex. These forces, desire, knowledge and power, are impacted by the characteristic of these ecosystems where the leading companies have more leverage than the other partners. The leading companies must be aware that the set object (roadmap and mission) alone is not sufficient to motivate the helpers, they must also see their benefit as receiver. Joining the ecosystem must bring profit or advantage to all ecosystem actors. On the other hand, all ecosystem actors should acknowledge the basic idea of leading company ecosystem, which is internationalization and growth of the participating companies' businesses.

Based on the interviews, leading companies steer and bring forward these ecosystems in many ways. They have in common the roadmaps and projects which must be linked to the ecosystem. All projects supported by Business Finland have in the long run the goal of international business and growth. The leading companies on the other hand have committed to increase RDI investments with tens of millions of euros and promised to also increase the ecosystem work. The responsibility of the leading company to push the development, which is in the core of its own business, makes these ecosystems strive. The goals set in the roadmaps are at the center of their strategy and the missions are so big that they cannot achieve them alone. The other ecosystem actors are needed for bringing the mission to successful end.

6.3 Joint R&D projects

This subsection first shortly runs though the concept of joint R&D project. Then the following passage provides insight to R&D projects' actor roles and relationships. The last two paragraphs examine the success factors and challenges of joint R&D projects.

The joint R&D projects are the practical tool for the implementation of the ecosystem work. These joint R&D projects generating new know-how, technologies or future business opportunities are linked to the topics of the leading company roadmaps. The study was outlined to Business Finland funded joint R&D projects, leaving out other research and development funders such as European Union and Academy of Finland. The expert interviews gave insight to the ecosystem collaboration in the joint R&D projects.

6.3.1 Actor roles and relationships

Based on the interview data, the actor roles and relationships of the joint R&D project were studied using the theoretical framework of Greimas' actantial model (Figure 21).

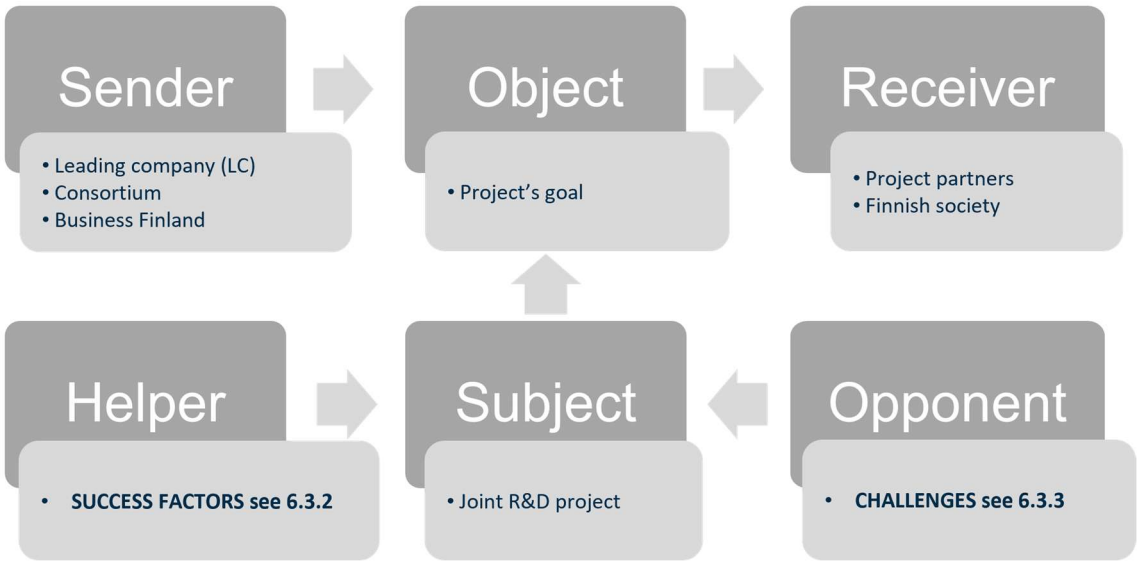

Figure 21 Actors from the joint R&D project perspective.

The subject is the joint R&D project, and the senders are the leading company, project consortium and Business Finland. The joint R&D project addresses a specific object defined by the consortium members and approved by the leading company and funded by Business Finland. For a project to be linked to the ecosystem, the leading company must confirm the connection to its roadmap and

in writing affirm the connection to Business Finland. Project partners and the Finnish society as receivers benefit from the results of the joint R&D project (subject) and object which is the goal of the project as defined by the consortium and which is linked to the leading company roadmap. The tension between helper and opponent are formed by the cocreation success factors and challenges, which are bolded in the Figure 21 and described in the sections 6.3.2 and 6.3.3.

The joint R&D project (subject) may be initiated by the leading company (sender) or one of the project partners, who later form the consortium (sender). Each partner commits to the implementation, which in case of its own parallel Co-Innovation project may be significant. Business Finland plays a strong role as parallel sender. Although Business Finland has allocated funding for the ecosystem projects, each project must make a funding proposal and Business Finland makes funding decisions case by case. Therefore, each joint R&D project has approval and expectations of Business Finland. In the joint R&D projects Business Finland wants to see broad consortiums with several actors. Joint R&D projects are built involving partners required to achieve the objective (object) and with partners able to take and scale the results to the market. Leading companies have strong say in the content of a project and the assembly of the project partners. Joint projects must have strong research consortium and to build the solutions, whole value chain is needed, including e.g. end-customers, subcontractors, and manufacturers. These actors are often an entity in the current or potential future value chains. The different actors of the value chain are required because the industries are going through big, systemic changes that no one can achieve those alone. Collaboration between the leading companies brings significant impact potential making joint R&D project with several leading companies an attractive choice.

The structuring of the joint R&D project into six actantial categories shows the complex and multilayered nature of the actors and their relationships which can lead to encounter unclear or contradictory objectives and situations in the joint R&D projects. The actantial model analysis helps to understand the factors impacting the co-creation and the dynamics of the actors' relationships. The relationships are further complicated by dynamics of the ecosystem. Based on the interviews, at the beginning these ecosystems are more focused on new knowledge and systemic changes. Co-Research projects which are typical for new knowledge creation may even evolve competitors.

> Co-Research may have a wide-ranging consortium with competing companies and their customers as it is a public research project without parallel company projects. Still, it requires a totally new mind set to join a project with competitors. EXP7

Based on the thematic analysis of the interview data, factors impacting the co-creation can be categorized into five key themes: Project preparation and management, consortium, objective, communication and exploitation. These four themes are described in the following two sections.

6.3.2 Success factors

According to the interview data various factors contribute to success of co-creation in the ecosystem projects. After initial coding the key prerequisites for successful joint R&D project were categorized under the five themes: consortium, project preparation and management, objective, communication and exploitation (Table 7).

Table 7 Key themes and success factors for joint R&D projects

KEY THEME	SUCCESS FACTOR
CONSORTIUM	▪ Whole value chain ▪ Clear roles ▪ Strong engagement of all partners ▪ All partners have enough resources
PROJECT PREPARATION AND MANAGEMENT	▪ Experienced coordinator ▪ Clear process
OBJECTIVE	▪ Strong vision from the leading company ▪ Right level of ambition ▪ Well-defined ▪ Win-win for all partners
COMMUNICATION	▪ Open, trust among the partners ▪ Partner sharing knowhow and insight
EXPLOITATION	▪ Clear customer or market need ▪ Partners know how project results can be exploited. ▪ IPR issues are agreed before project execution

The narrative interview data underlined the importance of the consortium and evolving the whole value chain with clear benefits and interest for every partner to join the project and the understanding of the individual actor roles. This means that all partners understand what each partner brings into the project and what is the shared goal which no one can achieve alone. The common understanding and clear roles ensure the motivation and commitment. Trust is a fundamental part of cocreation. These factors combined with well-defined research questions and research perspective support the shared objective. High quality international research collaboration is an additional positive feature.

> Success is a sum of many factors. It is a result of a long-term process. You must be very good in your area and have good references. Often it is a continuum. We keep collaborating with the same actor. EXP2.

Often a university or research organization is the coordinator of the joint R&D project. Sometimes the coordination is taken over by consulting company or innovation platform. Some of the leading companies have made the choice to always use an external facilitator who coordinates the project preparation and execution. Coordination is seen as administrative work and company's own resources are preferable allocated to actual R&D work. A big role of the coordinator is to connect leading companies and other partners to join the collaboration and the join R&D project. Also, especially universities' and research

organizations' know-how of the different funding instruments is appreciated. It is also expected that in the role of the coordinator, university or research organization supports the partners in their project proposal preparations. This way the joint application has good quality and chance of getting funded. The coordinators, regardless which organization, are expected to find the partners of the value chain, when possible, also horizontally and beyond the field of industry. New partnerships may be found among non-traditional customer or suppliers. The joint R&D projects are built to cover research topics that also fit the needs of the partners of the leading company ecosystem. Often the best approach is that the coordinator builds the whole joint project, collects the participants, writes the joint application, supports the companies, coordinates the execution of the funded project, reports and prepares potential follow-up projects.

> The coordinator must be a very skilled expert who can accomplish coordinating the whole preparation of the application, execution and reporting of the project and at the same time be a top scientist of the field. The truly tough ones are rare. EXP2

Clear project objective was emphasized by all interviewees. According to interviews a good joint R&D project has a narrative. The objective must bring clear benefit for all partners, and it must be exemplified. In a successful joint project, a clearly defined set of customer or market needs has been recognized and consortium is formed by companies that fit the project. Things take place in phases and each work package is linked to them. The narrative makes is easier to communicate the objective and actions of the project. It forms an action line which is structured in segments and phases. This action line can be function-based or value chain.

One factor which affects the collaboration is how clearly partners communicate which R&D topics they are open to discuss and do together. According to the interviewees communication is often more the characteristics of the individual, his or hers will and own way of doing rather than organization specific attribute. Sometimes the organizational culture affects the openness. In an ecosystem of open innovation co-creation depends on willingness to share and genuinely how prepared partners are willing to do so. The public joint R&D project focuses on issues that are common and can be published. The private company project is for those issues that the companies do not want to disclose or publish. To listen and to understand the need and vision of each partner is important for the commitment but there must be a consensus, everyone must contribute and there needs to be win-win thinking among the partners. The voice of each partner must be heard. Equally important is to have realistic, yet high-reaching objective. When preparing a project proposal, the partners must discuss and understand the ambitious but realistic objective and how they agree to collaborate.

Exploitation takes place after the joint R&D project yet planning and talking about it is important already in the project preparation phase. Common understanding of the aimed market or customer need helps partners to understand individual roles and expectation regarding the exploitation. The

leading company missions and ecosystem work bring significant business opportunities to the ecosystem actors. Understanding how the project results can be exploited, including especially the IPR issues, simplifies the later value capture and exploitation.

> We are heading towards green transition, which makes is possible also for our partners to growth internationally and find new markets. EXP8

> We try to make sure that SMEs benefit from these projects, not just us (the leading company). The starting point is that all partners gain advantage for their own business. EXP2

From the leading company perspective an improvement to earlier Business Finland funding is that they can use public funding for their own activities, they are not required to use all the public funding for subcontracting. Instead, spillover takes place as knowledge is spread and partners, including smaller actors, are supported through the joint R&D projects under the leadership of the leading companies. Multiple leading companies may join the same R&D project and leading companies from completely different business areas have found common objectives and exchanged ideas.

> To my opinion, best projects are those where several leading companies join. Then there is huge impact potential, that is the benefit of large companies. EXP8

6.3.3 Challenges

The interview data brough out several challenges in the joint R&D projects. These challenges are connected to the five key themes which were identified from the collated data of the interviews: consortium, project preparation and management, objective, communication and exploitation (Table 8).

Table 8 Key themes and challenges for joint R&D projects.

KEY THEME	CHALLENGE
CONSORTIUM	▪ Incomplete value chain ▪ Unclear roles ▪ Uncommitted partners ▪ Partner/s too small or lack resources.
PROJECT PREPARATION AND MANAGEMENT	▪ Unexperienced coordinator without mentor ▪ Unclear timeline and actions
OBJECTIVE	▪ Leading company is absent or indifferent ▪ Over or under ambitious ▪ Vague ▪ Partners focused on own benefit only
COMMUNICATION	▪ Unclear and secretive ▪ Partners keeping to themselves
EXPLOITATION	▪ Change in business model or value chain make partner/s obsolete ▪ Unclarity about rights to exploit project results. ▪ IPR negotiations are prolonged

Formation of the right consortium poses a challenge. As stated by the interviewees the leading company ecosystem funding attracts a mixed group of actors but at the same time Finland is rather small country when it comes to number of actors. Often the same organizations appear in the joint R&D projects. The number of the leading companies is so big in Finland that the space is getting crowded even though these companies are from different industries. The same companies, universities and research organizations recur in the projects. Finding the right companies and engaging them to the cocreation and parallel Co-Innovation projects is challenging. An issue merging from the interview data was that both private and public sector may fail to recognize the profound expertise of the other party. Expert interviews showed that projects start going wrong when the consortium members are not committed and do not put effort into cocreation. According to the interviewees even if the topic is very relevant but the consortium lacks needed actors, joining the project is waste of resources. Further challenge and one of the main reasons for negative Business Finland funding decisions is that the group of participating companies is too narrow. Sometimes the partners contact the leading company late in the proposal preparation hoping for a support letter or leading company's participating in the steering group of the project. From the leading company's perspective this kind of last-minute approaches are problematic and unwanted. In case the project is relevant and linked to their ecosystem, they want to be involved from early one to impact the content, objective and formation of the consortium. If the leading company doesn't recognize the prerequisites for commercialization, they are not willing to participate. If the consortium is formed by companies first signing up and not by critically assessing who are needed to reach the objective, the consortium may be formed by a random group of actors. Part of suppliers and consulting companies want to participate but are unable to clearly define their role or input. Some actors are not contributing directly to roadmap objectives but are selling consulting services. This is experienced as a burden by part of the leading companies. Sometime joint R&D project actors are motivated only by the funding obtained by joining the project and they focus less on collaboration and more on their own objectives. Part of the companies joining these ecosystems are looking for business with the leading company and do not see the ecosystem collaboration as a steppingstone to international markets.

> Sometimes a joint R&D project tries to fit together miscellaneous group of interest. It is like buffet with a variety of food items. Everyone may bring what they want, and no one planned the big picture. EXP5.

Other partners expect from the leading company either support in growth and internationalization or solid technology for building a shared offering to customers. Building shared offering is challenging as everyone in the value chain must be good and appropriate for the particular offering. For the offering to be competitive all actors of the value chain must be strong.

> Solidary might ruin the whole project and objective. Building the consortium is like choosing relay team two years before the competition. Someone in really poor shape is in the team because they were chosen two years ago. EXP5.

Poor project preparation and management process is one source of failure. According to the interviews, project preparation and management might fail due to inexperienced coordinator. For the leading companies it is frustrating to teach new external coordinator how to run the process of joint proposal preparation and management. The companies see value in the project preparation and management know-how of universities and research organizations. However, if a new person is introduced to the coordination, the coordinator organization must provide needed supervision and guidance. Interview data also highlighted external coordinator as a potential reason for failure. From the interview data contradicting perspectives rose regarding the project preparation and management of the ecosystem joint R&D projects:

> Would a coordinator from the leading company more likely take responsibility, leadership and ensure that the objective is reached? EXP5

> We have made the choice that in every ecosystem project there is an external facilitator or orchestrator who takes the managerial responsibility of that project. We do not want to use our leading company's resources to manage projects. EXP7

Unclear or inaccurate objective of the R&D project lead to lack of commitment. A problem is also if the project is too high level, or the objective is too broad. Sometimes the goal is left abstract. According to the interview date, if executive level persons plan the project, the project might end up too generic or high level. A grass-roots level employee might be better at defining the problem and approaching the solution after management has approved participation. An opposite challenge is low risk R&D projects. Playing it safe is one challenge. All project participants must take responsibility for defining clear objective, right level of ambition and motivation factors, which ensure the commitment of every actor.

The insufficient communication is a further reason for failure. Sometimes partners do not understand how each individual project is linked to the leading company's mission. According to the expert interviews this is mainly a communication challenge. The leading company, coordinator and principal investigator of the R&D project must understand the overall goal and be able to communicate this to the partners.

> The biggest disappointment was that the leading company was not committed or did not communicate the vision to us. It would have been good to see at the beginning of the project the target market of the leading company: this many countries and these areas. EXP5.

The interviewees provided insight to the importance to plan exploitation timely. The interview narratives emphasize how significant changes in the business models and value chains challenge innovating and cocreating in the joint R&D

projects. Extensive systemic changes are expected as a results of the joint projects, yet actors do not want to lose their purpose or position in the value chain in order to exploit the results and capture value. Continuous development and new optimum may lead to improved performance where one of the project partners is no longer needed or work description is significantly changed. According to the experts interviewed it is challenging to motivate partners to cocreate something where the structure and business changes and exploitation prospect is unsettled. Some actors may turn out to be more winners than other, and someone might even lose their business. This may lead to a situation where part of the actors opposes the objective because if might mean significant change in the value chain and for the actors. One reason for failure is to be stuck in the own way of doing and clinging to present status quo.

> Cocreation is difficult if partners hide in their fox hole, and everyone would like to hold on to their own role and position in the value chain. EXP8.

Company size and resources cause diverse challenges for co-creation and value capture. SMEs may pose a risk for the exploitation of the results if their resources are very limited and not sufficient for commercialization of the results of the joint R&D project. Large and mid-size companies are sometimes found inefficient and progress in projects slowed down by the large number of participants trying to find consensus. The atmosphere in projects and meetings can be very good but progress and concrete results minor regardless of months' work by several organizations. According to the interviews intellectual property right (IPR) issues pose also challenges in some of the projects. The conflict rises from the tension between knowhow, sharing and protecting. The core issue is how broad is the need for protecting intellectual property and how much is shared openly. More specifically three aspects are pointed out. For one, the prolonged negotiations on details and finding solution to organization specific practices. Secondly, Business Finland's funding terms and conditions as well as invention legislation are guiding the collaboration and regulate e.g. the ownership of the results.

> Quite often I have heard the comment that since all intellectual property created together is owned together, let not collaborate so closely. EXP3.

Third aspect is linked to the previous one, the interpretation of universities regarding IPR regulations. In case of commissioned research with profit margin Finnish universities' request to keep some rights to the results, e.g. for teaching, is seen as severe challenge for the co-operation. Principally IPR and protecting the research results is more in the interest of the companies but also in the interest of universities and research organizations. In cocreation and ecosystem work if the starting point is to protect and ensure own benefit without caring about the needs of other ecosystem partners, it is problematic. The openness of the collaboration, how much partners share with others and how much actors tell their partners about their own expectations for the collaboration helps solving IPR issues. Interviewees underline that to avoid feigned collaboration each

partner must clearly put into words their conditions for the collaboration and be prepared to discuss openly what they are prepared to share and what are their needs to protect project results. Solving IPR matters at the beginning of projects prevents later conflicts.

> In the beginning, it takes time to negotiate on IPR-related contracts so that they are agreeable for all partners. However, it prevents later conflict situations. EXP4

A further observation emerging from the data was that, although a project may initially appear to be a failure upon its completion, the situation can change over time. Occasionally, the new knowledge gained, or the results obtained from the project can become valuable and exploitable years later. Also, public funding is meant for high risk and high gain research and developments.

> We must understand that not everything will turn out to be a success. Developing new includes the possibility that the idea does not work. EXP8

6.4 Summary of the results

In this chapter the results of the interview and roadmap analysis are summarized. The chapter is introduced to tie together the results and to describe the interconnection between the digital sustainability, ecosystem and joint R&D projects. The three study aspects were 1) digital sustainability in the leading company ecosystems, 2) the leading company ecosystem and its actors and 3) joint R&D project's success factors and challenges.

The thematic analysis of the research data obtained deeper understanding of the digital sustainability objectives of the leading companies. While not present in all leading company ecosystem roadmaps, based on public material digitalization and sustainability are both present in all leading companies' business thinking. The companies do not define in their leading company missions the digitalization and sustainability links in such a detail that the use of digitalization would be restricted or limited in advance only for certain applications. The companies see digitalization as a comprehensive instrument and necessary tool e.g. enabling sustainable processes, sustainability monitoring and reporting. Figure 22 reflects connections between the key digitalization and sustainability themes of the leading companies. Digitalization solutions in the seven thematic topics reflect application areas which support environmental, economic and social sustainability.

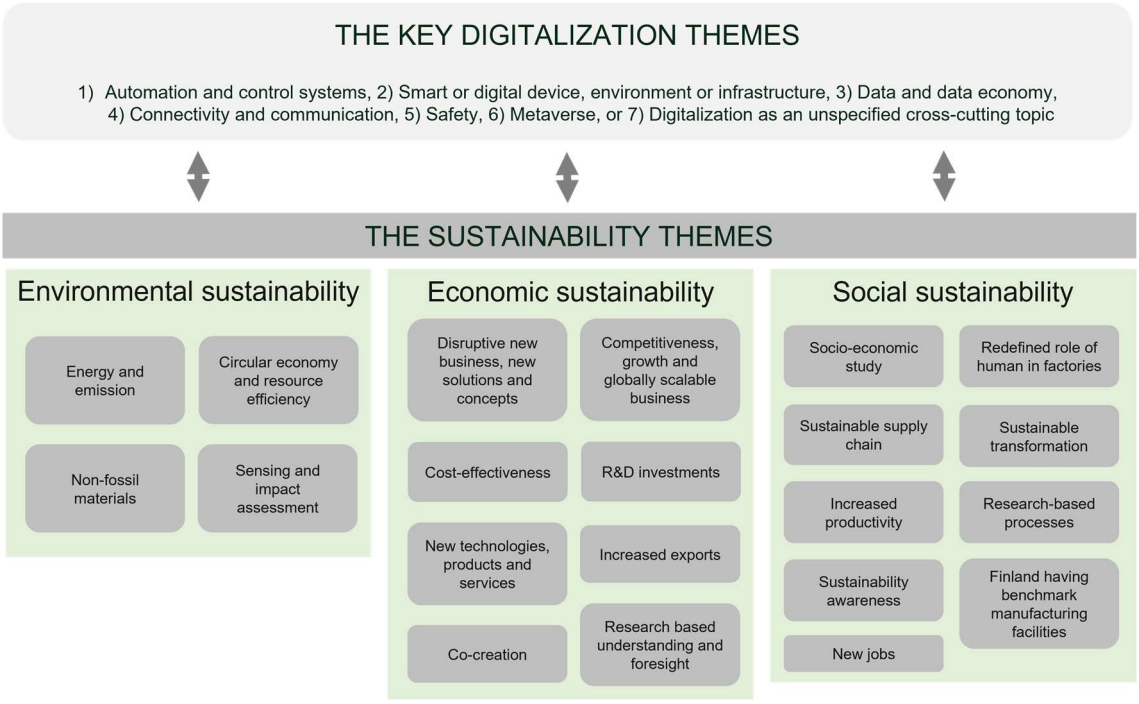

Figure 22 The interplay between digitalization and sustainability.

The study results stress that the sustainability actions are part of today's business activities, where neglecting sustainability issues may form a risk. The adoption of digitalization is business driven. Digitalization is an important instrument in promoting and enabling sustainability, not as an unconnected theme but with the purpose to enable concrete results and improvements related to e.g. energy efficiency, clean technologies, process optimization, new service concepts, data collection and analysis, product life cycle monitoring and sustainability reporting. Enhancing sustainability would be much more difficult if not impossible without data collection and analysis made possible by digitalization. For companies integrating sustainability and digitalization in their business may be complex but necessary. The study data shows that companies cannot focus on their own business only but the whole value chain must be considered and evolved. Digital sustainability demands collaboration and co-creation to develop solutions which enhance both economic growth and sustainability. Leading company ecosystems are one example of collaboration forms supporting such development.

The analysis of the actor roles in the leading company ecosystems make prominent the complex relationships and dynamics (Figure 23).

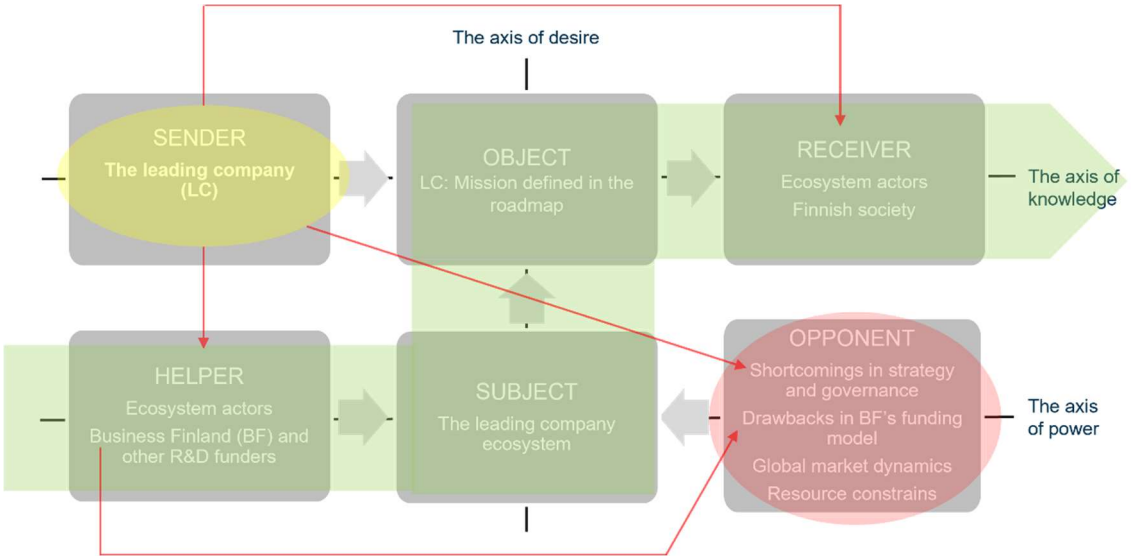

Figure 23 Graph highlighting the positive (green) performance path.

At the desire axis, the ecosystem (subject) wants to reach the leading company's mission (object). The leading company as sender has a great responsibility in communicating their mission and motivating the ecosystem actors (red arrow from sender to helper). The mission must bring benefits (receiver) to all ecosystem actors, not only to the business of the leading company. The leading company must build and communicate the mission in such way that the benefits are clear and real also for the other ecosystem actors (red arrow from sender to receiver). Research funders are motivated by the positive impact on society. The green path in the Figure 23 illustrates the flow of positive forces of desire, power and knowledge. The helper is motivated to act in the ecosystem when they understand the benefit they or their named beneficiary get as receiver. The helpers must be reinforced by communicating the benefits and ensuring goal-oriented ecosystem work. According to research findings a great responsibility lies with the leading company and coordinators of the ecosystem and ecosystem projects. An opponent that came clear from the interviews is the need for improving the ecosystem strategy and governance (red arrow from sender to opponent). Those are the important actors or matters that the leading company must acknowledge when planning, executing and communicating their leading company program. The leading company has the task to communicate, motivate and lead. The ecosystem actor relationships are further intricated by the role of Business Finland. It supports both the leading company and the partners of the ecosystem projects. There is need to clarify the funding instruments guidelines and rules as well as develop the instrument to better support the diverse groups of actors needed to achieve the ambitious missions set for these leading company ecosystems, including small agile companies developing new technologies.

Based on the study data and analysis, the key characteristics as described by earlier literature (Table 1) were determined for the leading company ecosystem (Table 9).

Table 9 Key characteristics of leading company ecosystem.

KEY CHARACTERISTIC	LEADING COMPANY ECOSYSTEMS' DESCRIPTION
Goal	The mission is set by the leading company and published in the form of roadmap. It is the responsibility of the leading company to communicate and lead the mission. Partners must be able to recognize their benefits for joining the ecosystem.
Strategy	Execution of ecosystems actions vary from leading company to leading company. Each leading company shapes the processes and practices that guide the management of the ecosystem. In their peer group (veturivarikko) the companies can exchange experiences and support each others.
Stakeholders	Successful collaboration reinforces collaboration and trust. Ecosystem partners tend to be the same between projects and even between the ecosystems. However, leading company ecosystem work has also generated new partnerships even cross industries.
Roles	Roles of different actors (academia, research organizations, private sector) are described in some ecosystems by indicating emphasis between research projects by research organizations and R&D projects by companies. Many ecosystems are missing description of function or positions wanted participants play within the ecosystem.
Relationships	The nature and dynamics of interactions and connections between different actors within the ecosystem are ambiguous and therefore complex. Due to different types of stakeholders and projects in these ecosystems, the focus of relationships changes between knowledge, innovation and business. Some ecosystems have also entrepreneurial activities aiming as startups and spinouts.

Successful ecosystem has a clear goal setting. Based on the interview data all ecosystem partners must participate and work goal oriented. A challenge is finding balance between the interests of different actors and ensuring that all partners are committed to the shared objectives. Leading company ecosystems offer a platform for the ecosystem actors to bring forward their strengths and co-create new solutions. New partnerships are an opportunity to promote innovation and growth of the business. For the leading company ecosystems, it is characteristic that they evolve from knowledge creation to innovations and business development. Some of the ecosystems also have targets related to entrepreneurship through spinouts and startups. Managing the multifaced partnerships and coordinating the co-creation requires knowhow, resources and effective project management. The leading company are expected to facilitate the exchange of information in the ecosystem and between the project and supports its partners in growth and internationalization of their businesses. The leading company ecosystems were also studied from the ecosystem structure perspective (Adner, 2017) to understand the relationships within the ecosystems:

Activities: In the leading company ecosystems value creation takes place in projects mainly funded by Business Finland.

Actors: Multiplicity and diversity of co-creation partners are essential for the ecosystem to accomplish the mission. Actors include leading companies, SMEs, universitates, research organizations, R&D funders, helper organizations such as innovation consulting companies and open innovation platforms. The same actors are very often involved in multiple projects. Leading companies prefer projects where several leading companies join.

Positions: The operational structure of the leading company ecosystem is dynamic. The objective is to evolve in the projects' actors covering the whole value chain but changes in value chain challenge the co-creation. New actors are needed. Often actors may need to revise their role or location in the value chain. Some actors may leave the collaboration or are not able to join the value capture due to change in the value chain.

Links: A shortcoming is weak links and transfer of information across the ecosystem actors' positions and between the projects.

The analysis of joint R&D projects focused on ecosystems' Business Finland funded joint projects. The interview data provided insight to co-creation in these joint R&D projects. The factors impacting joint R&D projects were categorized from the collated data of the interviews under five key themes: project preparation and management, consortium, objective, communication and exploitation (Table 10).

Table 10 Key themes, success factors and challenges in joint R&D projects.

SUCCESS FACTOR	KEY THEME	CHALLENGE
▪ Whole value chain ▪ Clear roles ▪ Strong engagement of all partners ▪ All partners have enough resources	CONSORTIUM	▪ Incomplete value chain ▪ Unclear roles ▪ Uncommitted partners ▪ Partner/s too small or lack resources.
▪ Experienced coordinator ▪ Clear process	PROJECT PREPARATION AND MANAGEMENT	▪ Unexperienced coordinator without mentor ▪ Unclear timeline and actions
▪ Strong vision from the leading company ▪ Right level of ambition ▪ Well-defined ▪ Win-win for all partners	OBJECTIVE	▪ Leading company is absent or indifferent ▪ Over or under ambitious ▪ Vague ▪ Partners focused on own benefit only
▪ Open, trust among the partners ▪ Partner sharing knowhow and insight	COMMUNICATION	▪ Unclear and secretive ▪ Partners keeping to themselves
▪ Clear customer or market need ▪ Partners know how project results can be exploited. ▪ IPR issues are agreed before project execution	EXPLOITATION	▪ Change in business model or value chain make partner/s obsolete ▪ Unclarity about rights to exploit project results. ▪ IPR negotiations are prolonged

Digital sustainability transition requires research and development through value chains and therefore ecosystems are good context for collaborative efforts. Joint R&D project in leading company ecosystem offer such possibilities for synergies and innovation. Finding balance between the interest of the project actors may be especially difficult when digital sustainability requires systemic changes and reforming of business model and value chains. Challenges of cocreation must be openly settled together. Key success factors of joint projects are clear roles and objectives as well as effective and open communication.

7 DISCUSSION

In this chapter the principal findings of the research are presented. The results are reflected against the main objective and the research questions. Discussion summarized the main objective of this study which was to explore digital sustainability, actor roles and co-creation in leading company ecosystems. The main objective was supported by four sub-questions, which are presented in the chapter Findings 7.1. The results help to understand the role of digitalization in promoting sustainability and joint research project in enhancing the goal of the leading company ecosystems. In this chapter also the master thesis practical and theoretical contributions are discussed. Finally, the limitations of the study will be discussed considering data collection, analysis and interpretation.

7.1 Findings

This study suggests that exploratory thematic analysis (Clarke & Braun, 2017) and actantial model (Greimas, 1983) can be used to study leading company ecosystems. They provided insight to the nature of leading company ecosystem, the actors, roles and relationships and link between digitalization and sustainability objectives. The findings of the four research questions are described next.

RQ1 How digitalization is linked to sustainability objectives?

The expert interviews showed that the terms digitalization and sustainability are understood similarly, although their definitions are not entirely identical. The study results show that companies have several key areas where they rely on digital technologies and innovations in their research and development. Digitalization strategies and their integration into the leading company ecosystem roadmaps are also linked to several sustainability objectives. The leading companies work on developing solutions related to environmental, economic and social sustainability. The findings consolidate that in the leading company ecosystem context most but not all leading companies are interested in the opportunity digitalization provides for strengthening sustainability. Similar observation was made by Lichtenthaler (2021) stating that some companies are particularly focused on enhancing sustainability through digital solutions. These leading companies have recognized the significant role digitalization has in enhancing sustainability (George et al., 2021; Ghobakhloo, 2020; Ha et al., 2022). Those twelve leading companies which link digitalization and sustainability in their roadmaps raise six key themes as R&D targets: automation and control systems, smart or digital device, environment or infrastructure, metaverse,

connectivity and communication, data and data economy and safety. This study indicates that leading companies see digitalization as a cross-cutting, enabling tool which helps to achieve sustainability objectives, which is in line with the literature (Santarius & Wagner, 2023). Interviewed experts highlight that digitalization is essential for managing complex data, optimizing production processes, and transitioning to a circular economy. Consistent with the literature, leading companies also recognize the need of digitalization for sustainability assessment, monitoring and reporting (Klymenko et al., 2021). The findings indicate that sustainability has evolved from being a niche or partly a greenwashing action to an important aspect of business strategy. Leading companies view ignoring sustainability as a business risk.

Interviewees' perception is that digital sustainability requires collaborative ecosystem and joint activities as supported in the study by George et al. (2021), but new solutions might require reorganizing value chain and collaboration as has been pointed out also by Hilali et al. (2020) and Kolloch & Dellermann (2018). The leading companies managing business-orientated digital transformation need vision, capabilities and new perspective as supported in the study by Mann et al. (2022). The findings support the observation of previous literature that digital transformation requires capabilities that sometimes are easier or faster to obtain from others in the ecosystem rather than trying to tackle intra-organizationally (Williamson & De Meyer, 2012). The study findings indicate that many interviewees felt that economic success and sustainability can and must coexist for leading companies and their ecosystem partners to invest in developing digitalization and sustainability, a similar view was expressed by Orzes et al. (2020) and George et al. (2021).

RQ2 What are the roles of different actors in the leading company ecosystem?

The leading company ecosystem can be seen as a structure which aligns activities, actors, position which form the foundation for value creation, similar to ecosystem as structure introduced by Adner (2017). In the leading company ecosystem, the multilateral coordination among many partners is important, as each partner has a role and activities dependent on others. The leading companies play a key role in coordinating and steering their ecosystems toward achieving the missions they have set as their strategic goals. The key characteristic of ecosystem is to create value (Felch & Sucky, 2023; Kapoor & Lee, 2013; Ketonen-Oksi & Valkokari, 2019) and it's the leading company's role to ensure that the ecosystem strategy relates to all ecosystem actors. Previous literature emphasizes the importance of the ecosystem strategy to relate to all ecosystem actors and to define the potential benefits, opportunities, engagement models and required capabilities (Krome & Pidun, 2023). Leading companies are expected to provide direction and support for the ecosystem, ensuring alignment with the ecosystem goal and assisting also partners to achieve international growth objectives. A versatile assembly of leading company ecosystem partners

provide the complementary input needed for the shared objectives to create value as supported by previous study (Y. Li et al., 2022). The ecosystem leader must manage incentives for partner to encourage their participation, as also emphasized by the literature (Helfat & Raubitschek, 2018; Van der Borgh et al., 2012). Aligning ecosystem actors towards the ecosystem goal and ensuring focusing on shared vision is the challenging but necessary role of the leading company (Hooge & Le Du, 2016). The findings conclude that all ecosystem actors play a role in identifying collaboration opportunities and understanding the ecosystem partners. Leading company ecosystem partners must look beyond direct collaboration of the value chain and consider their role within a broader ecosystem of value creation, similar to Adner's argument for the modern, interconnected business environment (Adner, 2017).

The findings indicate that leading companies highlight research-based, and academia or research organization led projects at the value creation phase and beginning of the ecosystem work. Academia and research organization are expected to produce multidisciplinary and disruptive new knowledge, which according to literature is typical for knowledge and innovation ecosystems (Cobben et al., 2022; Valkokari, 2015). The role of academia and research organizations is essential for the integration and dissemination of knowledge, finding which is also supported by Spena et al. (2016). At this stage the value of the developed knowledge is jointly captured and may evolve systemic changes as also supported by the study of innovation ecosystem dynamics by Paasi et al. (2023). The findings show that later as knowledge increases and new technologies emerge, the role of industry development and collaboration gets stronger as indicated by earlier literature (Cobben et al., 2022). At this stage the collaboration corresponds to characteristics of business ecosystem (Felch & Sucky, 2023). Developing new innovative solutions for customers and gaining value from the research is the task of the leading companies and the industrial ecosystem partners as is typical for business ecosystems (Cobben et al., 2022; Felch & Sucky, 2023; Valkokari, 2015). The study findings point out that the value capture phase takes place years after joint R&D projects end. It may take years after completion of the leading company ecosystem before the companies are able to capture value.

A special groups of potential leading company ecosystem actors are small companies and startups. They are expected to contribute innovative ideas and have agile implementation capabilities. By joining these ecosystems, they gain visibility and opportunities for co-creation and networking. Literature supports the role of startups not only in entrepreneurship ecosystems but also knowledge, innovation and business ecosystems (Clarysse et al., 2014; Cobben et al., 2022; Valkokari, 2015).

These findings indicate that all leading company ecosystems are a fusion of knowledge, innovation and business ecosystems. For disruptive new business starts, spinoffs or startups are raised as an option in three leading company ecosystems leading to leading company ecosystems (Konecranes, Mirka and Tietoevry) which include characteristics from all four ecosystem types described

by Cobben et al. (2022): knowledge, innovation, business and entrepreneurship ecosystems. The findings suggest that in these leading company ecosystems simultaneously in different projects small, isolated environments of knowledge, innovation, business and entrepreneurial ecosystems are created by the project consortiums. This co-existence and evolvement of different types of ecosystems within the leading company ecosystem make managing them more complex. This finding reinforces the previous review study of Cobben et al. (2022) where the authors emphasize a broader and more nuanced understanding of ecosystems, where ecosystems are not static but dynamic and evolving over time. Progress in research, development and collaboration shape the relationships, structures, and functions within ecosystems. The findings highlight the importance of strategic planning and execution, collaboration, and continuous improvement of the leading company ecosystems to support achieving the missions set by the leading companies.

RQ3 How do various factors contribute to the success or failure of joint R&D projects?

Leading company ecosystem joint R&D projects can be initiated by either the leading company or a consortium member, with also Business Finland playing a significant role as funder and setting expectations.

The study indicates five key themes for success: Project preparation and management, consortium, objective, communication and exploitation. Similar themes have been recognized to be important for collaborative value creation by previous literature (Bhalla, 2014; Cennamo & Santalo, 2013; Helfat & Raubitschek, 2018; Khademi, 2020). Project preparation and management require effective and experienced coordination, often by universities or research organizations, ensuring high-quality project proposals and execution. The project consortium must be well-formed covering the whole value chain or required functions as also supported by the literature (Gomes et al., 2018a). Especially sustainability and systemic changes in industries require involving the entire value chain. No single entity can achieve these transformations alone. The roles must be clear, and goal shared to ensure motivation and commitment of all partners. The objective must be ambitious, yet realistic, similar view is emphasized by previous literature (Gomes et al., 2018a; Khan et al., 2022). Open and effective communication about project goals and partner roles is crucial for the collaboration. Building trust among partners is also essential for co-creation. Plans how to exploit and commercialize project results ensure that outcomes are practical and beneficial to all partners. Openly discussed exploitation outlook also helps to avoid potential later conflict, for example, regarding IPR matters.

The same five key themes (project preparation and management, consortium, objective, communication and exploitation) form challenges for the joint R&D projects when insufficiently managed. Poor project preparation and management or inexperienced coordinator can impair the application or bring project off the track. Involvement and guidance from experienced coordinators

are necessary when introducing new coordinators to the work. Finding the right partners may be difficult due to Finland's small market and limited number of companies. Engaging the leading company and committed partners early is crucial to avoid insufficient consortium formation. Unclear or overly broad objectives can lead to lack of commitment by the partners. Projects need to balance ambitious vision with practical, doable goals. Miscommunication or lack of clarity can lead to disengagement and failure of both the collaboration and the project. Collaboration may be challenged when exploitation requires changes in the value chain. Significant changes in the value chain can lead to resistance from partners who fear losing their established roles or positions. Intellectual property rights issues can complicate collaborations. Addressing these challenges proactively help to fruitful and effective collaboration.

> RQ4 What are the key characteristics and structure of the leading company ecosystems?

The findings provide a general description of the characteristics of leading company ecosystems. The ecosystem goal is set by the leading company. The goal is gradually achieved moving from research-focused projects to public-private joint R&D projects and later to private-collaboration closer to the market. Each leading company ecosystem has its own way to manage and guide their ecosystem. The same actors recur in the different projects across the ecosystem and often the same actors are also evolved in several leading company ecosystems. Leading companies have left freedom for partners to define their roles in these ecosystems. Typically, in their roadmaps the leading companies only differentiate the roles of academia and private actors. Only few emphasize also entrepreneurial role of startups and spinouts. As these ecosystems comprise of multifaced projects starting from low technology readiness level and research-orientation to closer to market projects with only company-partners, the relationships, roles and type of collaboration varies. This dynamic adds to the complexity of the leading company ecosystems and put pressure on the leading company to manage and communicate the ecosystem work. The leading ecosystem environment supports joining companies in innovative activities by providing facilities, resources and collaborators. Similar view was pointed out by Van der Borgh et al. (2012) where the authors state that ecosystems enhance the value-creation potential by shared knowledge, resources, and a culture of collaboration. The leading company ecosystems have the potential to facilitate the innovation process of the individual companies as well as the innovation process of the ecosystem.

7.2 Theoretical contribution

Prior research has acknowledged that developing digital sustainability requires collaborative approach across industries and academia. Ecosystems are

cooperative environments that suite well tackling such systemic challenges, leading company ecosystems being an example of such ecosystems. This study has revealed that there are still questions about the transitions between ecosystem types, roles of various ecosystem actors and how to manage the cocreation to tackle the challenges and foster the success factors in these dynamic cocreation environments.

The study showed that applying Greimas' actantial model to the leading company ecosystem framework provides a tool for analyzing ecosystems by framing stakeholders (e.g., industries, SMEs, academia, research organizations and government) as actants within a narrative structure. This study contributes this narrative-based approach which allows for a deeper understanding of the roles and relationships between different entities within the ecosystem, as well as the motivations, challenges, and collaborations that drive the innovation process. Studies that combine the ecosystem framework with Greimas' actantial model have not been widely documented in innovation or management literature likely due to the interdisciplinary and somewhat unconventional nature of integrating semiotic theory with innovation studies.

A theoretical contribution has been researching an ecosystem case where a leading company manages an ecosystem with mission defined solely by the leading company, with defined duration and various type of projects corresponding to characteristics of different ecosystem types. In summary, the theoretical contribution is the aspect that understanding the ecosystemic digital sustainability development, one must first identify the characteristics of the specific ecosystem, its actors, their roles and relationships. Then the cocreation success factors and collaboration challenges can be recognized and better understood in the specific ecosystem context.

7.3 Practical relevance

The purpose of this study was to identify the key characteristic and structure of leading company ecosystems, actor roles, digital sustainability development objectives and cocreation factors. Practical relevance of this study is identified importance of defined roles, responsibilities, rights, and benefits for all ecosystem actors to avoid ambiguity and ensure effective collaboration. Leading companies can support the collaboration by establishing clear guidelines and frameworks for participation. Developing mechanisms for information sharing can facilitate better interaction between ecosystem projects.

The long-term goal of the leading company ecosystems is to generate international business growth for the joining companies. Based on the study, leading companies are encouraged to develop public strategies how they support their ecosystem partners to enter new markets and scale their innovations globally.

This study identified as one challenge the shortcomings in the Business Finland’s partnership funding model. SMEs and startups could bring agility and

innovative approaches to the leading company ecosystems but currently lack appropriate funding instrument to adjoin the joint R&D projects. The results of this study could help Business Finland as funder of leading company ecosystems to consider how to enable and support small companies and startups to get on board.

The study findings showed that effective coordination is critical in managing the diverse interests and contributions of value chain actors. Seasoned ecosystem coordinators are needed for managing the dynamic ecosystems which transit from knowledge and innovation creation to business and entrepreneurship creation. Skilled project coordinators are valued for their ability to manage project preparation, execution, and reporting, as well as for their knowledge of funding instruments. The dynamic nature of ecosystems means that roles and relationships within projects and the value chain must be adaptable. Continuous development and systemic optimization can lead to improved performance but may also result in significant changes to existing value chains. The findings of this study help ecosystem and project coordinators to acknowledge and identify critical topic. With clear communication and by addressing collaboration challenges, leveraging the strengths of all actors, and focusing on sustainable and international growth, these ecosystems can achieve their ambitious missions. Based on the findings, the leading companies should support more the information exchange in the ecosystem and link actors and projects on regular base. There already are examples of information sharing initiatives. Meyer Turku is an example of a leading company evolving the partner to join a regular Teams based collaborate platform for discussion and sharing ideas (*How to Join? - NEcOLEAP*, n.d.). Also, Picosun has set as one of the development targets a digital platform for enabling seamless collaboration (*Funding for Leading Companies and Ecosystems - Business Finland*, 2023).

To summarize the conclusions for the practical relevance of the findings, the ecosystem collaboration requires careful management of partnerships, clear communication, and a balanced approach to intellectual property and commercialization challenges.

7.4 Limitation of the study

The study is not without limitation. This research was completed with qualitative method using exploratory case study approach. Data collection, analysis and interpretation remain influenced by the subjective assessments of the thesis researcher. Critics may point to the lack of analytical depth due to wide study scope including ecosystems, digital sustainability and cocreation. For prior unexperienced qualitative research scientist, it was challenging to focus on the most relevant themes as the study scope was wide, a risk which has been pointed out by Myers (2020). As Myers also writes, the responses from the interviewees may have influenced the theme building as typical for semi-structured interviews. A further limitation is formed by the limited resources. The study

was conducted by single person, two or more researchers could provide more abundant data and also improve the correctness of the data (Benbasat et al., 1987). Lack of time may have impacted some of the interview situation causing potentially interviewee a demand to answer questions under time pressure or leading to incomplete data set (Myers & Newman, 2007). The thematic analysis of the interview data might have impacted the researcher's perception of the unique viewpoint of individual experts (Dierckx de Casterle et al., 2012). In this study the interview data was pooled together, not all leading companies were interviewed, and the analysis did not separate data gained from leading companies and challenger companies as the study aimed to understand general attributes of the leading company ecosystems. These generic features do not describe a specific leading company ecosystem. It must be acknowledged that each of these ecosystems from an entity with unique strengths, success factors and challenges.

8 CONCLUSIONS

This study was conducted to get a better understanding of the key characteristics of the leading company ecosystems funded by Business Finland. At the focus of the study were the part digital sustainability plays in the missions of the leading companies, the actor roles and factors contributing to success or failure in co-creation. The aim of the study was to understand better these ecosystems, the dynamics of the actor relationships and cocreation. The research questions were framed to gain deeper insight to digital sustainability, actor relationships and co-creation prerequisites. Developing digital sustainability solutions and co-creation in ecosystems set expectations to the actors, their roles and actions. This case study confirms the importance of ecosystem and joint project management which acknowledges the importance of understanding the actor roles, relationships and factors contributing to success in cocreation. These attributes become accentuated when researching and developing challenging systemic changes and topics like digital sustainability.

The study was conducted as a qualitative explorative case study. The study first outlined the digital sustainability and the ecosystem literature to provide the lens for the theoretical framework of the study. At the second stage the roadmaps describing the ambitious missions of the running eighteen leading company ecosystems (status 8.1.2024) were studied. Parallel to the thematic analysis of these roadmaps, semi-structured individual interviews were carried out. Nine interviews were conducted by interviewing executives and managers with practical experience of the leading company ecosystems. Six interviews were conducted with representatives from five different leading companies. Also, one interview was conducted with a Business Finland presentative, one with an ecosystem company partner and one with an ecosystem research partner. Thematic analysis of the interview data was carried out before combined data from the roadmaps and interviews was used for the analysis of the actor roles and cocreation in the joint R&D projects. The research process was iterative. The data, abstracted concepts, results and findings were frequently revisited before proceeding to conclusions. At the last stage the conclusions were reflected with the analyzed data and findings of the study to benefit from evolving nature of understanding.

The study results show that leading companies have several key areas where they rely on researching and developing innovative digital technologies to support also their sustainability objectives. Digital sustainability development requires joint efforts, but at the same time, new solutions may require reforming value chains. These changes in the value chain can cause conflicts in collaboration and development as new partners are needed and earlier roles in the value chain might disappear. Despite the challenges, economic success and sustainability can coexist, and digitalization offers companies new ways to create and capture value in sustainable manners. Digital technologies enable the creation of more sustainable systems, processes and practices across industry sectors. The study

reflects a systemic approach to integrating digitalization with sustainability objectives. These holistic development targets impact various industrial sectors.

The leading companies have a dominant role as they set the roadmaps and steer these ecosystems toward achieving the ambitious missions which reflect their strategic goals. They must make these ecosystems attractive for the needed partners to participate. The partners are expected to commit to shared object. The relationships and dependences make the ecosystem management and collaboration dynamic and complex. At the core are the expectations from Business Finland as the funder of these ecosystems: The leading companies together with the ecosystem partners are expected to create significant export business potential for Finland through increased research, development and innovation activities and new business. Ecosystem partners form a versatile group of actors mainly interacting with each other in the ecosystem projects. The role of an actor can change from project to another while new actors enter and previous actor may leave the ecosystem. Besides established companies, academia and research organization, startups and agile small companies are seen as important actors when developing innovative solutions. However, current Business Finland partnership funding model doesn't fit small, young companies to be applicant. This shortcoming of the funding model waits for resolution.

The practical ecosystem work takes place in projects, which are mainly funded by Business Finland but also by other R&D funders. The projects vary from research-based and new knowledge aiming to closer to market-based development projects. The multilayered goals, complex characteristics and purposes of the projects make the leading company ecosystem a combination of knowledge, innovation, business and entrepreneurship ecosystems. This changing nature of the ecosystem work is further attribute that challenges the management and collaboration in the leading company ecosystem. The findings of this study underscore the intricate dynamics and critical success factors in leading company ecosystem joint R&D projects. Linked to leading company roadmaps, with funding and guidance from Business Finland, these projects aim at achieving the ambitious missions set by the leading companies. The study recognized five key themes which impact the success of a joint R&D project: Project preparation and management, consortium, objective, communication and exploitation. These five key themes identified in the study are also recognized in previous research as important factors for successful collaborative value creation (Bhalla, 2014; Cennamo & Santalo, 2013; Helfat & Raubitschek, 2018; Khademi, 2020). Effective project preparation and management require experienced coordination which is crucial for the development of high-quality proposals and successful project execution. The formation of a well-rounded consortium that evolves the entire value chain is essential, particularly when addressing digital sustainability and systemic industry changes that no single entity can achieve alone. Ambitious yet realistic shared objectives, as highlighted by Gomes et al. (2018a) and Khan et al. (2022), are critical for maintaining partner commitment and motivation. Open, transparent communication about goals, roles and exploitation is vital for building trust and facilitating effective collaboration.

Discussion about the plans for the exploitation and commercialization of project results ensure that outcomes are practical and beneficial for all partners. These discussion in the project preparation phase might mitigate potential conflicts, such as those related to intellectual property rights. Conversely, the study highlights that insufficient management of these key themes can present significant challenges. Poor project preparation, inexperienced coordinators, and insufficient consortium formation can derail projects. Clear and well-defined objectives are necessary to prevent partner disengagement, and open communication is crucial to avoid misunderstandings and collaboration breakdowns. Partners resistance to changes in the value chain and complexities surrounding intellectual property rights can hinder collaborative efforts. Addressing these challenges proactively, through involvement and guidance from experienced coordinators and early engagement of committed partners, is important for building good and lasting collaborations. In conclusion, the study reinforces the importance of these five key themes for the success of joint R&D projects within leading company ecosystems. By ensuring thorough preparation, forming a well-rounded consortium, setting clear and realistic objectives, maintaining open communication, and planning exploitation, these collaborative projects can achieve their goals and drive significant industry development.

The findings from this study provide an overview of the characteristics and dynamics of the leading company ecosystems. The goals within these ecosystems are set by the leading companies and are progressively achieved through a transition from research-focused projects to public-private joint R&D project, and eventually to private collaborations closer to market readiness. Each leading company ecosystem has its unique management and guidance approach, yet they share some similarities. Same ecosystem actors often recur across various projects within the same ecosystem and across different leading company ecosystems. Leading companies typically allow partners the freedom to define their roles, distinguishing primarily between academic and private sector participants, with few emphasizing the entrepreneurial roles of startups and spinouts. These ecosystems are characterized by a range of actors and projects, from low technology readiness levels and research-oriented efforts to market-near projects involving only company partners. This diversity adds complexity, necessitating strong and skillful management and communication from the leading companies, ecosystem and the project coordinators. The ecosystem environment fosters innovation by providing necessary facilities, resources, and collaboration opportunities, following the findings from Van der Borgh et al. (2012) who highlighted the value-creation potential of ecosystems through shared knowledge, resources, and a collaborative culture. These ecosystems have the potential to enhance both the individual and collective innovation processes within the ecosystem. The study underscores the importance of clearly defined roles, responsibilities, rights, and benefits for all ecosystem actors to prevent ambiguity and ensure effective collaboration. The study brought to light several conflicting aspects regarding the collaboration. A contradicting observation of the study was that some partners are only looking for business relationship with

the leading company, while others expect the leading company to open for them international markets also with other customer. Some joint projects were seen as overly ambitious or unrealistic, other projects were unassuming and ineffective. Leading companies can avoid these contradictions and misunderstood expectations. They can facilitate the ecosystem collaboration by establishing clear guidelines and frameworks for participation, and by developing mechanisms for efficient, regular information sharing to enhance interaction between ecosystem projects and actors.

In summary, this study emphasizes that understanding the specific characteristics and dynamics of leading company ecosystems is essential for managing these ecosystems and for fostering digital sustainability development and successful co-creation. The study and the findings are relevant for several reasons. Emphasizing the coexistence of economic success and sustainability, the study illustrates how in these leading company ecosystems digitalization can create new value opportunities, contributing to both industrial advancements and sustainability goals. The study findings provide guidance for the leading companies and their partners and highlight aspects important for management and participation in these ecosystems and ecosystem projects. The study also can enhance collaboration. Understanding the dynamics and key success factors can help actors to deal with the complex relationships and roles, fostering better collaboration and reducing the risk of conflicts. By highlighting the importance of a join approach to digital sustainability, the study underscores the potential for ecosystems to drive significant innovations across various industries. The findings offer valuable insights for funding bodies like Business Finland, suggesting areas for improvement in funding models to better support all ecosystem actors, including startups and small companies.

The findings raised new questions for further research topics. The leadings company ecosystems could be further studied to gain understanding of the nature of the ecosystem work. Do companies use the ecosystem funding for something they would do regardless of the funding? Are the objectives sufficiently ambitious and high-risk for public funding R&D projects? An important topic for further investigation would be to follow the value capture of leading company ecosystem actors after the ecosystems are finished. What can be learned from the value capture phase and what insight the learning could bring to the new leading company ecosystems and value creation? This study results suggest that leading company ecosystems are in fact an evolving mixture of different ecosystem types. How do these transitions take place and how to facilitate and manage the transitions? How do the roles of the ecosystem actor change between projects and ecosystems? This study treated leading company and challenger company ecosystems the same. A following study could focus on investigating the differences in these two types of company ecosystems. A further area for further research could be combining qualitative and quantitative research methods, for example, to study the ecosystem formation and partner acquisition. This study was conducted emphasizing the leading company perspective. The actantial model from Greimas could bring deeper

understanding of the ecosystem actor relationships if it was conducted from different perspectives, changing e.g. the sender to represent alternately the varying groups of ecosystem actors. For example, Business Finland, startup, research organization, university, technology provider. Therefore, a new study could provide deeper insight how different leading company ecosystem actors experience the ecosystem collaboration and how the prerequisites for co-creation could potentially be improved. The study was initially inspired by the urge to understand the role of digitalization in sustainability. The leading company roadmaps show that digitalization supports sustainability in several ways and the companies are investing resources in utilizing digital solutions across multiple application areas. On the other hand, the study finding observed some discrepancy between the current talk about e.g. data economy and actually business cases based on data. A study focusing on exploitation of shared data in the leading company ecosystem could provide on interesting study aspect gain deeper insight into one aspect of digital sustainability.

APPENDIX 1 INTERVIEW QUESTIONS

Kysymykset vain veturiyrityksen edustajille:

- Miten ja miksi digitalisaation liittyvät aiheet nousivat nimenomaan tiekarttanne?
- Millainen rooli eri toimijoilla on ekosysteemissänne?
- Miten te haluatte partnereiden toimivan ekosysteemissä?

Kysymyksiä kaikille:

- Mitä digitalisaatio ja kestävä kehitys käsitteinä tarkoittavat ja ovatko ne muuttuneet ajansaatossa?
- Miten näette digitalisaation roolin kestävän kehityksen edistäjänä?
- Miten digitaalisia ratkaisuja tutkivat ja kehittävät yhteishankkeet eroavat muista T&K-hankkeista?
- Kertoisitko esimerkin hyvin valmistellusta ja toteutetusta yhteishankkeesta?
- Mitkä tekijät vaikuttavat ekosysteemien yhteishankkeiden epäonnistumiseen tai ovat haasteita yhdessä kehittämiselle?
- Mitkä asiat motivoivat osallistumaan yhteishankkeeseen?
- Mikä on Business Finlandin rooli?
- Millainen rooli teillä on Veturi-ekosysteemin yhteishankkeessa?
- Auttoiko yhteishanke kasvattamaan vientiänne?

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