Heavy Cloud Computing

Perceptions of innovation facilitators about tensions in sustainability and digital technology

Rafael Andrés Solís Moreno

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Abstract

Digital technologies and digitalization are increasingly being used for sustainability goals, including in industrial settings. Digitalization processes also show evidence of unsustainable outcomes, as seen in the large needs of energy required by data, data-based systems, and the computing power behind them. There are other material impacts and social transformations that become obscured as digitalization becomes an integral part of everyday lives. Nevertheless, assessing the full energy and climate effects of digitalization can be challenging, especially in the use of scaling technologies like artificial intelligence, that can be used to provide previously inaccessible optimizations, while also scaling up production and consumption patterns. The point of view of industrial innovation leaders who work in sustainability-oriented organizations or firms, and whose work includes the facilitation of digitalization processes, has been scarcely researched. Especially for the Norwegian setting, a highly digitalized economy and society, with high levels of consumption, and a lively public debate on the paths of decarbonization. This thesis answers the exploratory research question of how the tensions of sustainability and digitalization are perceived by seven innovation facilitators.

For Tanja, Arne, Maia & Gudrun

In no particular order,

Each of you held out your hand and I was able to climb up and down an invisible mountain.

I'm so humbled and grateful!

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List of Abbreviations

CBAM	Carbon Border Adjustment Mechanism
CSRD	Corporate Sustainability Reporting Directive
ESG	Environmental, social, and corporate governance
EU	European Union
FSAN	Financial Supervisory Authority of Norway (*Finanstilsynet*)
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GRI	Global Reporting Initiative
IN	Innovation Norway
NIC	Norwegian Innovation Cluster Program (*Klyngeprogrammet*)
R&I	Research and innovation
RNC	The Research Council of Norway
SDG	Sustainable Development Goals
SIKT	Norwegian Social Science Data Services (*Kunnskapssektorens tjenesteleverandør*)
SIVA	Industrial Development Corporation of Norway (*Selskapet for industrivekst*)
TFCFD	Task Force on Climate-Related Financial Disclosures

Glossary

Additive Manufacturing (AM)	Also known as 3D printing, is a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies (Song et al. 2023)
Artificial Intelligence and Machine Learning Algorithms (AI/ML)	Artificial Intelligence (AI) is broadly defined as the science and engineering of making intelligent machines, particularly intelligent computer programs. It involves the simulation of human intelligence processes by machines, especially computer systems. This includes learning, reasoning, problem-solving, perception, and language understanding. AI systems are capable of performing complex tasks that historically required human intelligence, such as recognizing speech, making decisions, and identifying patterns. Machine Learning (ML), a subfield of AI, focuses on the use of data and algorithms to imitate the way humans learn, gradually improving its accuracy. It is the part of AI that studies how computer agents can improve their perception, knowledge, thinking, or actions based on experience or data. In essence, ML is about creating and implementing algorithms that learn from data to make predictions or classifications. These predictions can be generated through supervised learning, where algorithms learn patterns from existing data, or unsupervised learning, where they discover general patterns in data (IBM, 2023).
Augmented, Virtual, and Mixed Realities (AR/VR/MR)	Augmented Reality (AR) enhances audio visualizations of the real world with layers of digital information; Virtual Reality (VR) immerses users in a completely digital environment; and Mixed Reality (MR) blends the real and digital worlds, allowing digital and physical objects to interact in real time. Have been used by businesses to engage customers, improve productivity, and train employees. Different challenges and implications of these technologies have been raised with issues related to privacy, data security, and the digital divide Farshid et al., 2018)
Big Data Analytics	Big Data is an information asset characterized by such a high volume, velocity, and variety that it requires specific technology and analytical methods for its transformation into value. Big Data Analytics (BDA) refers to the process of examining large and varied data sets to uncover hidden patterns, unknown correlations, market trends, customer preferences, and other useful information (Gandomi & Haider, 2015).
Black box problem	A reference to the black boxes, or flight recorder devices in aircrafts that are designed to survive accidents to aid in their investigation. It is used to exemplify the explicability issues of deep learning in artificial intelligence. For instance, children learn to recognize letters or animals by seeing multiple examples. Similarly, deep learning, a form of artificial intelligence, works by being fed correct examples of something it needs to recognize. Over time, it develops a "neural network" to

	categorize things it hasn't seen before. However, just like humans, we don't fully understand how a deep learning system reaches its conclusions. This is because it doesn't keep track of the inputs that informed its decision-making process (Rawashdeh. 2023)
Blockchain	Digital ledger of verified transactions locked together chronologically in an encrypted chain. It is a distributed storage of timestamped documents where no party can tamper with the content of the data or the timestamps without detection (DiPierro, 2017)
Business-to-Business (B2B)	Refers to a form of transaction or commerce that occurs between businesses, such as between a manufacturer and a wholesaler, or a wholesaler and a retailer. It stands in contrast to business-to-consumer (B2C) and business-to-government (B2G) transactions. (Chen, 2023)
Carbon Capture, Usage and Storage (CCUS)	CCUS refers to a suite of technologies that enable the mitigation of carbon dioxide (CO2) emissions from large point sources such as power plants, refineries and other industrial facilities, or the removal of existing CO2 from the atmosphere (LSE, 2018).
Cloud Computing	Model that provides on-demand services over the Internet. Unlike the traditional hosting service, cloud computing services are paid for per usage and may expand or shrink based on demand. Such services are, in general, fully managed by cloud providers that require users only a personal computer and an Internet access (Durao et al., 2014)
Cobots	Collaborative robots are a type of robot designed for direct human-robot interaction within a shared space or where humans and robots are in close proximity. Unlike traditional industrial robots, which are often isolated from human contact, cobots are intended to work alongside humans, sharing the same workspace and completing tasks independently or sequentially. Cobots are equipped with software-controlled sensors that enable them to detect objects, people, and potential collisions. If they detect something unexpected, the software immediately shuts them down, ensuring the safety of their human coworkers. They are generally smaller, have lower power requirements than their larger, autonomous counterparts, and often use collision detection to prevent injury to their human colleagues and other cobots (Wired Workers, 2023).
DALL-E	Publicly available application of Open AI's ChatGPT Plus chatbot product. It generates creative images based on textual descriptions prompted by the user. DALL-E 2 was the version available at the time of interview, December 2022.
Digital Twins	Virtual replicas of physical entities. Can be used to simulate, predict, and optimize the physical counterpart's performance, providing

	opportunities for improvements and innovation. Have been used in the context of urban planning and smart cities, and engineering, to model and simulate many different phenomena (Batty, 2018)
Dropshipping	Retail business model in which the seller accepts customer orders but does not keep stock on hand. Instead, the seller transfers the orders and their shipment details to a third party, such as a manufacturer, wholesaler, or a fulfillment house, which then ships the goods directly to the customer. The seller is responsible for marketing and selling the product, but has limited control over product quality, storage, inventory management, or shipping (Lei & Xue, 2022).
IBM Watson	AI and data platform developed by IBM since 2011 that provides services to businesses using NLP (natural language processing) for human language interface, industries-specific data analysis, customer support, decision-making; building and managing AI models for firms; and API (application programming interfaces, that allow different software to interact with each other) for querying firm-specific documents. (IBM, 2023).
Internet of Things (IoT)	The Internet of Things (IoT) is an emerging paradigm that enables the communication between electronic devices and sensors through the internet. It refers to a network that connects anything with the Internet based on stipulated protocols through information sensing equipment to facilitate information exchange and communication to achieve smart recognitions, positioning, tracking, monitoring, and management (Kumar et al., 2019).
Life Cycle Assessment (LCA)	Method for the environmental assessment of products and services, covering their life cycle from raw material extraction to waste treatment. (Widheden & Ringstroem, 2007)
Mobile Communications and 5G Grids	5G is the fifth generation of mobile networks, providing a high-speed internet facility, 5G networks are cellular networks where the service area is divided into small geographical areas called cells. All 5G wireless devices in a cell communicate by radio waves with a cellular base station via fixed antennas, over frequencies assigned by the base station. The base stations, termed nodes, are connected to switching centers in the telephone network and routers for Internet access by high-bandwidth optical fiber or wireless backhaul connections. The key features of 5G include increased speed and bandwidth, low latency, and the ability to connect a larger number of devices. (Dangi et al., 2021).
Process Industry	The process industry is characterized by operations that add value by mixing, separating, forming, and/or chemical reactions. These processes can be carried out in either batch or continuous mode (Dennis & Meredith, 2000).

Robotics and Automation	Robotics is an interdisciplinary branch of engineering and science that includes electronics engineering, computer science, mechanical engineering, and others. A robot is an electromechanically designed machine, programmable by a computer and capable of carrying out a complex series of actions automatically. A robot accomplishes tasks by moving into the real world. These robots have the intelligent connections of perception to action. Artificial Intelligence must have a central role in Robotics if the connection is to be intelligent. Automation refers to a broad range of technologies designed to reduce human intervention in processes. This is achieved by predetermining decision criteria, subprocess relationships, and related actions, and embodying those predeterminations in machines. The technique involves making an apparatus, a process, or a system operate automatically (Madakam et al., 2019; Rouse, 2021).

Introduction

Governments and societies around the world increasingly debate how to deal with the climate emergency, now an established scientific fact (UNEP, 2021) linked to industrial activity and characterized by more frequent and severe weather events, rising global temperatures and potentially irreversible environmental damage. At the same time, countries pursue socioeconomic development based on industrial policies of innovation and economic growth. increased levels of, and one of the most prevalent versions of these socioeconomic development is the digital transformation of the economy (Vial, 2021). This transformation is characterized by the continuous development and adoption of digital technologies, which can provide significant benefits to public and private organizations and individuals, as the generation of data and data systems enable or improve problem solving through the optimization of material and human resources, and provision of new or increased capabilities and knowledge.

Studying the interaction of these two large-scale transitions of sustainable goals and digitalization is important because digitalization is also now being pursued in high- and lower-income countries due to the expected sustainability gains in the economy without sacrificing economic growth (Beier et al., 2017). Nevertheless, digitalization processes also show evidence of unsustainable outcomes (Seele & Locke, 2017), as seen in the large needs of energy required by data, data-based systems and the computing power behind them. There are other material impacts and social transformations that become obscured as digitalization becomes an integral part of everyday lives. Nevertheless, assessing the full energy and climate effects of digitalization can be challenging (Bremer et al., 2023). This is due to their sustainability benefits of dematerialization and knowledge management, happening alongside the negative impact of increased use of resources and energy in manufacturing and using digital devices and infrastructure, and their impact on waste and carbon emissions that can be cross along many different industries (Chen et al., 2020).

In this context, this thesis sets out to explore how tensions in the interactions between sustainability and digitalization is perceived by professional practitioners who work in industry organizations and business firms specifically dedicated to help adopt the use of digital technologies by other firms in different industries across Norway. This study analyzes the responses given in semi-structured interviews by seven individual managers

and leaders who work in an innovation facilitation capacity, in settings that have an implicit or explicit sustainable orientation. The organizations where these practitioners work at have been encouraged through the direct support of public agencies like Innovation Norway and SIVA (or indirectly through their membership in industrial clusters). These leaders, due to their position, are expected to have an influential role in the adoption of digital technologies in industrial networks in Norway. However, their perspectives regarding these tensions between sustainability and digital technologies have not been sufficiently explored.

How do they perceive these tensions between digital technologies that can help mitigate or exacerbate economic, environmental, and social goals, what barriers do they perceive and where are these tensions located in their view? By collecting their answers to questions about risks, benefits, limitations, and dilemmas in the use of digital technologies in industrial settings, and analyzing them thematically, this thesis aims to explore the perspectives of leading practitioners and relate these findings with the existing literature on sustainability and digital technologies in business firms. Academic research on these types of organizations in Norway has been scarce, even though the country is highly digitized, publicly invested in developing innovation technologies, and grappling with the difficulties of decarbonizing its economy among very high levels of consumption, as will be discussed in the following Background chapter.

This thesis is organized as follows. The first chapter provides the Background for this study, by examining the current relationship between sustainability and digitalization in Norway and providing a brief overview of the institutions and regulations in which industrial digitalization is fomented in the country, and in which the 7 organizations where the facilitators work in, participate. The literature review of the topics of business engagement with sustainability (with a focus on barriers, strategies), digital technologies positive applications, negative impact, and the tensions in their interplay, as well as the role of intermediary organizations, will be discussed in the Literature Review. In the next chapter, I explain the methodology of my thesis, including documentation included in the appendices. The answers of the practitioners have been presented according to a thematic arrangement in Findings, and a discussion of their interpretation and implications against the literature is included in Discussion, including an overview of the limitations of my study. Finally, I elaborate the Conclusions that can be drawn from my research question and aims, based on the answers of the practitioners, in light of the academic debates and the current importance of this topic, including a brief suggestion of future studies.

1. Background

In this Background chapter I provide an overview of the challenges faced by pursuing socioeconomic development and sustainability goals through policy. This is a global perspective but is relevant to the Norwegian setting in which the leaders that I interviewed perform their professional activities. I detail further the specific policy and regulatory setting in Norway, including the industry innovation ecosystem and its programs that concern the organizations and firms where my informants work at.

Global challenges of industrialization policies in a climate emergency

Sustainability is a major topic of concern for governments around the world because of the scientific evidence linking industrialization to the climate crisis, which has moved from speculative theory to established scientific fact (IPCC, 2023) and the demands of impacted individuals and communities (Sivaraman, 2020). However, industrialization and economic growth have been the foundation on which socioeconomic development of countries around the world has been built (Sinding, 2019), so addressing the environmental and social aspects of the climate emergency requires different approaches to industrialization.

These difficulties are present in the way in which countries around the world use policy to both try to encourage industrialization and economic growth, while trying to mitigate or reduce social and environmental impact. For example, this can be seen in one of the major frameworks for articulating public policies that have been adopted worldwide, such as the 17 United Nation's Sustainable Development Goals, or SDGs (United Nations, 2015). The eight SDG is focused on pursuing economic growth while providing socioeconomic development that includes decent work for everyone. The UN itself recognizes that achieving this goal is challenging because it would require a comprehensive reform of the industrial and financial systems to tackle debt, economic uncertainty, and trade tensions, while promoting equitable pay and decent work for young people (United Nations, 2023). A critical challenge for policies that try to achieve aims like SDG 8 is the difficulty for any country to craft the right incentives that spur job creation (and adapt the current ones) in greening industrial sectors, by cultivating country-wide innovation systems and invest in sustainable industries, all at the same time (BS, 2019). Among the many social and economic changes needed to achieve this, public and private investments in creating and

developing technological innovations that help us reach decarbonization is considered fundamental (Georgieva & Adrian, 2022), including a focus on digital technologies and digitalization (Tsakalidis et al., 2020) due to the significant benefits they provide in terms of resource optimization in business (the use of inputs of information, material, human resources), that produce similar or better outcomes than previously available (Belli et al., 2020).

Tackling these urgent environmental issues in a way that is fair and inclusive to individuals and communities around the world is referred in policy circles as a green and just transition (ILO, 2021). Digitalization is another major transformation currently aimed for in societies and economies worldwide. The European Union's Joint Research Centre referred to this simultaneous objective as the twin transition (JRC, 2022), a double shift in which both trends ideally reinforce each other. This conceptualization links more closely together digitalization and sustainability policies that had been articulated separately and that are expected to take place for the most part in industrial setting. Aimed at the European Union's Single Market (to which Norway belongs through its membership in the European Economic Area), the most important cross-cutting sustainability policy has been the European Commission's so-called Green Deal, launched in 2019, which aims to have zero emissions of greenhouse gases by 2050, to accelerate the green transition, and which includes provisions for industrial policy, such as focused targets on incentivizing circular economies, eco-design, and digitalization (EC, 2023). Specifically geared towards digitalizing manufacturing industries and including them into the green shift policies is the concept of Industry 5.0 (Li et al., 2020), meant to have a stronger human-centric orientation, better adaptability, and a greater emphasis on achieving sustainable development (Alojaiman, 2023) by complementing the Industry 4.0 approach by reframing research and innovation (R&I) around a sustainable and resilient industry where humans are at the center (DGRI, 2023). This is in comparison to the previous iteration, or 4.0, that had been promoted for almost a decade, in which the benefits of a so-called fourth industrial revolution characterized by digitalization, would more deeply integrate digital technologies such as the internet of things (IoT), cloud services, and artificial intelligence (AI) into "smart," manufacturing processes for improved productivity (Davies, 2015), and the approach was aimed at creating policy tools to incentivize private investments in digitalization because of the significant transformation in how businesses produce,

innovate, and offer their goods, leading to increased efficiency and productivity (Vaidya et al., 2018).

Public policy researchers refer to the policy instruments developed with a specific goal as mission-oriented innovation policies (MOIPs). These are combinations of policy and regulation designed to strategically steer the science, technology, and innovation activities of public and private actors towards objectives related to a social challenge in a given timeframe, while coordinating the rules and complementing the execution with additional instruments (Larrue 2021). A prominent example of a MOIP is the European Union's Horizon Program (in which Norway participates), currently the world's largest R&I program (RCN, 2023). It uses missions-oriented R&I assignments that target societal challenges and enabling technologies, such as funding R&I for developing microbiome and food products and processes to improve the quality, quantity and safety of food across multiple food chains; or developing a framework for intelligent and interoperable building management in which energy distributors, providers and end users participate, allowing for end users that produce energy to use their assets and modify their consumption (ECIEEA, 2018). Mazzucato (2018), however, says that MOIPs are lofty and need specific toolkits for market co-creating, shaping, and fixing, in particular about creating institutional and organizational capacities through strategic deliberation.

Norway in the context of sustainability and digitalization

Norway has also been impacted by the climate emergency, as the country experiences annual increases in mean temperature and precipitation, summer droughts, rainfall floods, and sea-level rise (WBCCKP, 2023). Nevertheless, according to the United Nation's Sustainable Development Goals (SDGs) Index, Norway also ranks 6th among all countries that measure their own performance in achieving its socioeconomic sustainability goals, with strong results in social aspects like poverty reduction, health, education, and equality. (UNDESA, 2022). Norway also has important advantages like its abundant hydropower that aid in achieving its climate targets, and it has achieved significant milestones in decarbonization, such as leading the world in electric vehicles adoption (Figenbaum, 2020).

Another facet of its high socioeconomic development levels is the depth of digitalization in the country. Norwegian economy and society are among the most digital in Europe, according to the European Commission's Digital Economy and Society Index (EC, 2022),

which measures this in terms of broadband connectivity, internet use, business digitization, and digital public services. The industrial innovation public agencies in the country prioritize the development and adoption of digital technologies because it considers them enabling technologies for further technological and sustainable development (IN, 2023).

Such high levels of socioeconomic development among its population also take place in a country that among European countries' households has the second-highest levels of general consumption (SSB, 2023), including the highest level in electronic waste (Forti et al., 2020) and it is estimated that these figures, which only considers close to half of the actual consumption impact on global carbon emissions (Steen-Olsen et al., 2018) because they are based only on the visible impact within its own borders, but leave out emissions that happen elsewhere in the global value chains. If we consider these figures alongside Norway being among the largest exporters of oil in the world (ITA, 2022), the challenges of a comprehensive decarbonization may seem steeper.

Norwegian policy and regulation

The Norwegian government identified two decades ago that to maintain their high-level of socioeconomic development while moving away from oil-and-gas revenues, the value of non-carbonized industries needed to double (NMTI, 2002). It has also adopted mission-driven initiatives in its industrial policies. The backdrop has been the incorporation of the United Nations' Sustainable Development Goals (SDGs) into the national policy framework, which started in 2016 and was formalized as a supra-political guide by 2021 (NMCE, 2021). In that year, Norway approved its Climate Action Plan 2021-2030 to meet climate targets[1] under the Paris Agreement while promoting green economic growth (NMCE, 2020). Large components of the action plan are gradual increases in targeted greenhouse taxes. It also creates targets for public funding of R&I of 1% of the gross domestic product (GDP).

In terms of industrial policy, the government has published a Green Industrial Initiative Roadmap, in which it states that "the industry must lead the way through heavy investments in areas they believe are or will be commercially profitable." (NMTI, 2022, p. 62), while it also mentions the importance of fostering "knowledge environments" to contribute to the

[1] to reduce emissions by at least 50% compared to 1990 levels; and to at least 55% in the 2022 adjustment.

development of technology and knowledge that "can cut through emissions and increase profitability, and willingness to invest in green value chains." Closely related to this, in terms of digitalization, the government published a 2021 white paper on the data-driven economy and innovation which emphasizes data as a crucial resource for the country and aims to leverage specific drivers such as cloud services, sensor technology and Internet-of-Things (IoT), big data analytics, artificial intelligence, and high-performance computing to make business and industry more competitive domestically and abroad (NMLG, 2021), but it is not explicitly articulated around sustainability goals.

While these different policies may be closely related, they have not been developed in an articulated way that prioritizes sustainability goals. A major challenge to the effectiveness of MOIPs (Mazzucato, 2018), is being coherent with other policies and well-designed to address a country's sustainability challenges. In the case of Norway, Larrue (2021) highlights the need for better coordination between different policy areas and levels of government, as well as the importance of involving a wide range of stakeholders in the policy process. Flanagan et al. (2023) argue that a problem-oriented regional industrial policy could help address these challenges by fostering public intervention in framing, valuation, and market formation. This approach could enhance the effectiveness of MOIPs in promoting sustainable transitions and addressing the complex challenges faced by Norway and other countries.

In addition to policies, there are several regulatory instruments in the country that are aimed at driving sustainable behavior in business firms, and to set guidelines to appropriate use of digital tools as well. Many are industry specific (for example in the use of plastics, or conducting activities in the Arctic), but the two most important sustainability regulations (which have also been referred to by interviewees in this thesis are the Transparency Act and the EU Taxonomy. The Transparency act (went into effect in 2022), requiring larger companies to carry out due diligence (monitor and control) of the actual and potential sustainable and ethical impact in their value chains (their own operations, and their business partners), including human rights and working conditions, and mandating annual reports of these assessments, which will be supervised by the Norwegian Consumer Authority (Moen, 2022). The EU Taxonomy (implemented into law in Norway early 2023, with reporting obligations in early 2024), was incorporated in Norway because of its participation in the

European single market and creates stricter rules for companies in any industry to document their sustainability actions in order to access funds from financial markets. Firms that satisfy these rules receive better terms and conditions for loans. The taxonomy refers to the framework created by the EU to identify "green" and potentially green activities in 13 major industries, and includes standards for reporting impact (Moen, 2023). The EU Taxonomy is expected to impact Norwegian firms across industries significantly, including the energy sources definitions that affect gas and hydropower (ICLG, 2022). The Norwegian government has also signaled willingness to engage in mechanisms that involve carbon accounting beyond borders, such as the carbon border adjustment mechanism (CBAM), but has expressed concern that addressing carbon leakage may put local actors at a disadvantage if international parties do not agree on the most appropriate systems for this (NMF, 2021).

Two major regulations that affect digital technologies also originated in European law are the General Data Protection Regulation (GDPR), aimed at giving people more control over their personal data and regulating business obligations about this (NDPA, 2018); and the AI Act, agreed in Europe at the end of 2023, which stipulates how artificial intelligence can be used in different applications and classified depending on the risk they pose to users (more risk, more restrictions), with the goal of setting boundaries for how it can be used beneficially in healthcare, transportation, manufacturing and energy, among other uses (EP, 2023). Other recent regulations that affect digitalization and are focused on protecting consumers are the Norwegian Act Relating to Digital Consumer Purchases and the Digital Content and Services Act, both enacted in 2023 (ICLG, 2023).

This policy and regulatory backdrop informs the use of public funds to incentivize industrial digitalization for sustainable purposes through programs such as the Norwegian Innovation Clusters (examined in the following section), which have financed the industry clusters where the facilitators I interviewed for this thesis work, or to which their organizations and business firms belong to.

The Norwegian innovation ecosystem

While individual start-ups and entrepreneurs may innovate by themselves, public policy that is designed to support industrial innovation tends to favor the creation or the strengthening of systems where the interaction between academia, industries and

government takes place, because it is in these interactions where new knowledge is created or disseminated (Kivimaa et al., 2018). The Norwegian industrial innovation ecosystem comprises many different organizations that are linked through their R&I and production activities. This is a complex network of public and private stakeholders, including public universities, research centers, government agencies, public-private initiatives, private start-up accelerators, venture capitalists, industrial clusters, and business firms, among others, that through their linked activities, involving different stages of R&I, from design to implementation, develop the industrial capabilities of the country (Granstrand & Holgersson, 2020).

The private sector in this ecosystem includes organizations that have an R&I focus, as well as other organizations that may not focus on open-innovation practices (the use and promotion of external and internal ideas in business) among their clients as main activity (D'Silva, 2022), but that collaborate with other actors in this system. An example of this are the firms who employ two leaders who were interviewed for this study, one a consultancy, and another an in-house developer, that are business-to-business digital services providers.

The public sector in Norway dedicated to innovation includes different ministries and their portfolios, but has three main agencies that have an active, dedicated role of advancing these topics: Innovation Norway (IN), the Research Council of Norway (RNC), and the Industrial Development Corporation of Norway (SIVA). The RNC manages research funding from all the Norwegian ministries and allocates funds to basic and applied research and innovation within all fields and disciplines, SIVA aims to develop the national infrastructure for innovation (such as incubators and accelerators, business parks, innovation centers, real estate companies), and Innovation Norway is tasked with assisting Norwegian businesses to grow and find new markets by providing competence, advisory, promotion, and network services (Eurofound, 2022). IN provides direct support for individual companies' projects year-round or according to periodic calls, and this includes the development of industry clusters. In 2022, it allocated more than NOK 7 billion in loans and grants to Norwegian companies and cluster projects, with two thirds of these disbursements going to projects related to the circular economy, bioeconomy, clean energy, and energy storage (IN, 2023). Among the beneficiaries were industry cluster development projects, concerning directly as clusters, or indirectly as members, the firms and organizations where the facilitators interviewed for this study work at.

SIVA started financing in 2017 the Norwegian catapult test arenas (Norsk Katapult), which are facilities for testing and validation services for innovative technologies and solutions, helping companies to accelerate their development and market entry. They are intended to strengthen the national infrastructure for innovation, thus contributing to faster, cheaper, better development of ideas from the conceptual stage to market introduction. These centers are pilot plants where companies can test, simulate, and visualize technologies, components, products, solutions, and processes (SIVA, 2023). SIVA requires public applicants who want to start a catapult to already have a strong connection to business environments (established venues to meet, collaborate, share expertise, for at least a dozen firms), and the capacity and ability to develop a center as pilot plants. One of the programs' aims is to develop this infrastructure country-wide, including rural areas. The policy logic behind financing these centers is similar to the financial support given by IN's programs, in that they are intended to develop capacities for international competition among Norwegian business firms that tend to be small or medium enterprises and otherwise would be hard pressed to do on their own, due to the size of the Norwegian population and spread along a large geographical area. Academic research on the role of intermediary organizations for innovation suggests that accessing specialized loans and grants is critical for firms to develop "eco-innovations," as well as sustainable business models, so they can survive market pressures in the development stages (Kant & Kanda, 2019). One of the facilitators interviewed for this study is a leader of a catapult.

Innovation Norway (IN) defines the mission of its services as the facilitation of green conversion and sustainable development in companies, so that the country can have an export-oriented business life. Its website explains that Norway's goal of becoming a low-emissions country by 2050 requires a major restructuring of the entire society, and one of the keys for this green shift is innovation and technology development (IN, 2023 FIX). Some examples of projects for which they give grants are: developing, piloting and demonstrating environmental technologies; increasing the value creation based on bioresources (from the sea, soil and forest); holistic and circular value chains at the municipal level; loans for "capital-intensive" establishments of circular production processes; smart transport solutions (efficient, environmentally friendly, safe) for technologies, services or business models; investments in climate measures for agriculture, forestry and aquacultural industries (IN, 2023b). Across the board, the agency makes constant reference to digital technologies support because they are enabling technologies

that have great diffusion potential and contribute to innovations across industries, with examples in ICT, biotechnology, and materials technology which can also realize a low-emission economy with solutions in most areas of society, including food production, energy efficiency, transport and better health and care services (IN, 2023b).

One of its central programs is Norwegian Innovation Clusters, NICs (Klyngeprogrammet), which concerns directly four of the seven (and indirectly the other three), leaders interviewed for this study. This program aims to cultivate non-profit industrial clusters under the logic that these organizations provide the necessary capacity-building elements for a wide array of private firms, in this case with an enabling technology focus that is oriented towards green industrial transformation. The program includes partial funding for these clusters to develop and be sustained as organizations, and has several modalities depending on the maturity of the cluster and previous support. The program has been independently evaluated in 2017 (in English), and found to be successful in terms of industrial competitiveness and economic growth goals (Rybalka et al., 2017). However, as far as I know, the program has not been evaluated in English for its impact on the government's sustainability goals. The NIC program can be considered a type of MOIP initiative, that incentivizes private innovation with a mission mandate.

In the literature review chapter, I discuss the relevance of industrial cluster organizations for brokering knowledge and disseminating innovations that relate to sustainability, because they bring together a wide number of public and private actors as members and socialize among them and other industry players the latest innovations, as well as other specific services that few stakeholders also provide at a systemic level. All the organizations where the facilitators interviewed work at are also directly involved with digital technology or digitalization adoption, as described in Chapter 3.

The structural setting is obviously not the only determinant for sustainable behavior. Each of these stakeholders has different knowledge bases of the complex interactions of digitalization and sustainability, that both informs and incentivizes their behavior depending on their position in their systems, the structural barriers they face, and the motivations they have to create and deploy digital technologies to pursue their economic, social or environmental goals. The complexity of the interactions between sustainability and digitalization, can be made even more complex by the enabling characteristics of digital

technologies themselves. These topics will be examined through a literature review in the following chapter.

2. Literature Review

In this chapter I provide an overview of the different strands of academic literature that are relevant for my study. This follows the Background that situated the policy and regulatory setting in which the organizations and firms (where the interviewees of my research work at) exist and engage with other industry firms. In the first part, I will discuss and aim to synthetize the different (and at times opposing) scholarly views about how firms engage with sustainability, especially from the perspective of barriers to sustainable practice, drivers, and the strategies used by firms to overcome these barriers. In the second part I will do the same for digital technologies and digitalization, moving along from an initial definition and overview of positive applications for sustainability, then an overview of what has been discussed of negative social and environmental impact of these technologies, and a special focus on artificial intelligence. The third section will discuss how academic debates consider the tension, or perhaps unresolved balance, of these two aspects of positive and negative impacts, and this will include the relationship of these technologies to positive discursive framings, consumption and production patterns, the alignment of values and purpose of technology, and the difficulty of defining sustainability. That topic in turn leads to the final section discussing how intermediary organizations perform roles in innovation ecosystems that can help overcome some of the barriers related to alignment and meaning.

1. Business engagement with sustainability

There are many different ways of discussing how business firms engage with sustainability. While the obvious conflict between mostly pursuing economic profits and the environmental and social impact of doing so is a long-standing tension at the center of business firms engagement with sustainability, different academic fields have approached this issue to understand the complexities that interact to hinder the sustainable performance of private companies (Schaltegger et al., 2013). Businesses face many barriers to becoming more sustainable, including technological limitations, regulatory constraints, market pressures, and cultural factors. Overcoming these barriers often requires significant investment and a long-term perspective (Neri et al., 2018). Discussing these in detail is not within the scope of this thesis, but as these barriers are closely linked to the challenges of using digital technologies for sustainability purposes, they will be briefly mentioned.

Barriers to sustainable practice

The complexity of barriers to sustainable practice goes beyond profit maximization, and are linked to knowledge and awareness of sustainable impact, and attitudes towards it (Hariyani et al., 2022); resistance to change and transforming habits and lifestyles or being reluctant to share information and cooperate with their peers (Mouchrek 2022); as well as insufficient technical expertise (Durmaz & Budak, 2022); or lack of access to technological, material or processes even when they have the knowledge (Menon & Ravi, 2021); social norms and cognitive aspects of business managers and employees (Yuriev et al., 2018); as do the constraints of regulation, lack of incentives, policy distortion, and lack of external support (Neri et al., 2021); the costs of adapting business models and infrastructure to include sustainability goals (Rizos, 2016); to organizational or structural dynamics within a firm (Trianni et al., 2015); and there are specific barriers to each of the business functions or processes involved (process/production, product itself, supply chains, value proposition), as well as the specific industries hyper specific areas of practice where they operate and where they can implement sustainability practices (Souza et al. 2015).

Other authors point out to the particularities of geographies or supply chains, and their normative and regulatory environment (Giuffrida & Mangiaracina, 2020) as well as the domestic, and international market competition pressures, which can make sustainability performance costly for firms (Hadjimanolis, 2019), who in turn face demands from the consumer side not only to provide sustainable options but to provide value propositions in terms of convenience and cost too (Meyer, 2023; Nilsson et al., 2015; La Rosa & Jorgensen, 2021). Besides the expectations of consumers are the expectations of financial backers which can have their own normative, regulatory, or financial incentives to encourage sustainability or not (Wang et al., 2021).

Rather than tensions being only located in either of the three dimensions (economic, environmental, social) of sustainability (Ozane et al., 2017), Hahn et al. (2015) have argued that this is a matter of time and space, where leaders who must choose between economic and sustainability trade-offs, face complexities at different levels in the corporations and their environments, and throughout the process of becoming more sustainable. Hahn et al. (2017) have further developed the framework under the concept of paradox thinking for understanding how corporations and their leaders use different aspects of sustainability to make decisions, and while these may be described in terms of the three dimensions commonly known, deciding to behave sustainably can be both instrumental and normative

functions for their organizations. Wannags & Gold (2020) expand on this topic by examining the incongruence between desires for sustainable consumption and actual unsustainable behavior in specific examples, as well as the tensions related to legitimacy incongruences in different cultural or geographical contexts that clash in business relationships (for example, between suppliers and customers in different countries with diverging notions of what is acceptable within their respective sustainable norms). This can also help understand why business firms may engage in greenwashing, by presenting green credentials in their use of voluntary standards and certifications, that may not conform with their actual performance, while other firms, regulators, and increasingly consumers, understand that these are signaling activities to increase reputation (Zerbini, 2017).

This complexity goes beyond the, perhaps most obvious, forces of market pressures, regulation, and the normative expectations of being more sustainable. Different kinds of drivers have also been identified in the literature such as regulatory requirements, market demand for sustainable products and services, cost savings from efficiency improvements, and the desire to enhance corporate reputation (Neri et al., 2021). Other authors have pointed out to governance systems of the industries where firms participate as barriers when they create uncertainties (George et al 2016).

Regulations seem to play a crucial role to shift the practice of Industries with high environmental and social impact, such as oil and gas, mining, agriculture, and manufacturing (Ahmad et al., 2017; Ivic et al., 2021; Seth et al., 2018). These industries face significant challenges in becoming more sustainable due to their reliance on non-renewable resources, their environmental footprint, and their social impact. This includes even their digitalization efforts, to the point that some business interest groups push for regulation to develop improved mechanisms to import electronic waste, such as material data banks, so that the rare minerals in them can be recovered as they are becoming increasingly hard to source across supply chains (IKT-Norge, 2022). Having adequate regulation and reporting tools is also a driver, but this is closely related to having the internal capabilities for knowing what and how to report (Boiral et al., 2019)

Kiefer et al (2019) describe the multiple interactions as a dynamic of internal (resources, competences, and capabilities) and external factors (e.g., regulation, norms) when deciding about eco-innovating, and that in order for innovations to be “eco-innovations” they need to have a systemic and radical impact (not only marginal improvements). They point out to

research of multiple cases where the most important drivers seem to be: physical RCCs, involvement in green supply chains, an eco-innovation friendly corporate culture, technology-push and market-pull, and internal financing resources. However, they characterize as barriers mechanisms of cooperation, organizational learning, ecological certifications, and technological path dependency. The cooperation and learning are barriers in terms of the cost they imply to firms. As will be mentioned further, organizations that cultivate open-innovation among clusters are meant to reduce these barriers.

Strategies for sustainable business practice

Strategies for industrial sustainability that firms can adopt usually include adopting sustainable business models, investing in green technologies, improving efficiency, and engaging with stakeholders to understand and respond to their sustainability concerns (Despeisse et al., 2013). Many different frameworks have been developed to incorporate sustainability in business strategy. One of the oldest is the Triple Bottom Line, long ago developed by Elkington (1993), but which has seen different adaptations and survives to this day perhaps due to the flexible articulation of strategies around the three dimensions, in this case the three P's of profit, people, and planet (Joyce et al., 2015), where firms should commit to goals in terms of people and planet the same way they do with financial performance. However, when studying actual implementation of TBL throughout companies that claim to follow sustainable manufacturing principles, some authors have found the commitments to be very unbalanced, and the social dimension is usually the least operationalized. (Yip et al., 2023). A different three-dimensional model is Schaltegger's Business Models for Sustainability (2016), where sustainability is measured as the value created for all stakeholders (not only shareholders) that have contact with the value proposition of a business, its infrastructure, and at the customer interface.

Geissdoerfer et al. (2018) have defined sustainable business models as those that pay attention and include sustainable value creation, pro-active stakeholder management, and a long-term perspective. But given the vague notions behind this, a new configuration has been labeled business models for sustainability (BMFS) where there is an explicit consideration, jointly, of economic with social and or ecological value contributions. Their research on case studies of BMFS implementation find that three choices have to be present

for value creation (with limitations) to happen under this definition: wanting to address multiple purposes, behavioral consistency, and collaboration.

Environmental, Social and Governance (ESG), is one of the most common frameworks used to integrate sustainability metrics (social and environmental) with corporate governance (finances, audits, internal controls) into an operational concept of performance that (usually investors) can use as a standard. But this has been developed mostly from the side of financial markets in terms of decision-making and investment, such as risk of firms and industries. Nevertheless, scholars have also focused on diverse aspects of the use of this framework, from corporate responsibility, to disclosure or financing, without there being consensus of exact methodologies (Clement et al., 2023). Cort & Esty (2020) find that ESG data presents challenges at every stage of collection, aggregation, and validation; and that investors themselves require data systems to provide trustworthy metrics of material and environmental impact of business firms.

From the side of policy, two major paradigms have been promoted, as they articulate economic growth with practices that mitigate or reduce the environmental and social impact seen in detrimental extractive processes and waste management across productive chains: the circular economy (CE) and sustainable supply chain management. The latter concept sometimes is included within CE (Hazen et al., 2021) with the goal of reconfiguring core supply chain management processes to implement CE successfully. Circular economy models have been increasingly studied in theory and practice, especially in manufacturing processes, and there are many variations of them, all based on the principles of minimizing waste and making the most of resource inputs. This contrasts with traditional linear economies, which has a 'take, make, dispose' model of production. CE relies on reconceptualizing material and energy loops from the beginning of design stages so the whole industrial ecosystem (the firms, the supply and value chains, the regulatory frameworks) adapts to the five principles of CE which are closing, slowing, intensifying, narrowing, and dematerializing (Hazen et al., 2021).

This includes everything from product design and material sourcing to delivery and end-of-life management, which are not all functions where businesses can have sufficient levels of knowledge or dedicate the same level of attention. Multiple definitions and understanding of sustainability are also present in the practice of these models. Kirchherr et al. (2023) have found more than 200 definitions in use, and Hou et al. (2022), surveying

dozens of firms who self-identify as implementers of this model, found that almost every supply chain studied had a very different idea of sustainability, and these studies found that, typically, social impacts are the least integrated and measured. De Jesus and Mendonca (2018) theorize that the difficulty of defining CE is also due to the diverse areas it covers: sustainable production-consumption systems; closed-loop supply chains, and product-service systems. They also say that the methodologies for actually delivering circular economies are very blurred and uncertain. They explain that this has been usually defined through the concept of eco-innovations (EI), one closely linked to CE, as it is a particular pathway for increasing efficiency and competitiveness that also has positive environmental and social impacts, which can help move systems towards CE.

CE models, which are mainly technology-focused, have sometimes been also criticized as being superficial because, just as companies may do with voluntary standards, their implementation is cherry-picked, and does not fully account for firms' sustainable impact or reflect their true potential for changing practice, which is closely linked to the diversity of criteria in assigning values and understanding the implications of these principles in the design, implementation, and evaluation of these circularities (Velenturf et al 2021). Nevertheless, changes in production modalities and market dynamics that provide efficiencies with environmental and social benefits have been developed and experimented. Several studies have focused this on processes in manufacturing, such as refurbishing used goods, or focusing production on modular components; or in business models, such as leasing or locating operations closer to sources (Hermundsdottir and Aspelund 2022; Roy and Singh 2017), with multiple iterations (see Appendix B).

Among the barriers that prevent adopting circular economy practices (not only sustainable behavior), different studies have pointed out to the resistance in changing behavior: Kirchherr et al. (2018) in a large study of EU companies and experts, found that core barriers are cultural (lack of consumer interest and awareness, and a hesitant company culture), and Ranta et al. (2018) examining barriers to circularity in different countries around the world, categorize them as regulative, normative and cultural-cognitive institutional barriers.

Some industries have longer histories of having developed detailed measuring and accounting indicators to facilitate the reporting of environmental and social impact (and corresponding standards), and in turn to facilitate the implementation of practices that

facilitate circularity. These sustainability key performance indicators (KPIs) can take into account the results of systematic methodologies like the Life Cycle Assessment (LCA) of goods and services that aim to measure impact from "cradle to grave" (Widheden & Ringstroem, 2007), and can be quite specialized within industries, or even tuned for CE models so that goods and services are designed with "cradle to cradle" principles in mind (McDonough, 2010). However, other authors have criticized the utility of these methodologies in practice, and suggested they are mostly catchy sounding vision articulations (Bakker et al., 2010; Toxopeus et al., 2015), which may not be good enough tools for decision-making (Lazarevic, 2018).

Other authors criticize CE and related accounting tools as being the result of financialization of values (including social and environmental), which reflects on the purpose of reporting initiatives that have left out moral components and created a narrative of business strategy that objectifies social and environmental issues (Van Bomel et al., 2023), or that tries to depoliticize sustainable growth under unclear technical grounds (Corvellec et al., 2022). The criticisms of LCA tools have also focused on their limitations regarding social impact (Gutowski, 2018), including in the variations of LCA that are designed for such assessments (Venkatesh, 2019), and this is in part due, according to Weidema et al. (2018), to how these tools depend on defining systems on the basis of attribution of impact, or on the basis of consequences of impact, without justifying their modelling choices. They say that value chain assessments provide a convenient way of demarcating full responsibility of business firms, because it assigns responsibility of predecessors, but separates actual consequences of decisionmakers.

Looking at the difficulties firms have in implementing specific measuring tools already, it would not surprising then that research on how business firms operationalize large scale policy frameworks find these even more challenging to actualize and prone to greenwashing. Heras Saizarbitoria et al. (2022) conducted a large-scale study of more than a thousand organizations, operating in almost a hundred countries, that self-report on SDG performance, and found that engagement is superficial for the vast majority of them, as they cherry-pick their goals and results.

Given the complexity of interactions in drivers and barriers to sustainable practice and frameworks, some authors point out that another way of looking at these is through the lens of the challenges of metrics. This includes the measuring and accounting impact reflected

in the multiplicity, or lack of clarity, of metrics, insufficient knowledge about these issues, inadequate technical capacity to measure, complexity of stakeholders' expectations, and how these issues in turn are contained in having inadequate reporting frameworks, confusion in understanding these frameworks, and a lack of appropriate accountability systems (Álvarez Jaramillo et al., 2019; Mangal, 2022).

In this context, businesses may find different sustainable benefits of adopting digital technologies due to the measuring and accounting improvements they provide (George & Schillebeeckx, 2022), turning them into decision-making tools and capacity enablers, as well as the optimizations in resource efficiency (all of which may lower the different barriers they specifically face). These gains may be secondary, or supplementary, to the profit gains that drive their digitalization processes (Brenner & Hartl, 2021).

2. Digital technology and digitalization for sustainability

Definitions and purpose of digital technologies and digitalization

Data and data-based systems, digital technologies, and digitalization have had a significant impact on businesses and economies. There are many contemporary definitions of digital technologies but they can be broadly defined as a wide range of tools, services, and applications that facilitate electronic services or activities to create, store, process, transmit, and display information (Rice, 2003). They digitize information and knowledge, modernize information networks, drive productivity growth and are used for optimizing economic structures for efficiency (Zhang et al., 2022).

Digitalization is the process of integrating these digital technologies into various facets of business, economy, and society, creating digital artifacts or devices, and becoming embedded in the social and institutional processes they modify (Gradillas et al., 2023; Calderon-Monge & Ribeiro-Soriano, 2023). These technologies are also frequently characterized as enabling technologies, because they significantly facilitate, improve, or transform other existing processes and technologies, or make new ones possible, thus creating opportunities across diverse industries (Han et al., 2023). Digitalization, particularly through IoT and Big Data, enables businesses to develop new market and consumer insights and reengineer business processes, products, and services (Sestino et al., 2020). Digital technologies are sought after in business because they optimize productive activities, increase knowledge and analytical capabilities, and improve the definition,

prediction, and solving of problems, or improve performance and impact monitoring (Ha 2022; Liu et al., 2023; Haleem et al., 2022; Kalischko & Riedl, 2021). Riso & Morrone (2023) say that because of this ability to measure and account for various aspects of business operations in improved ways, they can accelerate their own benefits by further providing more accurate and efficient data collection, processing, and analysis, and leading to better decision-making and performance evaluation. It plays a significant role in the economic performance of firms, but also in countries' economies at large, though their impact may vary depending on a country's level of socioeconomic development that may facilitate their adoption (Zhang et al., 2022).

Digitalizing processes creates new points of data and insights from data that was previously unstructured and inaccessible, and this provides better conceptualizations, measurements, and models for advanced problem-solving and prediction (Ha, 2022). In turn, Ha says, digitalization can lead to improvements in resource efficiency, particularly when the digital transformation process reaches a certain level that allows a firm to use new and more intelligent ways to develop products and services, or even manufacturing processes By optimizing resource efficiency, digitalizing processes can produce dematerialization, which refers to the reduction in the quantity of materials needed to serve economic functions. Digital technologies have facilitated the shift from physical to digital forms in various sectors, thereby reducing material consumption and waste. Nevertheless, there is debate about the net effects in terms of dematerialization (Santarius et al., 2020), as will be discussed further.

Digitalization is no longer just a strategic advantage for firms' market competition, it has become a requirement in many aspects of business due to its prevalence and how it allows firms to create and capture value in improved ways (Nambisian et al., 2019). The optimization benefits brought by digitalizing business functions allows to capture economic value that otherwise would have been inaccessible outside digitalization, so pursuing it is a major driver for business firms (Kohtamäki et al., 2020). Digital technologies are applied across many industries at different rates, from finance, medicine, education, and public administration, to processing, maritime, and heavy manufacturing, simplifying and accelerating work processes, increasing the need for skilled work, and creating value in goods and services (Kutsuri et al., 2019; Saritha et al., 2023). These technologies are not only the technologies themselves, but also the platforms that use digital information (in the

form of data points and associated data-based systems), and some of the most prominent[2] for their use in industrial settings include: artificial intelligence and machine learning (AI/ML), cloud computing, internet of things (IoT), big data analytics, 5G and mobile technologies, robotics and automation, virtual and augmented reality, digital twins, and blockchains (Tulinayo et al., 2018).

Positive applications for sustainability

The benefits of digitalization have been studied in terms of how they optimize the measuring and accounting of sustainability indicators (Mondéjar et al., 2021), as well as creating or improving the systems used for managing this knowledge (Di Vaio et al., 2021), while providing new ways of characterizing impact. Many studies focus their attention on dematerialization (less impact on extraction and waste) effects of specific components of value chains that can be framed as conducive to circular economies (Massari et al., 2023). Another facet related to human and social impact has been the development of academic fields around design thinking (Wang, 2022), inclusion in engineering and industrial design (Beddoes, 2023), or human-machine interactions (Krupitzer et al., 2020), though these academic and industrial developments may have co-evolved and not originated within sustainability studies.

The use of digitalization for environmental or social goals has been studied in specific settings, such as their use for better accessibility and flexibility of public healthcare (Senbejov et al., 2020), improved biodiversity monitoring (Pimm et al., 2015; Stephenson, 2020); agro-food systems efficiencies (Cook et al., 2022), or for optimizing energy grids management for security and efficiency (Giannakis et al., 2013). Sustainable applications of specific digital technologies can be found in the use of digital twins, which have reduced significantly the cost of R&D of manufacturing by fully virtualizing, or dematerializing specific aspects of otherwise very expensive, carbon footprint intensive experiments in materials engineering (Wagg & Worden, 2020) or inducing circular economic practices in the built environment (Crespi et al., 2023); the use of Internet-of-Things (IoT) infrastructure, such as sensors, to monitor biodiversity information in real-time, enhancing the protection of natural ecosystems (Gallacher, et al., 2021); or the use of augmented and virtual realities for expanding access to specialized healthcare, for example in the performance of remote surgeries (Desselle et al., 2020).

[2] an extended definition is included in the glossary

Some case studies have focused on sustainability benefits of digitalizing very polluting or resource-intensive industries. These include reducing human and environmental risks of oil and gas operations (Al-Rbeawi, 2023), electrification and management of urban transportation systems (Frost et al., 2019), the use of blockchain technologies for impact assessment in the construction industry (Figuereido et al., 2022) or for impact accounting in fashion supply chains (Caldarelli et al., 2021), digital twins for improved design and significant reduction of waste in manufacturing (Miehe et al., 2021), and data analytics and modeling for improved agricultural use of land (Clapp & Ruder, 2020). Other cases include the use of remote sensing and monitoring in biodiversity conservation (Stephenson, 2020), or improved water provision services in cities (Stein et al., 2023).

Other studies have focused on the indirect sustainability benefits of digitalization. For example, in the proposals for Digital Product Passport tools in Europe which would compile manufacturers' data on products to facilitate circular economy by overcoming knowledge gaps in value chains (Adisorn et al., 2021); or the benefits of modular and additive (also known as 3D printing) types of manufacturing in terms of resource extraction compared with traditional industrial practices (Sturgeon, 2021). Even more, other studies have focused on sustainability knowledge management gains in firms as seen through: increased competency for integrating environmental management (Wang, 2015), Increased awareness and knowledge of such impact in managers (Ojo & Fauzi, 2020), improvement to the quality of environmental audits and their standards (Paton Romero et al., 2021), the use of blockchain contracts that can facilitate carbon credit and emission trading among firms (Howson, 2019), the use of blockchain for reducing consumption in IoT enabled networks (Sharma et al., 2020), communication technologies adoption to enhance distance work and reduce transportation emissions (Galanti et al., 2021), or using AI for better decision-making about safety and environment risks in environmental governance systems (Nishant et al., 2020).

In their scoping review, Beier et al. (2020) categorized the research on digitalization for sustainability within the Industry 4.0 policy paradigm into four groups: human benefits, technological benefits, organizational benefits, and other overarching features. However, they noted that advancements in these categories do not necessarily translate into significant improvements in sustainability under the Industry 4.0 paradigm. While digital systems are expected to enhance due diligence, most studies have focused on the benefits these systems provide to corporations in assessing the financial risk of mergers and

acquisitions (Stein et al., 2018), rather than fully attributing responsibility across the value chain. The effectiveness of AI-driven decision support has also been found to be inconclusive (Bleher & Braun, 2022). Using a more localized focus, Klymenko et al. (2021) examined the use of digital technologies for sustainability accounting in Norwegian manufacturing companies. They found that these companies do not fully utilize the advanced data generated by their automated sites to understand their environmental impact in manufacturing activities, instead focusing on the Life Cycle Assessment (LCA) of the products they produce.

Negative impact

Other studies have focused on the negative aspects of digital applications too. Piscicelli (2023) criticizes that most studies don't analyze the intertwined relationship of sustainability and digitalization, so she categorizes possible impact in terms of first, second, and third-order effects. First-order effects are direct environmental, social, or economic impacts of digital technologies, which can be positive (reduced waste due to digital-twin modeling) or negative (competition for scarce raw materials, high-energy use, electronic waste). Second-order effects are indirect impacts related to changes in products and processes, often identified as positive in literature, such as reductions in resources, energy consumption, or waste, and development of eco-designs. Negative second-order effects, not studied as often, include economic impact on firms and displacement of low-skilled jobs. Third-order effects are the indirect impacts on the environment due to increased consumption or higher economic growth due to digitalization, which have been scarcely studied in the context of digitalization in circular economic models.

Some scholars have raised concerns about the energy and rare-earth material use, and the rebound effects, of digital technologies (Berkhout and Hertin, 2004; Hilty and Aebischer, 2015). The prediction that digital technologies will account for 20 percent of total electricity use in 2030 (Jones, 2018) underscores the challenge of ensuring that the digital transformation is also a sustainable one. This impact is not limited to energy use but extends to the manufacturing processes that are felt across global chains of production and consumption (Huang et al., 2013; Benoit-Norris, 2012). Particularly in the industrial manufacturing of digital devices, the economic and social impact of mining rare-earth resources necessary for these devices is significant (Klinger, 2023; Pan, 2023).

Moreover, the management of electronic waste presents additional hazards. The toxic disposal of such waste pollutes land and water environments (Barba-Gutierrez et al., 2008; Osibanjo and Nnorom, 2007), a problem that is compounded by the short shelf life of small components like sensors and microelectronics in IoT networks (Chakraborty and Gupta, 2016). These issues can be exacerbated in waste management chains that are not well governed across countries (Ismagilova 2019), further contributing to the environmental and social impact of transferring risks of electronic waste to other geographies (Ali, 2014; Jouini et al., 2022).

Finally, the rebound effect, which is particularly difficult to measure in the case of digital technologies and digitalization (Kunkel & Tyfield, 2021; Kopp & Lange, 2019), adds another layer of complexity. This is due to the rapid impact that the development, use, and interaction of these technologies with other factors create across multiple geographies (Lange et al., 2020; Santarius et al., 2020).

The increase in CO2 emissions associated with the use of personal digital devices has been a topic of study for some time (Miyamoto et al., 2001). Despite ongoing debates about achieving carbon neutrality (Murgesan, 2008), the aggregate use of these devices contributes to overall electricity use (Asongu et al., 2020; Tamburini et al., 2015). This seems to be due in part to continuous data generation, unnecessary data copying, storage, and computing in the cloud, all of which have increasing energy needs (Monserrate, 2022; Castronuovo, 2022). Emerging digital technologies that require large computing power also contribute to high energy consumption (Howson, 2019).

Furthermore, digitalization does not seem to decouple economic growth from energy consumption (Lange et al., 2020; Wang et al., 2022), which complicates the assessment of their net effect (Bohnsack et al., 2022). In a comparative study of several countries' digital economies and carbon emissions, Dong et al. (2022) found that the advancement of the digital economy is not uniform across nations, leading to a widening gap between highly digitalized countries and those that are less connected. While the growth of the digital economy can lead to a decrease in carbon emission intensity, it can also result in an increase in per capita carbon emissions. Factors such as economic growth, financial development, and the upgrading of industrial structures serve as intermediaries in the relationship between the digital economy and carbon emissions.

The process of datafying systems such as banking, employment, education, or welfare, introduces cybersecurity vulnerabilities that can compromise the integrity of these social and economic needs (Popkova & Gulzat, 2020; Parn & Edwards, 2019), but these vulnerabilities need to be balanced with the convenience of adopting these systems. Furthermore, pre-existing inequities in societal systems, such as education can manifest as a data literacy divide in the population (Carmi & Yates, 2020), and between countries, leading to the exclusion of certain countries in the process of digitalization (Dong et al., 2022). The complexity of current global value chains, which have more boundaries that need to be managed, coupled with the varying capabilities among its participants, and significant governance issues, further complicate the digitalization process (Loonam & O'Regan, 2022), and the possibilities of benefitting from the digital capabilities in the knowledge management of these chains.

Another facet of this, is the creation of gig economies around digital platforms, which can reproduce labor inequities and precariousness of workers' livelihood (Graham et al., 2017; Vallas & Schor, 2020). But not all workers may be able to adapt to digitalization of the economy. The risk of employment displacement, particularly among "low-skilled" workers due to automation, has been a significant concern (Acemoglu, 2021). A comparative case study of Norwegian and UK institutions by Lloyd & Payne (2019) explored the perspectives of industry experts on the potential mediating effect of strong labor unions, coordinated market economies, and welfare policy. The study found skepticism among industry practitioners regarding short-term predictions of mass unemployment. In the case of Norway, the high levels of automation, the potential market benefits of "onshoring" (returning labor tasks within the country), the influence of unions and other organizations in mitigating adoption impacts, and significant differences across industries, made the balance uncertain. However, all interviewees expressed long-term fears of displacement.

Additionally, there are also human rights and labor exploitation concerns, for example in the mining of rare earths (Ali, 2014; Sadan et al., 2022), and associated geopolitical competition for the control of rare-earth components (Thibeault et al., 2023). Still, the ethical and social implications of digitalization extend beyond individual harm and have been linked to the erosion of open societies and democratic institutions. Digital technologies and platforms can be used to intentionally spread disinformation, sow distrust of previously reputed sources of academic or journalistic knowledge, increase political divisions among communities, or facilitate state surveillance of the population (König &

Wenzelburger, 2020; Manheim & Kaplan, 2019; Rubin, 2022; Bontridder & Poullet, 2021; Kertysova, 2018). These problems are considered especially acute in the current capabilities of AI models to create "deepfake" information pieces or audiovisual content that is designed to look real or legitimate but are actual fabrications (Whyte, 2020), which can in turn be very easily disseminated through social media and digital communication platforms (Aïmeur et al., 2023), eluding fact-checking.

Artificial Intelligence

As is the case with other digital technologies artificial intelligence (AI) can be defined depending on the academic disciplines and industrial settings of its applications, with definitions varying based on the context (Kühl et al., 2022). At its core, AI involves the aggregation of data, such as big data analytics, through machine-learning and deep-learning algorithms. These algorithms construct AI models that enhance the capabilities of systems through their effects on networks and other technologies (Gregory et al., 2021). This process enables the convergence of different technologies and platforms in electronic markets that can also be construed as socio-technical systems.

AI and machine learning (AI/ML) models have been highlighted for their significant benefits for environmental applications (Tomašev et al., 2020). For example, they have been applied in improving and managing knowledge and monitoring environmental impact in areas such as marine environmental pollution (Agarwala, 2021), soil microbial diversity, and water quality parameters (Kim & Park, 2009). In energy systems management (Nabavi-Pelesaraei, 2018), AI/ML has facilitated planification of various circular modalities of reusing, reducing, recycling, or recovering materials (Yu et al., 2021). However, the extensive capabilities of these technologies for business and technology have raised concerns among scientific communities, regulators, and civil society groups (Dwivedi et al., 2021; Mittelstadt 2021; Landers & Behrend, 2023; WHO, 2021). These critiques have focused on how complex AI interactions with other systems can accelerate them as both drivers and barriers of sustainability (Nishant et al., 2020; Van Wynsberghe, 2021), to the point of being considered sustainability risks at a systemic level (Galaz et al., 2021). For instance, the carbon footprint of AI is growing due to the large amounts of energy required for computing and its self-development (DeWeerdt, 2020).

According to Kopka and Grashof (2022), the socio-economic impacts of AI, particularly in relation to sustainability issues, remain under-researched (2022). Their research indicates that the effect of AI on energy consumption, whether it increases or decreases, is heavily dependent on regional conditions and the technological and industrial portfolio of the area. Dauvergne (2022) considers that while AI is expected to greatly enhance productivity and efficiency in supply chains, something that has been heavily promoted by corporate discourse for its sustainability benefits, this is an exaggerated claim because these gains are rebounding into more production and consumption, accelerating extraction, "and the distance of waste, casting a dark shadow of harm across marginalized communities, fragile ecosystems, and future generations" (p. 696). The implementation of AI has also been reviewed for its potential harm to individuals and vulnerable communities (Wirtz et al., 2020; Acemoglu, 2021; Floridi et al., 2021; Trewin et al., 2021). This harm has been documented in highly sensitive cases related to law enforcement and policing (Pastaltzidis et al., 2022; Berk 2021; Noriega, 2020), immigration policy (Laupman & Schippers, 2022), work recruitment and selection (Hunkenschroer & Luetge, 2022), healthcare provision (Wiensa et al., 2020), and the development of lethal weapons (Shoker et al., 2019). In all these cases, the application of AI models for simplifying decision-making processes that determined whether individuals or groups could have access to welfare or healthcare, or should be considered dangerous and required additional screening, led to harm of many people. These issues behind these faulty systems have been attributed to gender, racial, or other types of bias in the collection or processing of datasets and algorithms used to train and develop these models (Roselli et al., 2021; Panch et al., 2019).

The deployment of AI in these cases has reproduced and escalated existing social and environmental inequities, which is something that had been studied already (Zajko, 2021; Howard & Borenstein, 2018), and has generated academic interest in developing frameworks to audit decision-making issues of AI related to the transparency and explicability of the models, also known as the black box problem (Hasan, 2021; Dwivedi et al., 2021; Landers & Behrend, 2023). Because of these significant risks, some scholars and policymakers have advocated for banning the public use of AI/ML models due to their potential to evolve into artificial general intelligence (AGI), which is AI that could far exceed human performance to the point of becoming uncontrollable and a potential existential threat to humans (Grace et al., 2018; Müller & Bostrom, 2016). However, others argue that legal bans on AI/ML development are futile and impossible to enforce in

practice, as these models have been widely disseminated (Lau & Guo, 2023). They suggest that the only way to improve these models is by actually using them (Nivel et al., 2013; Turchin, 2018), although some authors consider these methods of improvement through use, also known as recursive self-improvement, to be flawed and potentially unjustified given the risks (Steunebrink & Thórisson, 2016).

These debates have been reflected in public discussions and regulatory measures (Robinson, 2020), but there are meaningful gaps in how impact is understood between practitioners and policymakers (Krafft et al., 2020). Even the current landscape of standards and principles to regulate AI have been found lacking. Fukuda-Parr & Gibbons (2021) reviewed 15 ethical AI guidelines, finding that while half are based on international human rights law, they could be more operational and less vague. Nevertheless, this highlight the need to consider sustainability and ethical issues at all points of digitalization processes, including before data generation starts happening (Martinez-Martin et al., 2018), in the design of categories created around data, also known as data ontologies (Bonacchi & Krzyzanska, 2019), and in challenging the perception of neutrality in digital technology to make sure that these reflective processes take place (Shadikhodjaev, 2021). This has also raised the need to focus on the design stages of digital technology to properly incorporate environmental and social values. This has been developed in the design-thinking approach that problematizes the needs of users by practicing empathy, experimentation, and collaboration in the different stages of design. This approach is not new and has been used for long in software and user experience designs, but its use in regards to sustainability and on digital technologies that have not been developed with this human-centered approach is newer (Ferati et al., 2021; Pruneau, et al., 2021; Vendraminelli et al., 2023).

Contrary and perhaps obfuscating these debates, have been the viewpoints of business industry groups, who have framed this as an issue of labor supply, a lack of technical expertise seen in a deficit of knowledge workers with skills to develop AI/ML models. The business interest group IKT says that this is a major obstacle for implementing projects like the EU Digital product passport in Norway, because “under 3,000 students within various ICT programmes, and 90% get a job in large companies, almost none work in public sector with exception of NAV and Skateetaten which are large IT environments (…) very few are working at universities, so the great struggle of digital innovation is due to lack of

manpower, especially people who master the borderland between material knowledge and IT" (IKT, 2022).[3]

3. Tensions

Dematerialization and virtualization can obscure impact

The optimization characteristics of digital technologies and digitalization that create positive impacts can also contribute to the negatives because dematerialization and virtualization of specific aspects of goods and services can create the impression that material and intangible impacts elsewhere is not happening. However, it is known that global value chains of production and consumption also involve a growing number of multiple actors with different degrees of power of influencing the public debate and acceptance of issues (Dallas et al., 2019), in many geographies (Golgeci, 2021), at local and global scales (Connell et al., 2018), at a very fast pace (Loonam & O'Regan, 2022; Nyagadza et al., 2022). These effects are expected to increase as these technologies are implemented (Kaltenegger et al., 2017) and also expected to dilute responsibility across such value chains (Hon et al., 2012). An exploration of this was done by Clarke and Boersma (2017) in their examination of Apple's supply chain governance and the ethical dilemmas present say that contradictory public discourse of the seriousness of these issues complicate the matter because customers don't penalize Apple, who manages to contain its reputation despite exposure of the serious offenses in its supply chain, and that the company benefits from weak labor laws and enforcement that doesn't protect employees. They say this shows the weakness of global supply chain governance, on which Apple has ultimate responsibility, even if they never publicly own it. The authors explain that similar supply chain conflicts elsewhere have been improved through the use of multistakeholder initiatives that give platform to voices usually silenced, producing debate and allowing policy reform.

Optimistic framing

Dwivedi et al., (2022) say it is critical to examine how these tradeoffs, positive and negative impacts happen on the environment and in the reality of communities around the world,

[3] The original text is in Norwegian, and I used an automatic translation into English

because digital technologies are now considered an integral part of climate emergency's mitigation measures through information management. In addition, the positive impact can create a normative framing of these technologies that reinforces these tensions. They may be seen as neutral tools or artifacts, and understanding of their impact can be colored by its positive developments. Brenner & Harti (2021) have studied the optimism associated to digital solutions in the public discourse of sustainability. Lenz (2021) says the location of the disconnect between perception of digital technologies and actual impact lies in the political discourse of futures of sustainability (Adloff & Neckel, 2019) which is a view of the concept as a contestation around modernization, transformation and control- that envelops digital technologies and presents them as visions of futures of green growth. He offers that the interaction of digitalization and sustainability are mediated by whether they legitimize varying practices or not, as has been seen in the discursive use of digitalization to maintain normality (production and consumption), and academic research is needed to further examine this, including the practice of digital technology in people's everyday life.

One aspect of this is their enabling characterization that emphasizes their value-capturing nature, also in sustainability, which among its drivers for implementation has the conveniences facilitated in compliance, so business-models will prioritize digitalization for its value creation aspects, including reducing barriers to sustainable business practice (van Bommel & Rasche, 2023). In relation to this perspective is Mouthaan et al.'s (2023) who in their critical scoping review of systemic sustainability effects of digitalization, appraising more than a hundred academic studies, consider the public discourse around digital socio-technical systems and conclude that academic research and corporate discourse understands poorly the connections of digitalization and sustainability due to patterns of "reductionism, determinism, and optimism," patterns, they say, that neglect the systemic effects of digital technology (Mouthaan et al., 2023, p. 12). According to them, the determinism is seen in the fast spread in large scales and scopes of digital technologies that become pervasive, which in turn lead to the optimistic expectation of potentially transferring achievements in one domain to many other applications, and the reductionism compartmentalizes focus on specific benefits of digital artifacts, without studying the co-evolution of practices and institutions with these digital technologies. As a case in point, they also analyze the internet from its emergence in the first wave of digitalization, including the ambitious goals its deployment promised, and its complex evolution across

societies and economies in the current era, with important positive, negative, and uncertain consequences affecting the whole world.

Complications on existing systems of production-consumption

Some researchers have highlighted that it is hard to change production and consumption patterns because they are deeply embedded, quite complex and entangled with habits, history, culture, and norms (Hodder, 2014; Ozaki & Shaw, 2014). It would be expected that this may also be the case for digitalization, even if it facilitates escaping some of these mechanisms. Bengtsson et al. (2018) say that these patterns need to be changed systemically, not only in terms of efficiencies (these are not enough) and part of the problem is that the paradigms used to define these patterns such as the SDGs are organized around efficiencies. Panizzut et al. (2021) don't explore digitalization, but conduct systematic literature reviews to analyze whether environmental sustainability can be achieved under current consumerism (acquisition of goods and services beyond survival needs) lifestyles in capitalist societies. They conclude that it is possible to achieve a balance in the long run but only with huge amounts of efforts and resources to produce transformation, but that this is paradoxical in itself.

Another layer of complication is that consumers, who may be increasingly driven in different ways by normative preferences for sustainable options, may not understand the whole lifecycle implications of goods and services that seem less tangible in their daily contact, and whose transformation processes involve very complex and technical processes (Loaiza-Ramirez et al., 2022). Guandalini (2022) has pointed out that this hyper specialization is also reflected in the focus given to these topics in research; that research on industrial digitalization and sustainability seems to still focus on narrow practical applications in industry and there are significant gaps in researching the complexity of interactions, including clarifying definitions, and understanding the factors that create trade-offs in.

Some of these issues are deeply entrenched, and despite progress in previous years around achieving specific environmental targets, there is huge uncertainty on our collective feasibility of reaching climate goals by 2030, because there is still a disproportionate amount of material footprint (10 times as much) caused by high-income vs low-income countries, a decrease in reporting on sustainable consumption and tourism, and a dramatic

increase in fossil fuel consumption post pandemic nearly doubling from 2020 to 2021 (Sachs et al 2022). Despite these figures that would justify the implementation of policies for a sharp decoupling of economic growth from resource use this still doesn't happen. This disconnect between the outcomes defined in policy and political discourse on the one hand, and evidence of impact related to systems of production and consumption is prevalent in the systems of the most essential societal needs such as energy, food, or transport, which are characterized by high demands of energy and resources, high levels of emissions and waste (Markard et al., 2020; IPCC. 2019). The production and consumption patterns in these systems are deeply linked to the climate emergency and other societal problems because of their greenhouse gas emissions, resource depletion, and environmental degradation (Markard et al., 2020; Wiedmann et al., 2020; Schäpke, et al. 2017). Transitioning to more sustainable production and consumption systems has been continuously demonstrated would mitigate these issues and promote overall sustainability, but this would require challenging the economic growth models, and the discursive responsibility should not be laid on the choices of consumers, when production levels are still expected to increase (Akenji, 2014).

Gaps between values and purpose

According to Niehoff (2022), the problem is also looking at digitalization as a way of doing business as usual but more effectively. He looked at sustainability management in corporate digitalization across large listed corporations, and those that focus on satisfying customer demands without involving stakeholders in sustainability efforts reproduce negative impacts through increased consumption via digitalization. While, he finds, there are pioneer companies that address this, stronger regulation (and not soft policy alone) is necessary to avert what he calls unsustainable digitalization. Other authors point towards a real examination of the business models for sustainability in digitalization, saying that social and environmental values have to be there from the beginning (Centobelli et al., 2020; Goni et al., 2021). Related to his other academic critique of value-capturing, Rasche (2023) also sees an issue with how valuation is understood in prevailing ESG models of governance, and certification frameworks, that shift (moral) values-driven sustainability towards a sustainability that is defined in company value. Other authors, however, say that the gap is located in our governance systems that have not been able to properly weight responsibility

for these values (Kramarz & Park, 2016), so we cannot expect digital technologies to solve these issues by themselves.

Other researchers have said, however, the importance of the design stage of the actual business models for digital technologies that should incorporate environmental and social values from the beginning to prevent negative outcomes like the ones mentioned above (Lucivero et al., 2020; Kunstman & Rattle, 2019; Sætra, 2021); but that our current digitalization processes reflect that these technologies have not been designed with these values in mind from the start (Sparviero & Ragnedda, 2021; George & Schillebeecks, 2022). However, other researchers say this is not possible with prevalent business models backing the developmentof digital technologies because ultimately they are meant to optimize only for economic capture (Costa et al., 2022; Samuel et al., 2022).

This has been explored too from the perspective of the landscapes where people interact in digital platforms, which are now also the domain of large corporations that have concentrated power there, says Oberhaus (2020). And, in the analogue world, this is also seen in how digitalization of their markets has given incumbent corporations the potential to concentrate power and to dominate their industries with unsustainable practices (Dahl Andersen et al., 2021). These authors point out that digitalization has allowed large firms in unsustainable industries to achieve specific efficiencies that can be promoted to greenwash their reputation, as has been studied by Makitie et al. (2020) in oil & gas firms' CO2 reduction claims, or on food systems control of value chain integration (Clapp, 2021). Dahl Andersen et al. (2021) also call for more research on how Big Tech incumbents have achieved success not only by deploying their technologies, but also by forcing on users the terms in which these technologies are used, and mastering the predicting capabilities of analytics of users' data for the purpose of pushing continuous use, and optimizing the advertising of corporate customers in these platforms. This has been studied too by Campbell et al. (2020) in how the economic gains that derive from optimizing marketing can be a powerful, principal driver for adopting digitalization.

This has also been studied from a political ecology perspective in the critiques of corporate valuation of personal data as capital that involves processes of datafication, accumulation, and extraction (Sadowski, 2019). Foster et al. (2018) on the other hand, describe that the societal processes around data can be discussed as data work, because they present opportunities for discovery, value creation and decision-making, while also raising issues

of ownership, privacy, and trust, and that these trade-offs must be negotiated. Nevertheless, Horcea-Milcu et al. (2019) point out that values are inherently hard to define and operationalize in sustainability transitions, and the values perspective needs to be situated in more specific terms for different purposes: being implicit in research and practice, negotiating the inclusion of plural values, eliciting them in decision-making, or using them for systemic transformation (including from the perspective of research on digitalization). That multiple values have to be accounted for to increase participation and legitimacy of stakeholders.

Sustainability is a contested concept

Stepping back from discussions of digital technologies and business engagement, it is relevant to explore issues around defining value in sustainability, and this is deeply linked to the difficulty of defining sustainability because it is a contested concept. Sustainability has been usually conceptualized as a trilemma, the ability to meet the three most commonly discussed dimensions of environmental, social, and economic aspects that need to be balanced, and these dimensions recognize the interdependence and interconnectedness of environmental protection, social equity, and economic development, in addition to considering the needs of the present generation without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987) . Still, sustainability is not easy to define with precision, as it is sometimes analyzed in relation to other dimensions, or around concepts closely related to it, such as the above-mentioned intergenerational equity, but also in regards to claims of justice and ethics, and demands for reparations, and the impact on individual humans, and the Anthropocene. Intergenerational equity emphasizes the fair and just distribution of resources and benefits between present and future generations (Rawls, 1971). Justice and ethics reflect the moral aspects of sustainability, considering fairness, equity, and ethical responsibilities (Sen, 2000), while the Anthropocene highlights the significant influence of human actions on Earth's ecosystems (Crutzen, 2005).

In science and policy, several frameworks for conceptualizing sustainability have been developed, such as: the planetary boundaries framework, which aims to identify and maintain the safe operating space for humanity within planetary boundaries (Steffen et al., 2015); or Raworths' (2017) doughnuts model, which try to balance the needs of people

within ecological boundaries, advocated because of the practicality of looking at these two issues as interconnected systems that cannot be substituted. The issues of having multiple definitions of sustainability has been explored even in the context of research itself, as presenting transdisciplinary challenges (Scholtz et al., 2024).

Nevertheless, sustainability is still commonly equated with the concept of sustainable development, but as seen in the multiplicity of its meanings and related topics, these are not synonyms because sustainable development is a paradigm where economic growth is central, even if efforts are done to decouple it from environmental impact (Hirai, 2022), and the meanings of sustainability are in movement and contestation (Salas-Zapata & Ortiz-Muñoz, 2018). The tension within socioeconomic development and the negative impact on people and the planet is at the core of the SDGs (UNDP, 2023) mentioned in the Background chapter, perhaps the most widespread policy paradigm of socioeconomic development used to balance these three aspects, around access and provision of societal needs of food, health and sanitation, education, employment, gender, and social equality, as well as protection of the natural environment.

According to O'Brian & Sygna (2013) because sustainable transformations touch on different spheres related to the practical, the political and the personal, there is misunderstanding and resistance to the proposed changes in part due to lack of clarity about "what exactly needs to be transformed and why, how, in whose interest, and what the consequences will be" (p. 1). Hallin et al. (2021) also suggest that sustainability will always remain contested because it is performative, it is a concept that "is filled with meaning across time" (p. 1948) and it is always used in association with local spaces, specific times and through personal values and perspectives, which makes sustainability a local, temporal and political concept, inherently being always contested and it is important to recognize that the transition is towards sustainability.

Whether the issue is the notion of economic growth as an unquestionable premise or not, is continuously debated. Some argue that it is not, and it is a matter of having much stringent public policies to constraint this growth and make sure that environmental targets are achieved (Cohen, 2020). The complications of arriving to consensual definitions of sustainability on which all the relevant actors can act upon may never end because, on the one hand, it is a continuous process of societal transformation (as examined in the transitions literature) where socio-technical systems shift towards sustainable practices.

These authors emphasize the importance of discourse in shaping sustainability transitions, arguing that the way we talk about and understand sustainability can influence how we act towards achieving it (Markard, Raven, & Truffer, 2012). The contestation is not resolved in part due to the variety of definitions and paradigms associated with the concept. The polysemic interpretation of sustainability can pose challenges in achieving a shared understanding and effective implementation of sustainability actions. This is because the variety of concepts associated with sustainability can become buzzwords lacking well-defined meaning (Antoine-Moussiaux & Leyens, 2023). Moreover, the emphasis on justice – particularly environmental and social justice – has highlighted the need for equitable distribution of resources and opportunities, further elevating the status of sustainability as a norm (Bulkeley et al., 2014).

However, these concerns may end up being framed as climate change mitigation policies, and these are not the same as the more accepted public policy perspective of sustainability conceptualized as sustainable development, which makes it hard to seriously challenge the primacy of its economic dimension and related aspects that don't question the role of economic growth, the extent of lifestyle changes required, and the balance between individual and collective responsibility (Hess, 2014; Hallin et al., 2021). So, debates around these issues often involve differing perspectives on the urgency of sustainability challenges, the feasibility of proposed solutions, and the distribution of costs and benefits (Hess, 2014). Some authors also argue that the way these debates are being rearticulated around questions of affluence between regions and populations may prove effective to address environmental challenges and improve human well-being (Wiedmann et al., 2020).

Taking all of this into account, it would not be a surprise that different decision-makers can have a wide variety of notions of what sustainability is, even if there is agreement on its normative principles. Some authors, like Hahn et al. (2018) who have studied how business leaders consider sustainability along other business decisions, have used the concept of paradox framing, to explain how in specific settings, under moderating factors, economic values not always prevail in corporate motivations, and this is part due to the evolution of contestation of sustainability that permeates different firms' units and employees, reflecting that sustainability will always be a normative concept (Binder et al., 2010; Connelly, 2007; Rose & Cachelin, 2018).

Another view about stakeholders' claims is that these can be disputed among different stakeholders because the claims can be concurrently legitimate in specific contexts (Haack & Rasche, 2021; Scherer et al., 2013), depending on the definitions of sustainability used (Bausch et al., 2022), and the position of these stakeholders in a given system (Fritz & Binder, 2020). Positionality has been studied extensively in transitions literature, and pertaining digitalization, this has also been conceptualized by Lock & Seele (2016) in how different actors can have different roles as digital collectors, users and generators.

Disentangling these topics and creating more sustainable knowledge and practices not only requires reflective use of the technological innovations as has been widely discussed (Anadon et al., 2016), but also the capacity by these stakeholders to consider a plurality of perspectives about sustainability. This has been called a co-creative process of meaning by different actors (Kruger et al., 2018; Arnold, 2017), that induces reflection and dialogue (Woiwode et al., 2021), that is inclusive and responsible (Tooth & Renshaw, 2009). Co-creating practices inevitably require an examination of the different perspectives present in these issues by diverse stakeholders' (Bulgacov et al., 2015). This inclusive, proactive, and reflective management of stakeholders' perspectives to co-create meaning in practice, has been studied, for example, in how responsible innovation frameworks can be integrated with social practice using justice framings in energy systems (Sovacool et al., 2021). In the case of digital technology, these processes have been studied in the specific context of deliberative frameworks for assessing sustainable knowledge and value in digital technologies (Madaio et al., 2020; Zhang et al., 2019; Almeida & Melo, 2017).

But more generally, it has been used in multi-stakeholder initiatives (MSIs) that involve bringing together private, public and third sector institutions, in addition to various stakeholders of civil society (Vachani & Post 2012), and some scholars consider these initiatives have emerged to counter the self-regulation of corporations and fill governance gaps, and to allow stakeholders to have spaces for cooperation along global supply chains (Dahan et al. 2015; Perez-Aleman & Sandilands 2008) with increased legitimacy. De Bakker et al. (2019) in their cross-disciplinary review of research on business ethics in multi-stakeholder initiatives, point out that most research has focused on the necessary inputs to create, institutionalize, govern and understand the impact of MSIs, but that there is evidence that much more needs to be studied in relation to how these initiatives face challenges in practice around: the justification of existing norms in systems for deliberation, a focus on utilitarian reasoning in their adoption, lack of moral justifications of initiatives'

impact, and lack of emphasis of ethical business leadership. While this thesis is not related to the participation of intermediaries and their leaders in MSI initiatives, I consider the purpose of these initiatives as an additional source that highlights the importance of examining stakeholders' perspectives in understanding the complexity of impacts of digitalization and sustainability. Especially regarding the perspectives of leaders who may experience these normative challenges in their practice of promotion of industrial digitalization.

4. Managing tensions through intermediary work

In the academic discourse on innovation and sustainability, transition intermediaries have emerged as pivotal agents in bridging knowledge gaps and fostering synergistic collaborations. These public and private intermediary actors (with a wide variety of shapes and levels of institutionalization) have been described as central in the development of innovation ecosystems, where they facilitate collaboration, knowledge exchange, and resource mobilization among diverse actors (Barrie et al., 2019). Central to their function are activities of knowledge brokering, network development, and coordinating innovation initiatives, or managing collaboration projects among different stakeholders in an industrial system (Dedehayir et al., 2018). De Silva et al. (2018) have studied how these organizations provide their networks with value, primarily through knowledge sharing, collaboration, and improving innovation capabilities, and the literature on innovation makes reference to how this type of systemic value is one of the reasons that firms decide to participate in the networks created or supported by these intermediators, as they help them expand their capacities in terms of technological innovation. In the context of sustainability transitions, intermediaries have been described as accelerators, particularly in mobilizing resources (such as "green funds") and specialized knowledge to drive sustainable innovation (Gliedt et al., 2018). This has also been described in terms of open-innovation practices and projects, which can be understood as socialization of best practices and information and accessing and sharing external knowledge (Chesbrough & Bogers, 2014), as opposed to older corporate practices that favored commercial secrecy and competition around these resources. Their role extends to open innovation landscapes, with collaboration managers, or facilitators, serving as intermediaries to foster knowledge sharing and resource mobilization in open innovation projects (Ollila & Yström, 2017; Randhawa et al., 2018). Several studies have focused on how in the context of decarbonization efforts, and under

certain conditions, intermediaries are even able to help steer incumbent towards sustainable practices and technologies (Sovacool et al., 2020).

In the case of sustainability-oriented intermediators, their role has been also studied in helping stabilize sustainable transitions in critical moments where, without their presence, eco-innovations may not survive (Kivimaa et al., 2019a). Kanda et al. (2018), studying how these intermediators help eco-innovation in SMEs, identified several roles that are deemed critical for eco-innovation survival: forecasting and road mapping, information gathering and dissemination, fostering networking and partnerships, prototyping and piloting, technical consulting, resource mobilization, commercialization, and branding and legitimation. In particular, the authors say, some of these roles were specifically aimed at validating the environmental benefits of eco-innovations within the firms themselves, and outside the firms, in a market context. However, compared with other studies that have mentioned the role intermediators had in affecting policy through articulation of needs, they didn't find evidence. Other authors, like Kant & Kanda (2019), have found that intermediators themselves face challenges to their survival over time, which require policy support and other institutional settings. Kivimaa et al. (2019b) have explored the literature on sustainability intermediaries and mention that some scholars consider that intermediaries may not have such a prominent role in facilitating transitions, as expected, and in part this is due to their vulnerability over time.

While the literature on sustainability intermediaries has grown in the last decade, not enough has been researched about specific settings like Norway, in the context of digitalization. The previous study by Klymenko et al. (2021) has focused on digitalization in manufacturing companies, but not from the perspective of intermediators. Another study by Klymenko and Halse (2023) investigates how maritime companies in Norway interpret the concept of sustainability, and find that these companies operationalize it around regulation and customer pressure, as well as through voluntary standards that earn them legitimacy. They also find that firms seem to increase their adoption of sustainability measurements and disclosure, as well as the use of digital tools for this, in line with their environment's increased attention to supply chain, and their belonging to industrial cluster organizations that articulate carbon-neutrality visions. However, they say that for this industry, engagement is technology dominant, economically driven, and needs incentives to deepen in the environmental and social aspects. Finally, another study also by Klymenko and Halse (2022), studied the impact a maritime industry cluster organization has on their

members for reducing barriers to sustainable production, find that firms belonging to this cluster have unique knowledge and expertise that can be collectively exploited, but that diversification in the cluster may weaken these communication benefits.

This literature review was done with the objective of exploring the diverse academic perspectives of the issues at the intersection of digitalization and sustainability. In the last section of this review a brief discussion was provided about the role of innovation intermediators -especially those oriented for sustainability, and their mangers- as this provides the basis for exploring the perspectives of leaders who work in such organizations, which as will be detailed in the Methodology chapter, are all distinct organizations, but all sharing characteristics that fulfilled the criteria for including them in this study.

Several of the concepts present in the literature debates will be used to thematically analyze in Chapter 5, the findings presented in Chapter 4. These relate to the definitions and positive applications of digital technologies for sustainability, the tensions perceived by these industrial facilitators in terms of negative outcomes and risks, barriers to sustainable performance, misalignment between values and purpose (including questions of consumption, responsibility, and artificial intelligence), and the difficulty of defining sustainability. Finally, strategies of how these firms manage these tensions, and through the work with intermediary organizations.

While the literature at the intersection of digitalization and sustainability has grown across disciplines, not enough has been explored from the perspective of innovation facilitators who engage with these issues in everyday practice and may have significant influence in their industrial networks. And with the exception of Klymenko and Hasle's research, which have touched on these issues, to my knowledge no research has been performed so far on the issues from this setting. My study, then, aims to explore how these topics are perceived given the importance of these issues in Norway.

3. Methodology

The aim of this study is to explore the perceptions of selected facilitators of industrial innovation about the complex interaction of sustainability and digitalization. The objectives I set out to do in my research are:

1. To collect answers about the perception that selected professionals have about the tensions in the intersection of sustainability and digitalization (directly mentioned as such or indicated indirectly through the discussion of examples relevant to their practice) and present them around themes.

2. To interpret the perspectives of the innovation facilitators, and then briefly discuss the theoretical and practical implications I see in relation to the academic debates of sustainability tensions of digital technologies and digitalization.

The results of my first objective will be presented in Chapter 4 "Perceptions about sustainability and digital technology," and the second objective will be addressed in Chapter 5 "Discussion." With these objectives, I intend to answer my research question: how do industrial innovation facilitators perceive tensions in sustainability and digital technologies?

Research design and method

I am interested in exploring the perceptions of digital technology and digitalization sustainability issues by leaders or managers, whose practical experience tends to straddle between theory and practice. I will not look into relational aspects within their organizations or offer case studies. Rather, this is an exploration of the interviewees' understanding of the tensions of sustainability in digitalization, as told by them in their own words. My ambition is to explore the themes that emerge in their narratives, while preserving interviewees' rich personal experiences of these issues. Based on the literature review, I conceptualize these leaders as "facilitators" of industrial innovation, due to their job positions in organizations and business firms that have an intermediary role in the diffusion of technology and knowledge, as understood in the literature.

For this reason, this thesis uses a qualitative empirical approach, based on inductive and deductive thematic analysis of material collected during semi-structured interviews with

seven managers and leaders of innovation intermediary organizations in Norway. As has been discussed in previous chapters, sustainability knowledge is complex, with multiple meanings that can co-exist in different settings, including industrial ones, and the breakthroughs that digital technologies and digitalization have achieved can also bring with them newer impacts and concerns, but the perception of these as challenging is a matter of subjective opinion in some settings. In this complex interaction of sustainability and digitalization, exploring the perspectives of practitioners themselves requires approaching their insights with enough academic flexibility and the capacity to reflect the nuance in their accounts. Using semi-structured interviews is appropriate for this type of exploratory research (Brinkmann, 2014) because it loosely structured our conversations along preset concepts that I was most curious about, while letting their observations on a range of connected topics take precedence.

Recruiting interviewees

Originally, I intended to target professionals with the job position of "sustainability manager" as I thought that would be the best type of worker profile with whom to talk about the intersection of digitalization and sustainability, a personal interest of mine. However, as I was trying to decide for a criterion to select first the type of firms from where to do this sampling, I remembered from previous work experience that business firms in many industries tend to belong to interest-based industrial organizations that articulate their interests around specific goals that provide them with access to resources for capacity-building. This is how I first learnt about Innovation Norway (IN), and their Norwegian Innovation Cluster Program (NIC), which seemed like a great place to start. Based on the published information at IN about the industrial clusters supported in the program, I inspected each of them separately. All the clusters described in their webpages working directly with digitalization or described using digital technologies as enabling technologies, and due to the requirements of the NIC program, are dedicated to one of the following thematic priorities of IN: circular economies, green mobility, renewable energy and systems, ocean-based "solutions for the future," demonstrations of bioeconomy solutions, and enabling technologies (IN, 2022). Then I created a data base (circa 200 organizations) with firms and organizations affiliated to 10 of these cluster organizations. I chose clusters that had a more accessible overview of firms and organizations that were their members, and that in my opinion also advocated a sustainability-oriented mission.

Looking at the visible organizations listed as members in the clusters, I also selected companies in these clusters that presented their missions of developing digital technology applications using descriptions that, also in my opinion, signaled a sustainable mission or goal, and that had among the personnel visible in their webpages, leaders who had a "sustainable manager" position, similar or higher in terms of responsibility (director). At the start of the recruitment process my intention was to interview leaders from these firms, in addition to leaders or managers of the clusters, and leaders of projects affiliated with NIC who were working in academia, to compare differences among their opinions. I started contacting first the leaders of business firms and the leaders of clusters, and to my surprise, the people who responded first (and much faster, almost exclusively) to the circa 40 recruiting emails I sent, were the leaders of the industry clusters. With this response, and after a second review of their websites, I decided that their insights were likely interesting and varied perhaps even more than the firms themselves, because there was much more open alignment to sustainability and innovation principles exhibited in their webpages, which had a less obvious inclination towards corporate image seen in the business firms websites. Among the organizations that responded, and which I contacted first without knowing the difference between them and the clusters, was the leader of a Norsk Katapult, which as mentioned in the Background chapter, is a publicly funded organization that provides different services than the NIC clusters, but also has a digital and sustainability orientation. After a second round of emails (Appendix B), in which I described the general aims of my research, how the interview would be conducted and explained aspects of confidentiality, consent, and data handling, I ended up with nine potential candidates. Seven of them were available for interview in the period I had allocated to conducting the interviews (November and December 2022): one of the nine declined the invitation and the last person only replied after the period in January, when I had moved to the next phase of data analysis.2

Overview of the interviewees

This resulted in 7 interviews conducted with 4 leaders of NIC clusters (non-profit business cluster or organizations), 1 leader of a catapult (non-profit R&D testing facility organization). 1 director of a business-to-business digitalization consultancy, and 1 manager from a business-to-business technology company who focuses on engineering automation. The first five received or were receiving, at time of interview, financing under

the NIC program by Innovation Norway or by SIVA as discussed in the Background. After the initial academic literature review, I understood that the business firms (informants 5 & 6) for some authors do not fit in the category of innovation intermediary in terms of running open-innovation activities, but were interviewed before I decided that the intermediaries (the NICS and Catapult) would turn out to be the main informants. Nevertheless, they do conduct what the literature considers knowledge brokerage services, but on a one-on-one basis with clients. Given their practical experience engaging with sustainability and digitalization with a portfolio of clients, their answers are also valuable. It is important to mention that these two firms were, at the time of interviews at least, visible members in one of the other NIC clusters contacted, but it is unclear to what extent they participated in the cluster activities. The distinction between the first five interviewees and these two informants is made when necessary in Findings and Discussion. Table 1 provides an overview of the participants.

Table 1. Overview of informants and their organizations

ID of practitioner	**Role**	**Background of interviewee**	**Mission of the organization**	**Type**	**Open innov. type**	**S. orient.**
1. “Ingrid”	Senior leader	Engineering	Digital transformation and A.I. application in business	NIC	Yes	Yes
2. “Eirik”	Senior project manager	Engineering, grant-seeking, international markets	Healthcare technology innovation	NIC	Yes	Partially
3. “Sara”	Senior project manager	Engineering, circular economy logistics, academic research	Digitalization, sustainability, and new business models for the process industries	NIC	Yes	Yes
4. “Tobias”	Senior leader	Data science and management, business leadership	Digitalization and A.I. capacity building across industries	NIC	Yes	No
5. “Ada”	Senior leader	Engineering, telecom	Development and testing of materials technology	Katapult	Yes	Partially
6. “Sofie”	Project manager for clients in Oil & Gas	Oil and gas, business strategy	High-tech equipment and engineering, developer of in-house robotics and automatization products and services	B2B-Multi	No	Yes
7. “Emil”	Director level leader	Management, digital business, business leadership	Digital transformation business consultancy	B2B-Con	No	Yes

Table 1: ID: Number and pseudonym assigned for interviews (used in chapters 5, 6, and Appendix C); role: type of job leadership position, which is kept relatively vague for anonymity; Background: synthetized from explicit responses in the interview; type: Refers to the type of organization where the interviewees work at,

where NIC is a Norwegian Innovation Cluster non-profit business cluster or organization, Katapult is a non-profit R&D testing facility organization, B2B-Multi is a business-to-business multinational company, and B2B-Con is a business-to-business consultancy firm; Open-innovation type: Whether their activities correspond to the open-innovation functions of innovation intermediaries ("yes") or are primarily focused on client firm's demands ("no"); S-orientation explicit: whether the organization explicitly communicates being aligned to sustainability principles in their main webpage.

Content of the interviews

I developed an interview guide for the semi-structured interviews that covered the issues I considered relevant in examining opinions about the intersection of digitalization and sustainability. As I was going to conduct thematic analysis with a mostly inductive approach first, I decided that this interview guide was appropriate. After the first interview, I realized that the logical sequence of the questions should be adjusted and that some of the questions would work better as prompts in case the issues were not brough up by the participants (adjusted version found in Appendix A, A04 Interview Guide).

The questions first touched on the participant's background, work responsibilities, organization's profile, definitions of sustainability and digital technology, this was done to build rapport and also ensure that their practical experience would make them fit for my research. Then I brought up issues related to sustainability implementation, digitalization impact on sustainability, digital technology breakthroughs for sustainability, ethical concern, design of technology, and examples used in practice. Since I suspected that some of these questions could be perceived as being compromising in their answer, I tried to introduce them with as much neutrality as possible. Whenever I felt that their previous answers already covered one of the following questions, I omitted them unless it was necessary to clarify. It is important to say that while they were asked their own opinion about these topics, sometimes they referred to how the business firms they work with as clients, customers or members of their clusters understand these issues, and sometimes to how they as practitioners understand these issues. Whenever relevant for the analysis, if I know the difference, I make note of this in Findings and Discussion. I still consider these to be coherent views on how these issues are perceived by them.

Regarding three areas where I wanted to elicit a deeper conversation about their practice, I created and shared with participants three visual aids (Appendix A, A05 Interview visual aids). Each of these three slides included a set of concepts for them to discuss: the use of a sustainability focus on areas of business, the use of strategies and models for sustainability, and the use of standards and certifications. The sources that I used to collect information

for the slides were mostly inspired on industry publications (A4S, 2022; C&S, 2020) and intended as a conversation aid. My goal was not to discuss in detail these extensive lists of concepts, but rather present them in a thematic way so that the participants could choose which ones they wanted to talk about and provide examples of from their own organizations. This ended up working well. Participants often elaborated on these issues in more detail than during other parts of the interviews.

Each of the 7 interviews lasted between 55 and 70 minutes, with all participants agreeing to extend beyond the original time (one hour) when requested. 6 were done remotely via Zoom, since the participant's offices were outside of Oslo (except one, whom I met at their office). Participants agreed for interviews to be recorded, and they were told that even though only the audio component was going to be processed, the software only had the option to record audio and video at the same time, and extraction of audio after initial conversion of the files. Participants confirmed their consent, which they had also signed in the corresponding consent forms.

Coding and methods of analysis

I used the f4transkipt software to create an initial transcription, and then manually corrected interlocution against the audio files. Then I used Nvivo for creating an initial round of coding of the interviews based on the topics that I had included in my interview guide.

Following Braun & Clarke (2021) I used thematic analysis as a method for detecting, organizing, describing and analyzing themes I found in their answers, as reported in Findings and discussed in the following chapter. My research process can be characterized as inductive/deductive thematic analysis (Fereday & Muir-Cochrane, 2006), given that I iterated between both modes as I understood better the data and the literature, yet my interview questions reflected an awareness of topics that I expected were going to be relevant in the analysis (and as such, not truly grounded theory fully without expectations or assumptions of themes that would emerge). While I proceeded to read the responses of interviewees several times and did several rounds of coding their answers, as are the guidelines for this method in exploratory qualitative research (Guest et al., 2019), given my previous knowledge of some of these topics, I don't consider I could approach the interviews with a fully grounded theory approach. The inductive/deductive mode was a better fit, as it was possible to have a flexible structure for coding as the analysis developed,

not strictly guided by a codebook since I was not anchoring my exploration on specific assessment tools or a deductive approach to prove theory. Working through the data, these "a priori" codes, were complemented with new codes (inductive), and informed the need for a revised, in-depth engagement with the literature. After this engagement, the analytical framework was developed and used in the second stage of the analysis.

Ethical considerations

To conduct my study, the following personal data was collected with consent from interviewees: name, contact information, online identifiers, voice on audio recordings, and following the legal requirements of the GDPR. Participants were informed of this prior to the interviews and reminded of their right to withdraw consent or exercise their rights about their data at any time during or after the interview too. During the interviews they all confirmed consent. They provided job descriptions in the interviews, no sensitive data was collected, and the identities were anonymized in the final report, to protect their privacy. The audios and transcripts were stored and handled at UiO servers. The information is scheduled to be deleted after defense of the thesis (January 2024). A copy of the agreement (Ref. #169712) and the notification form registered with the Norwegian Social Sciences Data Services (SIKT), as well as the consent form given to interviewees are found in Appendix A.

Limitations and reflectivity

My research has several limitations. The first is that the interviews were conducted in English and this is not the native language of any of them, nor mine, and which could lead to difficulties for them in expressing their ideas clearly. The time and resources available also meant that only a small number of participants were interviewed, which implies that these results cannot be generalized. This limitation was also reflected in the scope of the study, as it is difficult to engage deeply in the many topics that arose in the interviews. However, the open nature of these interviews also provides valuable insights to explore similarities among the responses, which is a strength of using thematic analysis as a method. This approach was preferred as this is an exploratory study of personal perceptions in an emerging field, and not intended to test theories using cognitive instruments more appropriate for established areas of research.

Doing thematic analysis as a method also implies a certain degree of bias. While I am focusing on the themes I identify, the coding process prior to the themes involves a subjective valuation of topics that leans towards my own interests and knowledge. As much as possible, I engaged with the material with an open, neutral, and reflective attitude.

My interest in this topic is based on my work experience in government in my country of origin, which put me in contact with policies aimed at engaging different stakeholders, but mostly private firms, in the creation of infrastructure for encouraging interest in science and technology among high-school students.

4. Findings

My thesis aims to explore the perceptions of selected facilitators of industrial innovation about the complex interaction of sustainability and digitalization. For this purpose, in this chapter I present the answers collected through semi-structured interviews and coded through inductive/deductive thematic analysis. The perceptions of the interviewees were explored using this method for patterns and themes, and this led to organizing them around three main themes: 1. definitions of digital technologies and positive applications; 2. tensions of sustainability and digital technologies; 3. management of tensions. The second theme was mainly analyzed in terms of where these tensions were perceived to be: in the negative outcomes and risks, in structural barriers, in misalignments of values and purpose (including questions of consumption, responsibility and artificial intelligence), in the difficulty of defining sustainability. The third theme was mainly analyzed through the general strategies used by firms, and through the work with intermediary organizations. In the following chapter I will discuss the theoretical and practical implications I see in relation to the academic debates of sustainability tensions of digital technologies.

As discussed in the previous chapters, there is a difference in work objectives between the cluster facilitators (interviewees 01-04), the catapult facilitator (interviewee 05), and the business consultants (interviewees 05-06). The last two, are assumed to be more focused on providing strategic business guidance to their customers, which may include developing capacities for sustainable practice, but under a principal goal of enabling business competitiveness through digitalization. The other facilitators (clusters and catapult), work at organizations that provide these services to some degree or another to members of their cluster, but these are assumed to be part of a range of services where open innovation practices (such as developing the networks of the clusters, exposing companies to one another, or making them work together in projects with mission-oriented goals) are common. In the case of the catapult this happens because it is, by itself, the physical space where these activities happen. The innovation intermediation functions in terms of open and sustainability orientation also vary among the clusters and the catapult, but when facilitators 01-05 talk, the role they play as developers of networks comes to the surface and the conceptualizations used, or the examples provided also tend to be contextualized for the collaborative and sense making role they play. Facilitators 06 & 07 also provide a

distinct and contrasting view that seems to reflect the kind of one-on-one relationship they would establish with clients, which may also provide insight into how the challenges of sustainability and digitalization can be perceived from a business practitioner's own vantage point. Appendix B contains fuller quotations of the interviewee's answers, as coded by me under the following themes into corresponding tables (though several have been redacted to maintain anonymity).

1. Definitions of digital technology and its positive applications

The second question in the interview asked for a definition of digital technologies. In this question I didn't ask about specific digital technologies, or for them to explain them in terms of sustainability, nor did I ask about digitalization as a process, however sometimes this was prompted when their discussion touched on these topics later in the interview. While most gave a concise answer about digital technology, the relationship to sustainability came up when the interviewees explained how specific technologies (or the process of digitalization) are being used for sustainability goals or discussed in terms of tensions (the following theme) about these goals, so this was included in this theme.

All the descriptions of digital technologies and their impact ranged from neutral to positive in terms of the efficiencies they brought (except for artificial intelligence, which is a subtheme discussed separately) so they are included here (Appendix B, Table B01), but the analysis of whether they are discussing the actual framing of technology (and my interpretation of a positive description as framing itself) will be part of chapter 5. The potential of digital technologies is also included here, and this includes positive developments in other fields that are expected to be beneficial when fully mature, or when transferred to other domains, or when a barrier is removed. Some of their descriptions also reveal tensions between these technologies as tools and the goals for which they are used, but I isolated the more descriptive concepts and its attributions for this theme, and the tensions for another theme because they seem to be distinct in their answers.

Some interviewees said these were mostly the electronic tools and automatic systems designed to collect store and process data, from computers to social media. Sofie qualified the answer to her organization "for us internally, that would be making data available on our activities, all our projects (…) dashboards, having charts and graphs and making that accessible to all the employees" but because she doesn't work with defining sustainability

measures in her firm, she said she just receives these reports "so I can get information on how (the firm) is improving their KPIs on this" and that she sees it's the same process with her customers, "there's a lot of reports coming out (…) so technology is helping in making this information easily available to people." (Table B01, row A) Now, Emil, said that data is "no longer just data, because of the huge size of it" and how the technology itself was "helping us all using data in another matter. So digital and digitalization is more about helping data delivering the best way of making decisions, not as it used to be." Where data as only a "component, not the substantial part of it." (ibid., B). On the other hand, Ingrid, whose projects work much more with digital transformation and application of A.I. in business, says to that specific question, that it is a tool "for humans to be more effective…" but points out that "it is important we look them as tools and not a goal in itself, it is a tool to make change and we should do it the right way." She doesn't make a link here to sustainability or ethics, as she does later in the interview when asked about decision dilemmas, where she says that "we have to acknowledge that digital technologies are tools for achieving something and it's the something that has to be evaluated and of course you can discuss if this digital tool is the most effective tool we can use" or whether we have different ones that "takes into account sustainability for instance." (ibid., C). However, Tobias does say in allusion to the SDGs: "they are an enhancement, a solution for several of the, is it 17? Sustainable targets we have (…) so we need to use technology as a tool to solve a lot of these issues." (ibid., D). To this question Ada asked if I meant digitalization for sustainability purposes, and I told her that whichever definition she wanted to give, so she elaborated: "it's important to do digitalization, to reduce the raw materials in a better way. For instance, in the process industry this is very important." (ibid., E). Later, when discussing industrial digitalization, she used a reference to the Industry 4.0 and 5.0 paradigms: "…that's why I like the industry 5.0, more than the industry 4.0, in industry 4.0 the forest you can say is the optimization and robotization, but industry 5.0 is collaboration between robots and digital technology, AND people. And I think that the five is definitely a step above the four."

The facilitators described cases of positive uses of digital technology for sustainability (including A.I.) when presented with the visual aids (Appendix A., document 5) to prompt discussion of: business functions where the firms they work with in their networks find opportunities for sustainable practice; whether the firms use deliberate strategies to be more sustainable; or their thoughts on the role of regulation and voluntary standards. Some of

them offered these examples in their answers, and some when prompted by me if they thought there was a specific application that had had a significant benefit in sustainability.

Some of the answers given by Ingrid included the use of AI to monitor power lines and reducing time-consuming and dangerous work for people (Table B02, row A). to count biodiversity overtime with a higher reduction of margins of error compared with having scientists on boats, or for optimizing the meat industry to save at least 3% of waste meat. In this last example, Ingrid also comments "of course, you can discuss if you want to make the meat industry sustainable but I think we do because it's cultural and we will eat meat. So I think it's a great effort." Eirik explained that digitalization in healthcare provision has had a big impact to lower the need of human resources, raw materials, and transportation. That virtual and augmented reality helps in "avoiding long travels of patients, increasing capacity of existing surgeons for example that can do remote surgery" as well as increasing training of staff and therapy done at home, such as rehabilitation for mental or physical health disorders (ibid., B). Tobias explained that carbon capture, digitization, the Internet of Things, because "we're going to solve a lot of things with digitization and virtualization." He also mentions "drop-shipping" which I didn't include in my slides, as "more sustainable for some companies" since it doesn't go into a warehouse. (ibid., C). After saying that digital technologies were very important for the process industry, Ada explained that "if you have raw materials going into a melter for minerals, metals, (..) recycled materials will often have a broader variation of input material than (using) mined raw material or virgin raw material, and you need to measure these variations" and how A.I. is used to process the data to calculate how to adjust instruments and make it possible to use these recycled materials once again. (ibid., D). She also explained how digital twins were very important from a "production perspective" because it allowed to have a digital replica of the whole process, production line before doing it in practice, plus also being able to "build digital prototypes."

Emil, whose firm provides digitalization consultancy, says that "we use as a rule of thumb that digitization is in itself a sustainable contribution to the world." That when you use digitalization to optimize all platforms and tools available with AI and others, they are "in itself a contribution." That digitization is important to consider for being more sustainable because of its "higher effectiveness" besides other factors that could contribute to it. (ibid., E). When prompted to point out to a specific digital technology or strategy that could be very significant, he said that "things go fast and slow at the same time. So, what could have

been a big change six months ago wouldn't be anymore now." But that he would say to use "machine learning algorithms for optimizing is extremely effective," and he explained their use of AI to optimize grids, to balance surpluses of energy and electricity across countries, for time or regional dimensions, and that there is a "revolution now for data engineering from more technology platforms" but also that these insights are not "easy to discover unless you are very much into it (giving) double digit efficiency gains on using those types of technology," that "we have just started. Many would think that we have control over that area. We don't." and that this is important because of how expensive power utilities are now in Norway, and that every gain you get in an industry like that "is good basically," also because it reduces the need for more gas.

In discussing positive applications, sometimes the examples were of potential or future applications that were not happening yet. Eirik said that there was "a lot of attention given to personalized medicine and drug development," so that medications could be targeted not for specific conditions but "specific conditions in a specific person," and this was relevant because only in cancer therapies "only 30% of the drugs that you take actually have a strong effect. So most of the drugs, they're either not doing anything, or then they're counterproductive." So these developments could not only "reduce the amount of drugs first and also side effects" including hospital follow-ups, so these are all "environmental, sustainable and societal impacts…" (ibid., F). Another example of potential applications were mentioned by Tobias on how the seafood innovation cluster is working on making fish farmers "more sustainable", one of the maritime clusters is working on "carbon emissions" and another company helps people to reuse "steel, concrete, everything, when tearing down a house." In discussing the link between digital technology and sustainability, Emil said that we are just seeing the start of a "huge industry with global investments (…) of 5,000 trillion dollars when it comes to the green shift," and that half of the investments required to replace fossil energy with more sustainable energy would go into digitalization. And that there were two aspects to this. The first was that there would not be a green shift unless we have "the best way of using technology and digitalization" and the other was "seeing what kind of technology you put in this," including the best way to use ML/AI, and other efficient ways of "predicting, using and optimizing beyond the human capacity." (ibid., G).

2. Tensions of sustainability and digital technologies

In the interviews the facilitators were asked about whether they thought there were barriers to sustainability in digital technology. This usually led to diverse answers that either mentioned barriers as such, or in few cases, the direct negative outcomes of digitalization. Sometimes they described these barriers as challenges, difficulties, or issues, and sometimes this happened after I prompted a follow up question on whether there were risks, dilemmas, or concerns involved in these situations. But in all the interviews, in part due to the questions of the interview that asked for specific examples or situations, at some point they all gave detailed pictures where either the firms they provide services to, or themselves as facilitators or intermediators working with these firms, encountered tensions in sustainability. This usually happened when they described how the firms, or their clusters, managed a situation. In this theme I've included how they describe these tensions and organized them according to what I think is their main characteristic. Many of the answers could be placed in several categories at the same time, but they will be discussed where they make more sense. The four main areas discussed by them can be grouped as: negative impact (environmental outcomes, risks to data infrastructure), structural barriers (competence, markets, governance, norms), issues of misalignment (purpose, values, responsibility, consumption), difficulty of defining sustainability. While their discussion of A.I. also relates to all the other tensions, I decided to place it separately as a subtheme because of how discussions of it seem to emphasize significant risks in its deployment, in contrast to other examples of digital technologies.

Tensions perceived in negative outcomes and risks

When asked to describe challenges or risks to sustainability brought by digital technologies or digitalization, Ingrid said that they relate to the direct environmental impact of storage of large amounts of data due to "excessive copying of data" in the cloud which demands a lot of energy (Table C03, row A), but also to "how you use technology and for what purpose." She also says later on that energy will be an even larger challenge for digitalization in the coming years. While all interviewees offered perspectives that reflect tensions related to purpose or values, they were usually discussed separately from the environmental question, and she is the only one linking these issues in the same answer, so these will be described separately. Related to this, Emil (from the consultancy firm), when later prompted about whether he saw increased consumption as a dilemma exacerbated by

digital technologies says that while "most people would think" that the largest "CO2 footprint (…) is producing the algorithms running the technology, storing data, (…) actually, most CO2 consumption is done by the end user level because the sheer number of devices is so huge (…) got me to think that this is not an easy dilemma" (ibid, B).

On the other hand, Tobias says that discussions he's had related to "sustainability within IT" have only been about the source of the energy required or the waste generated; he later also mentions that there are companies helping with sustainable reporting with digital tools for other firms, but that discussions are about the use technology to be more sustainable, not about "making technology more sustainable itself" (ibid, C). However, later in the interview, he explains that "of course there will be some negative impacts" because of the unemployment caused, "but mostly we see that the effectiveness created is positive." Ada, whose background is in engineering, says that "the only risk I can see is a more divided society (…) if you can't make sure digital technology is something just as basic as mathematics or languages that you learn at school" (ibid, D). Four of the interviewees mentioned cybersecurity risks, in terms of threats to data and data-related systems or infrastructure, as a challenge. Sara said that "everyone talks about cybersecurity" and data privacy, because of the consent required from customers of using data generated by sensors in industrial equipment (ibid, E), while Eirik says that cyber security is in everybody's agenda, and that every once in a while, data is being leaked and then "some people's private life being hurt because a digital solution was not fully functional" (ibid, F). Regarding cybersecurity, Tobias said that there are always risks, as "routines and code standards" are needed to create security, since there are always "companies or individuals that trying to destroy or do harm. And that's a big challenge." (ibid, G)

Tensions perceived in structural barriers

Tensions related to structural barriers seemed to be described by the facilitators in a few ways: those that pertain to competences and market pressures (Table B04), those related to regulations (Table B05), voluntary standards (Table B06), and those related to norms and cultural practices (Table B07).

Tobias and Emil referred specifically to a lack of technical competence as a challenge for sustainability. Tobias said that the shortage of digital developers in the market is the "greatest problem for all industry in Norway" (Table B04, row A), but it was unclear if he

links this clearly to the use of digital technology for sustainability goals. Emil, on the other hand says there is a lack of "insight into what technology actually could do," and if those taking decisions lack the "the competency or lack the will to actually get that competency, that will be that is a huge barrier for using optimized technology to help on sustainability," that the barriers with emerging technology are about "who is making the decisions and where this takes place." (ibid., B). All the other interviewees allude in some point to the lack of knowledge about sustainability in firms and how this relates to their decision-making in business, but the emphasis was placed on other aspects adjacent to that lack of knowledge which are discussed further in this chapter in this theme, or on how either the firms or the facilitators try to bridge that gap. All of them also mention the difficulty of having business models for sustainability, as Ingrid says: "companies are struggling because it's hard to make great business models that really they can profit on." (ibid. C). But some of these pressures are not only related to making profits. Part of this struggle is related to adapting to the ESG requirements "from the market itself and the customers" in the right way, says Emil (ibid. D), and that it's a big challenge for some industries which are more "adaptable to obey or align" to these if they get even more pressure from the market and customers. When prompted about whether they do research on sustainability impact or perform beyond regulatory requirements, he said that they strive to be as compliant as they can and beyond but "not doing anything else needed in the competitive landscape we are in," (ibid. D) yet some of their many customers have projects related to circular economy or dashboards of C02 emissions. Sara gives an example of how market uncertainties can discourage sustainability proactivity when explaining (at different points in the interview, elaborating on the same example) how a maritime firm started experimenting with getting back from their customers some components with a long lifespan in order to refit them and then put them in the market again. However, this company found that there "was a lot of work" in assessing, cleaning, repurposing and storing these products was much harder than they thought and they haven't found an actual market where customers would buy these back, and uncertainty of how to proceed, so "they still haven't found a solution, sadly." (ibid. E). Another facet of these market pressures can be seen in the funding of healthcare in Norway, according to Eirik, who in his discussion of cultural barriers to sustainability with digital technologies, mentions the competing incentives of different actors such as the insurer who would be interested in patients getting the best care possible from the first time to reduce readmission of patients which is costly, against the interest of hospitals who are paid by the number of patients that go through the

door, which in turns creates disincentives to innovate in “practices to reduce number of patients” even if everyone is interested in doing the right things (ibid. F).

All the interviewees explained situations where governance aspects seem to be an important source of tension. They gave examples of how it can act both as a driver and a barrier, playing a central role in orienting a firm’s behavior towards sustainability, but there were also instances when there was a mismatch between regulations and the reality of practice in their industries, where there was a need for regulatory measures to establish guardrails for action, or where there are gray areas related to normative pressures or where other aspects of norms or culture that may seem unrelated to sustainability become barriers themselves. Two facilitators discussed the disincentives to circularity of strict or costly regulations. When discussing strategies used in the maritime industry, Sara said that many companies are suppliers to the shipping industry, so “requirements are very strict,” as some components are used in oil and gas or in vessels. So, because their production strategies are “engineer to order” the companies are afraid that the “class societies” who do physical verification of products may not approve of reused components, which in turn makes them averse to exploring the development of circular markets (Table B05, row A). In turn, Eirik explained when discussing the use of certification standards, that remanufacturing for “closed loops” and circular supplies for circular economies was a “no go,” that very few companies do it in part because with medical devices the design, including “all the materials, quantities, manufacturing process, everything (…) gets locked in for several years, you cannot change it,” because it costs “a couple million euros” and changing them is needed for recertifying according to continuous improvement standards such as the ISO certifications, that are audited yearly, so companies don’t do that and instead focus on the supply chain, packaging, or the use of devices,” but even that can be challenging, given that many things “need to be individually packaged,” that it is not necessarily a lack of will, but the clinical trials required for certifying a medical device make it hard to modify products for sustainability after they have been put in the market (ibid., B). Ada gave an example of EU regulations that impede using goods already categorized as waste as new raw materials, of how in the process industry “car tires could be used as a source of energy instead of coke” (high-carbon coal-based fuel), but this is not allowed because of CO2 released which still happens with coal, and then she says later, some companies end up dumping tires into the fjord (ibid., C). Eirik in turn explains that in healthcare GDPR can also be a barrier for “facilitating innovation” through the exploitation of existing data in

hospitals because even if data is anonymized, consent is required by patients and much of this data was collected from before this regulation, which also crosses with ethics regulation and the medical devices regulations, so the opportunities to use this data are lost (ibid., D).

Nevertheless, they all mentioned at some point that regulation is also an important driver for sustainable behavior in their industries. Emil said that sustainability is an important part of his job because his firm is a "listed company" and they are aware that ESG is a driver for putting value in the company, that their customers use it as a criterion, also their employees (ibid., E). Tobias, at some point said that regulation that is not appropriate for all the processes can be big obstacle, but that it also should help digital technology "go farther,", yet that it is hard to classify specifically what process can be digital and what not (ibid., F). One of the benefits of upcoming regulation, said Sara, was that the mandatory audits with the CSRD will provide verification that companies actually assessed their impact and are reporting on it correctly, so that it is no longer "it's not something you just guess or is done just once", because apart from the LCAs in which some companies have competence, she doesn't think companies can do it themselves (ibid., G), even though they have been facing pressure from customers of adopting international standards. They all consider the EU Taxonomy a significant governance tool, and all the firms they work with are concerned about it, it's seen as a "a very important tool" to push the industry in the right direction with "regulations that are actually possible to fulfill" (ibid., H), it's also "really exciting" for Ingrid, but she is concerned that while they say "capital will flow naturally towards sustainability choices," that she doesn't know if they will disadvantaged if China or the USA don't act too (ibid., I). Sofie points out that actors in oil and gas may be struggling with understanding it (ibid., J), and Tobias is in contact with a company that develops digital tools for taxonomy reporting (Table B06, H).

When discussing voluntary standards (Table B06), all the facilitators explained whether they were appropriate for their settings. Regarding different ISO certifications, Ingrid said they are quite good "but challenging for small businesses" (ibid., A). Eirik, who said he has experience with them (for software, energy, environmental management, medical devices) also says they are very good for continuous improvement, but that the "huge hype around them, 15, 20 years ago" has dissipated, and that they are underutilized in healthcare due to the high costs associated with strict regulation (ibid., B). Miljøfyrtårn (the Eco-Lighthouse), "has been the most used in Norway," but it is not clear that it provides continuous improvement towards more sustainability, so Ingrid's organization chose not to

certify with them. Sofie says that Miljøfyrtårn and the Nordic Swan are more relevant for consumer goods, and that the automation industry is quite familiar with some types of standards regarding quality, and that they have work processes that facilitate them to handle new types of standards, to integrate into their workflows, but not necessarily to adapt them for sustainability assessment, and "she hasn't heard of anyone using them as such", but that customers are uncertain of how to report their sustainability KPIs (ibid., C). Eirik mentions that some of the standards presented have probably never been heard of in Norway, but this is also because some countries and continents "adopt much more some trends" (ibid., B). When prompted about the adequacy of standards for measuring purposes, Emil elaborates that they are a good driver, but "never been actually measuring the right thing," but that it is a matter of perception. That perhaps the Nordic Swan is one of the most accurate, given that it has survived in the market for so long (ibid., D).

This uncertainty of how to report for some of the standards is also closely related to their views on the SDGs. They all refer to the SDGs in positive terms with skepticism regarding their implementation and association with corporate greenwashing. Ingrid says they are "of course very useful, but not easy to make concrete in companies and very easy to use them for greenwashing, interpreting them as it suits you." (ibid., E). Eirik says they are "too general" and that all companies are "kind of obliged to mention them" but once you talk more with them "most people don't know what they are and how to report on them, but it also depends on the products (ibid., F). Sofie says that it is interesting that sustainability reporting is "becoming a business" in itself, and that she sees a lot of customers using a handful of SDGs in their strategy work or corporate presentations, such as a firm working in wastewater management who says they are "helping ensure safe and healthy water for everyone" (ibid., G). Emil also said that the SDGs are not something he would consider measurable, "the 17 and their 164 or so index," that he has never seen them used that way, only as a stamp of recognition and a "way to categorize the world" (ibid., D). Tobias said that in the cluster itself the SDGs are not being used, but they are "for a lot of other projects," but when prompted about their adequacy, he said he doesn't know if they are such, but he sees a lot of companies using them (ibid., H). Ingrid said that it is easy to forget that the SDGs are "not so much about how a company can make things better in Norway, but about what goes on in less fortunate countries," so that "practices that activate the SDGs" are key, but it has taken a while to figure out what that means for Norway (ibid., E).

Some of the previous answers prompted direct follow-up questions regarding the role of culture or norms as barriers to sustainability in digital technology (Table B07). To this, Ingrid said she thought that "we are poor at adopting technology and taking care of the value we create", and that some said this is at the core of why around 80% of AI projects fail. But also, that too much data in Norway is "siloed" without a culture for "sharing company data openly," which she said has developed after building many proprietary systems and silos in a mature digital society such as Norway. A solution to this would be to "break the silos, to share data on a higher level to solve sustainability issues" because it is all about the value chains and how to use resources (Table B07, row A). Sara details how she also sees this reluctance to sharing industrial data among firms that distrust other members of their geographical cluster, that these companies are interested in refurbishing products and components, in leasing, but then it becomes complicated because they are "not there yet" for industrial symbiosis, even when the most sensitive data is left out and they have been told several times how this could work (ibid., B). Nevertheless, when discussing the Digital Passport, Ada does not reflect on this as an issue, but more of an opportunity to bring circularity to manufacturing. Sofie in turn, said that while she would understand why open data and open innovation practices could seem threatening and undesirable for specialists working on operations in oil and gas, these are practices that is more and more common in different places.

In healthcare, according to Eirik, an important barrier is the "conservatism of the sector," yet "digital technology is at the same time a problem and a solution" to the difficulty of changing work practices in hospitals. He believes most people in the healthcare communities would say that staff can be the biggest obstacle for innovating in hospitals, because they have "very tight protocols and processes," which in turn is due to regulations. So, one "needs to bring them on board quite early (…) massage them" to think about the value they will get from a new digital solution or change to processes such as clinical validations. This is such a strong factor, that one company he knows works specifically with staff practices and of hospitals sharing usbs (ibid., C). Finally, when discussing limitations of technology, Emil makes reference to global governance issues, and says that while he may sound like a technology optimist, he is not that, and that "the world alignment on politics is something I don't think technology will help at all," that how the world cooperates for sustainability and in particular the climate part, it is a big challenge where

technology may not play a part. However, he points out that in some industries, digitalization works really well, such as finance and banking, and energy (ibid., D).

Closely related to normative barriers (and to the following section related to barriers in misalignment of values or purpose) is the issue of a techno-optimistic outlook as a possible obstacle to understanding the challenges of sustainability in digital technology. This question was prompted as a way of deepening or even clarifying the discussion when digital technology was being described in positive terms, but at the same time the barriers mentioned by the facilitators seemed to include aspects of technology itself. Eirik said that he didn't think the problems were perhaps related or made worse by digital technology, that it could be that "it's in the blood of every entrepreneur" to see opportunities without seeing the risks, and that they have a "strong bias" to believe in the positive, but this is in contrast with the regulation driven stakeholders that "look at the negatives and the challenges" (ibid., E). Emil did say that "obviously" it could be a problem, that we have a tendency of only seeing the positive parts (ibid., D). Nevertheless, Sara said she didn't think it was an issue, that technology is one of the enablers of sustainability, "not its own enabler," and it's good for companies to know about how to use it, but this would not prevent them from seeing the negatives (ibid., F).

Tensions perceived in the alignment of value and purpose

A different set of tensions emerged in the interviews when the practitioners were discussing either barriers or limitations of digital technology that could be characterized as issues of values, or of purpose, where: these are not aligned with each other for a specific technology; the values between different stakeholders (designers, business owners, end users, external groups, or even society at large) are not aligned; or determining responsibility (from accounting for it at the early stages of design and development, to the deployment of technology and its outcomes) is not clear or easy (Table B08). Finally, I have also included here their responses to the dilemma of overconsumption (Table B09), as I consider it too a tension related to misalignment of values because the efficiencies in production enabled by digital technology can lead to increased consumption that is not offset by the claimed digital efficiencies.

Discussing barriers to sustainability, Ingrid said "I think it's what we use the values for." However, because she had previously mentioned how there was a culture of not taking care

of the values created, it is not so clear here whether she meant using an axiological system to determine which values are important (such as ethics, care, responsibility, preservation, or other principles), or (perhaps more likely in the context of her answers) values produced by business activities that include both material goods and services, and values of intangible worth (wellbeing, fulfillment, knowledge, reputation, convenience, etc.). She goes on to say that the "economic system" might be a barrier for creating value, and not just for technology but "everything we do," as we need to have incentives to produce "other values that are not monetary," and here, she touches on the topics of responsibility and consumption, as she says, "we need to make different business models profitable (…) closed-loop circles, so companies start to push these to customers" or, to maybe have a business model that "makes sure that when we have increased revenue, at the same time we generate less CO2 emissions, or something else that is relevant for sustainability," and focus on using digital technology as tools and not goals in themselves, for which business owners "have to have the discussion" of what sustainable impact would it have to increase revenue and push more products (Table B08, row A).

Later on, when discussing the silos created for data in Norway, she bridges the relationship of data creation with responsibility awareness of its exploitation and governance, as she says that barriers can also be "the data ontologies, because there are different measures everywhere" and that the "challenges start with the ungenerated data"(…) because we have to be conscious of "how we develop these assets (…), who developed the models and how we deploy them." Because in the end, there are "so many obstacles here and traps there (…) in every section," that one can solve a lot of problems with technology but "we need the right system" (ibid., B). A similar perspective was offered by Eirik who previously described the conservatism in healthcare practices and regulation for sharing data, while saying later that "bias is an issue very present" in Norway's databanks due to them being so "unparalleled" in depth, reflecting a population that was historically very homogenous, but whose data reflects this bias too (ibid., C)

Tobias, Sara, and Ada, while not directly referring to values and purpose, said that a limitation of digital technology is that it cannot replace humans, their decision-making or expertise. Tobias explained that this technology can solve many different issues, but what it cannot do is "mindset and management (…) putting competence building on the agenda," that only people can do it (ibid., D). Ada referred to how the competence of welders is still necessary to guide robots and input technical information based on their experience (ibid.,

E). While Sara said that in an experiment where cobots were being considered for work in furnaces, they realized the precision of workers, who know how to get very close to the extreme heat without wasting the metals, can't be replaced by the cobots which are not resistant to heat (ibid., F).

When prompted about whether the design stage of digital technology, or other stages (development, deployment, scaling, review), would be the most relevant to address these issues, they offered varied perspectives. As mentioned before, Ingrid considered all the stages have their own challenges, but emphasized discussions were necessary from the beginning. Eirik said that "as early as possible" into the design because it goes back to the regulatory boundaries which several companies don't even consider when they start developing products unilaterally without talking to customers or "documenting all the design, ethics or privacy considerations" and then they "have to go back to the beginning" (ibid., G). Sara also said that "from the very beginning", and not only consider the environmental and social aspects, but also the economic "to a really high extent" (ibid., H). Ada, referred back to her previous examples of composite materials, since it is difficult to make products that can be recycled that don't blend materials together, so "design for quality, in recycling, is very much an issue for us," while also, one needs to consider "all the input" given to the machine, including the data, because if you change your production line and you use data from the previous line, it is outdated, and "the data analysis will be wrong," and one has to be careful, the same way when one "reads an article in the newspaper (…), who has written it? What is their intention?" (ibid., I). Emil pointed out that "definitely in the design phase, obviously," that they are aware of it and working hard to convince customers to always "take a step back in the design phase," for several reasons that could be sustainability, or optimizing the running costs later on, or risks," and from experience over the years they know that rushing the design phase "is not very smart or profitable." (ibid., J)

About the related topic of attributing responsibility, when prompted whether voluntary standards were adequate, Sofie said she didn't "dare to make a statement about that," but that we needed to start somewhere even if it "may not be 100% correct." She shared how she has "heard there's different ways of calculating it," and depending on that, "do I see my responsibility from here to here, or is it only here? What kind of impacts? this is based a lot on the numbers." She remembered that one oil and gas customer presented different ways to calculate impact and "how beneficial each of these results would be for them," and

whether to measure the whole lifecycle of equipment bought, or from production to end of life, or only time used in the field. That while maybe "someone would probably misuse the reporting numbers, hopefully only a small part of it," that no serious company would allow for that (ibid., K). Another point was raised by Ingrid, when she explained that in artificial intelligence sometimes it is "out of the hands of the developer, because it is when you apply it (digital technology), when ethical risks are there of course," and while these can be "built-in already in the solutions," when you apply them is when the "value or the harm is created" (ibid., L).

Finally, all interviewees were asked at some point if digitalization was enabling more consumption, either purposefully or unintentionally, and if so, whether this dilemma had a solution. All of them said this was a dilemma but approached the issue from different angles. Ada directly linked this to how "marketing is always a dilemma," of how in Norway marketing specially targeted to kids has been banned, and that there are discussions of what should be legal in exploiting users' browsing data in webpages to suggest more purchases, so this is a dilemma about what should be regulated (Table B09, row A). Later, as she brought out examples of how to work with the firms on long-term thinking for sustainability, she said that sometimes manufacturers think of how products could be repurposed and sold at lower prices, but this can be based on how they wish customers might behave without properly understanding how these consumption behaviors actually are. Sara said that "it is really a debate, how to reach a balance" because with sustainability we are "encouraging or discouraging overconsumption, the rebound effect," but that she didn't know how to reach that balance (ibid., B).

Eirik said that it "certainly can be solved, but we cannot expect technology to solve it." He described the common scene of morning commuters glued to their phones in public in part because there is an industry selling our behavioral data, which is exploited in a vicious cycle of consuming both more information and more digital devices. That digital technologies are used to enhance the problem, so the solution is in behavioral change that needs to be "affected in the right direction." Then later he linked this to greenwashing, where he explained that it typically happens because the average consumer "doesn't understand the lifecycle implications," and there are different factors at play. He offered two examples: that in Norway where there's many electric cars, these are not be the most sustainable option if used for less than 300,000 km given their manufacturing impact; and that he knows a company that produces a healthcare component that used to be discardable

and can now be sterilized and reused, yet the hospital workflow hasn't been changed so the staff knowingly still throws it away, the institution buys them because they are reusable, but the manufacturer knowing all this has no incentive to intervene as they would sell less (ibid., C). In that vein, but with a contrasting point of view, Sofie said that while perhaps consumers of retail goods would be easier to "nudge or to bait," through digital technology, that this was harder to do from business to business and she hadn't seen digitalization used like this yet, but since industry usually "tries to follow" what is done in consumer business, that she assumes they may have "similar discussions later" (ibid., D). Emil said he didn't think this dilemma could be easily solved as this reminded him of his previous example of how the end users of digital devices have a larger CO2 footprint than the data storage centers, so perhaps this required to make easier, more accessible, centralized data centers (ibid., E). Ingrid said it was a "two-sided story" that was challenging because we "often stand in this dilemma where digital technology has been used for increased consumption," because it can be used to "optimize value chains," but also to "push more products or make people want more, or marketing that is more effective" (ibid., F).

Artificial Intelligence

Discussion of artificial intelligence happened organically in most interviews, since almost all the facilitators work with A.I. in digitalization projects, in some situations more than others. As discussed in Chapter 2, A.I. can have an acceleration effect (by itself or through convergence with other technologies) in the outcomes of its efficiencies, whether negative or positive, and several issues related to this were raised by the interviewees in connection to transparency and accountability. However, some of their examples were not necessarily used to describe digitalization at large and their concerns seemed specific to A.I., so they were grouped here even if they could also relate to the previously mentioned tensions of regulation or values.

Sara's projects are more involved with implementation of circular economies and may be the farthest linked to A.I. compared with the other interviewees, so when prompted whether she thought ethical concerns were risks in A.I., she said she knew a company working with machine learning but "hadn't heard anything about that" concern (Table B10, row A). Sofie said she knew discussions of these risks, but that she thought "AI/ML debates" are still more related to consumers, but not to customers of her industry segment, since

digitalization hadn't come that far yet, and questions were still related to accessing data securely, about problem solving, not even whether algorithms could shut down whole plants (ibid., B). Eirik said he "didn't see a big risk so far," that many people in healthcare think the use of A.I. will be ethical, as many people have "good intentions… for the benefit of the patient," but that there was also the other side of the coin being discussed, he said, that "pharma companies will know a lot about patients and will exploit that," by processing data in real time with A.I. engines to make more money out of single individuals or cohorts (ibid., C). Ada, whose digitalization examples had been so far related to materials engineering for sustainability, said that she didn't think there were such risks with A.I., that "everyone who's used a chatbot knows that it has a limited capacity for thinking about people," and that A.I. will still be limited to the areas where it's been trained on. She says this happens the same way that we get biased, and it is "more obvious when you see it in a computer," then interestingly mentioning the past controversy of when it was used for job hiring process. But that, in the end she was optimistic for its medical applications, because A.I. provides an impressive capacity to do so much more and she expects "breakthroughs in the coming years," and that technologies get better only through developing them (ibid., D).

A different perspective is offered by Ingrid, Tobias, and Emil, who in different ways, say that these are significant concerns. Tobias described a paradoxical approach, where in first instance said that when they talk to firms in his cluster about adopting A.I. they don't discuss sustainability, and they rather create a "bit of panic" (market pressure panic, perhaps) by showcasing different kinds of AI solutions to encourage companies to start using ML or cognitive technologies. But when prompted about whether he saw risks within AI, he said that "of course" there were a lot of problems. "From bias to black box," that we "don't know what's happening here," when we make a black box solution, which isn't tested enough, so it "develops itself and we can't explain why," and that is a "real, real danger," that "if you can't explain it, then you shouldn't use it," that there would always be companies and people using technology for bad, but as long as we use the "Norwegian government or the EU guidelines" on how to develop AI, then it should be no problem (ibid., E).

Emil, also said there are a lot of risks, that "we all know" about, and we see them in the misuse of AI related to "bias, less transparency, less control," and that basically "every aspect of AI is high risk." In terms of transparency, he explained that it's not traceable how

a decision is taken, and this is a big problem, for example, in developing AI robots and weapons, if we know there will be decisions, but we don't know what these were, so the wrong AI is a problem. But that even "without thinking of a Robocop," we see that it creates bias, which is a risk in itself. He mentions "financial risks, human risks," and then in the long term too, it gets scarier when you see what A.I. can actually do now because we haven't yet decided what we should do with it and its limitations (ibid., F). He described risks to the global governance of technology infrastructure, because "we store data in other countries" and we don't know in 10 years "if we will be friends at all." But that physically there's risks to the undersea cables too as they are laid along gas pipes. That there are risks related to surveillance, "like in China, really scary," and also to how we run our governance, politics in the US or the UK," and on a smaller scale as a society, he didn't know whether technology has helped much. Asked to elaborate more about surveillance, he said that it is easy to see regimes like China does now, for extreme surveillance of their own people, which couldn't be done without A.I., and "they develop their A.I. at the same pace" as the West does with open augmented reality. It is unclear here if he meant that China develops AI with a fast pace, perhaps without the ethical concerns that make it slower in the West where other digital technologies can be faster to develop without those concerns (such as AR). But, he said, "not hard to see that in 10 years we would use AI on that area," and China would export their systems to many countries, and here (Norway?) too, but then "in bits and pieces for surveillance with good intentions," but in the end all of us surveilled, which worries him. However, he said, when we think of sustainability, we "really need technology, and take those risks," to reach the global warming targets we have (ibid., G).

The interview with Ingrid, whose cluster brings together actors from different industries and is focused on digitalization and applications of A.I. among its projects, touched on this topic early on, and frequently addressed the topic of misalignment of values and purpose of digital technology, which in the other interviewees, were topics prompted much later. When asked whether she saw ethical concerns as risks in A.I., she said that "for sure it is a risk, which we are already experiencing," because this technology is "scaling impact so much" that it can "really generate large ethical problems." She also pointed out that "data science had not been regulated in the same way as other sciences when it comes to ethics," that only in 2017 ethical checkpoints were included before publishing models or results (ibid., H). When prompted which stage of development would have these issues, she related it to a point that can be concurrent or previous to the design stage, from the action of data

collection itself, from "how you collect… what kind of data." That, when training models on historical data there would be "a lot of bias," and that an example was when she asked DALL-E to create pictures of a "caretaker feeding a child," it only showed her "women feeding children, and not men, because we have inherited this bias in our data," that it was "not the model itself, but the data." Here I asked her whether techno-optimism could be an issue for seeing these risks, to which she answered that "it's a problem when you don't have the right information (…) the knowledge, and someone decides what society should do because it's a trend." But that the solution is "more open information." Later, she said that using AI as a technology for sustainability, as in the case of the SDGs, is complicated because "AI is not a neutral technology at all, and it impacts ethical, moral and environmental factors," but that it can be out of the hands of the developers. However, the "AI Act is pointing towards that," by making all the actors in the value chain responsible if "the system is unethical or it produces harm to some groups (…) not just the developers," but that another issue will also be that countries not as digitized "as ours, will not be included in the technology, nor in the datasets."

Defining sustainability

The first topical question that the facilitators were asked (after being asked to describe their job positions and activities, and their organizations' profile) was to define sustainability in the context of their work (Table B11). This question was chosen as the first one to set the tone and give them space to start exploring these topics and was contextualized from the beginning into the work of these informants to directly go towards their practice and start the discussion from there. Obviously, the work activities of these practitioners are not the same for each organization, but they all described as a major task they were responsible for having to find business or market opportunities for the business firms that were members of their clusters. Ingrid said right at the outset that "so many dimensions and so many flavors" and that she'd like to know more later about my research, because it's a common challenge in their practice. And that the understanding of systemic sustainability is much wider now, but the "holistic understanding" of sustainability varies a lot between businesses, that the economic aspect, which was the main focus before, has given way to a much wider understanding of systemic sustainability; to the point that in some businesses, these are already "hygienic" factors (Table B11, row A). Four of the five main interviewees explained at some point that there were "different ways" to define it, and that definitions

would vary a lot among their clients. One of the cluster facilitators (whose background was in business management) and the consultants defined sustainability as subordinate to a an economic or business case. Another of the consultants starts by describing sustainability in terms of resource efficiency, but soon also says that "maybe it's a difficult subject, but it is also a license to operate for many of our customers." She later on explained that most of the customers in her area are oil and gas firms, and it is unclear if she literally meant that having access to operating licenses meant they needed to pay for compensating mechanisms established by regulation (so there was no voluntary effort), or it was a figure of speech about the expectation of these companies having to present a green profile. Given their role as consultants, she offered the precision that "there are two perspectives (…) internally looking at what we are doing (…) and then helping customer activities on the other side." (ibid., G). And that most of their customers have that perspective too. One of the cluster managers says that he guarantees that "90% of the members" in their cluster would first say it is about having financial revenue and there is more awareness of the environmental side, but this was done with a humorous tone, as if to say that in their role as facilitators, he doesn't think this, but he didn't offer his own definition either (ibid., B).

3. Managing the tensions

As explained in Chapter 3, the objective of showing the interviewees visual aids (Appendix A) that listed business functions, strategies for sustainability and a range of regulations and voluntary standards related to sustainability, was to prompt discussion of how they understood challenges of digital technologies in relation to these topics. While the objective of this thesis is not to analyze whether the specific strategies or functions discussed by them are the most appropriate for a given situation, I decided to group some of their answers as a smaller, shorter theme that relates to how the firms they work with manage some of these challenges (Table B12), or themselves in their own organizations with an intermediary role help the firms with this (Table B13).

Firms managing tensions through their own toolkits

When the facilitators give examples of challenges, they also describe how firms use their own tools, or develop strategies that are constricted by the context of these specific industries. For example, as Eirik mentioned several times, many activities related to

rematerializing that are common in circular economies, are difficult to implement in medical devices due to strict regulations, and these are significant obstacles for smaller companies, but some of them still want to engage in open innovation, and he sees that in how they are keen to share working spaces with other players. He said his industry tries to focus on other aspects related to sustainable purchasing processes and logistics, including having "production close to the source," but that project funding and customer satisfaction are the "biggest drivers" for sustainability (Table B12, A). He described that there is increased momentum in creating health services that are customer-owned, citizen initiatives, and that Norway participates in some research pilots about this with other European countries, but that much of the procurement side is defined by the central purchasing agency in the country.

In most instances of the interviews, however, it was not immediately clear whether there was a deliberate intention to achieve more sustainable outcomes as part of the decision-making of the firms, and it seemed (as perhaps would be obvious given the business setting) that the priority was to achieve economic efficiencies through digital technology, which also gave them leeway to interpret and communicate these gains as sustainable benefits. As Emil clearly states, from his consulting activities, they help customers on their path to certification "if they are working with them on a strategic communication level," otherwise, they work mostly on "physical to virtual," implementing digitalization through "programming, dev-ops, heavy data," and wouldn't be concerned with the standards "at all" yet in the "last three years, value proposition, reporting and value creation" are the three functions where they focus on digitalization, and when helping their customers, digitalization is closer to "the core hypothesis for us in sustainability." And the use of ESG, is seen as necessary because their customers use it "more and more as a criterion," but also their "own employees" want this (ibid., B). Sofie, also in a business-to-business company, says that she considers aspects of sustainability in her own work as an "indirect result" of what they do with specific customer requests, for example, in the reduction of flaring in oil and gas projects (ibid., C). One way of interpreting why firms engage the services of consulting businesses is that it may not be only developing capacities they lack, but also access the expertise of someone who is able to frame sustainability challenges in more accessible terms and incorporate this in their value creation. Sofie says that other than specific customers who have this as their core proposition, she hasn't seen this as a specific request, but they do help customers in the processes of handling the disposal of heavy

equipment that needs to be replaced, and that their offer is mostly on the "physical to virtual" aspects, including predictive and remote maintenance, and that other aspects of digitalization can be part of the sustainability equation as there are "different perspectives" on how their own customers have incorporated this in their strategy and operations. She also says they participate in some of the few carbon capture projects in the world, which would be "oil and gas moving maybe closer to circular economy."

Sara explained that companies in the maritime industry used to be focused a lot in "lean practices," and her colleagues help cluster firms a lot with this, but now companies seem to be more interested in implementing circular economy practices and Industry 4.0, in "physical to virtual" transitions, including experimenting with leasing models. In this case, she described the use of sensors within components that firms no longer buy or own, but that are leased (and this includes agreements on sharing data of the components use with the manufacturer), so that the manufacturing companies can monitor the condition of the products and schedule preemptive maintenance services which reduces unnecessary visits (with operation and transport reduction) and extends the life of the components as much as possible (ibid., D). She said that, besides the efficiencies created, one reason companies are using Internet-of-Things practices like the sensors is that they "make more money in the after sales services." In terms of design production strategies, she said that modularity is practiced much more, so they are shifting from "engineer to order" towards "configure to order", and 3D printing which gives them much more flexibility in responding to actual demand of customers, warehousing, transport. In waste management, firms are focusing less on downcycling and more on upcycling, and she gives the example of a company who made metal casings and used to have lots of waste in their foundry. They started working with a company who'd buy their metal residues, and after a while decided to create its own "spin-off" company dedicated to this. That also, some companies are experimenting in incrementally increasing the use of recycled materials in their production, with one company aiming to move from its current 80% raw – 20% recycled use towards 50-50. In terms of the supply chain management, she said that "stewardship models" are still not much present in this industry, even though firms say they would try to "take control" of the whole value-chain but that she thinks they are not really there yet.

Managing tensions through intermediaries' work

The second way in which the facilitators explained this topic was related to their own role as facilitators of innovation. There were some examples of the specific strategies or work done by their own organizations, but in general this still refers to the work done by the firms and incorporates the specific services of the clusters. This could be in helping the firms: connect with peers, find new markets for sustainable products, develop sustainable business cases, understand, or comply with regulation, acquire new capabilities related to sustainable knowledge or practice, accessing testing facilities, or even having some of their notions regarding sustainability being challenged. Ingrid implies that in her role she helps firms understanding the challenges seeing different dimensions, working together outside and inside their organization (Table B13, row A). She had also discussed elsewhere how they use a lot design thinking in their cluster, but not like LCAs, rather as in whether systems are fit for purpose. Eirik describes how due to the tight conditions of his industry, it was very important to bring companies on board early on, and "really massage them" about the value they will get (ibid., B). On the other hand, Sara describes how they survey companies in their cluster to understand their pressing needs, what they need to learn about, and they provide some of these services, but also challenge them when they might want to outsource greenwashing to them (ibid. C). Tobias, however, describes services that seem more related to direct services, perhaps without too much intermediation knowledge boundary aspects: as they "solve their issues by using technology, building proof of value, building MVP [minimum viable product] solutions. Then we put different resources into that project, and we build the AI solution together with the company so that they are capable to build the project." (ibid., D).

Ada, on the other hand, among the many instances describing the services of the catapult, describes how they have made their site labs in 3D to facilitate access by clients, that they challenge them into thinking that it is not always more costly to "find sustainable alternatives," and that compared to research technology companies, they also have competencies in shared resources, and help the firms re-evaluate how they handle waste in processes, so that they can put them back into product lines (ibid., E). Sofie, describes how they work on sustainability internally, but also externally, with their customers, and that they are aware many of their customers do the same in their due diligence (ibid., F). Finally, Emil also describes knowledge brokering activities, however his descriptions are mostly

focused on business strategy and seem to be shaped by the services contracted by their customers. (ibid., G)

In this chapter, the perceptions of the interviewees were explored for patterns and themes, and this led to organizing them around three main themes: 1. definitions of digital technologies and positive applications; 2. tensions of sustainability and digital technologies; 3. management of tensions. The second theme was mainly analyzed in terms of where these tensions were perceived to be: in the negative outcomes and risks, in structural barriers, in misalignments of values and purpose (including questions of consumption, responsibility and artificial intelligence), in the difficulty of defining sustainability. The third theme was mainly analyzed through the general strategies used by firms, and through the work with intermediary organizations. In the next chapter, I will address the second aim of my exploratory research, which is to interpret the perspectives of the innovation facilitators presented thematically in the previous chapter, and then briefly discuss the theoretical and practical implications I see in relation to the academic debates of sustainability tensions of digital technologies and digitalization

5. Discussion

The purpose of this chapter is to address the second aim of my exploratory research, which is to interpret the perspectives of the innovation facilitators presented thematically in the previous chapter, and then briefly discuss the theoretical and practical implications I see in relation to the academic debates of sustainability tensions of digital technologies and digitalization.

As presented in the previous chapter, the perceptions of the interviewees were explored for patterns and themes, and this led to organizing them around three main themes: 1. definitions of digital technologies and positive applications; 2. tensions of sustainability and digital technologies; 3. management of tensions. The second theme was mainly analyzed in terms of where these tensions were perceived to be: in the negative outcomes and risks, in structural barriers, in misalignments of values and purpose (including questions of consumption, responsibility and artificial intelligence), in the difficulty of defining sustainability. The third theme was mainly analyzed through the general strategies used by firms, and through the work with intermediary organizations.

Interpretation of the themes

1. Definitions of digital technology and its positive applications

Their description of digital technologies applications and digitalization processes ranged from neutral to positive regarding sustainability. They relate their utility in terms of making data available, having dashboards, having the right KPIs; digitalization as helping data deliver the best way to make decisions; as a tool for humans to be more effective; good for optimization; or as a process to reduce raw materials in better ways. One facilitator directly says these are solutions for the SDGs, and two others make reference to them in the context of the Industry 4.0 policy paradigms. However, as will be discussed further below, when describing artificial intelligence (AI/ML), there are sharper differences in the characterization of these digital tools and they are closely linked to scales of impact, value gaps, or responsibility.

They provide detailed examples of applications they perceive as positive in the context of: digitization that is by itself sustainable: reduction of risks to workers in power line laying;

counting biodiversity more precisely; optimizing meat production; augmented and virtual reality for expanding access to healthcare provisions; reduction of transportation and its impact; carbon capture; optimization of energy grids, among other examples they mention in passing. They also contextualize digitalized processes or digitally enabled technologies in manufacturing settings that aid in reducing barriers to circular practices, such as: material appraisals in foundries; digital twins and digital prototypes for dematerializing production and experimenting; IoT enabled services that incentivize maritime companies to experiment with business models such as leasing; having better tools for measuring impact and reporting it across the board.

Their descriptions in this and other topics have to be seen in light of the limitations of the semi-structured interviews I discuss further below, and in the scope of my interpretations. Still, their initial descriptions of digital technologies and digitalization in these examples seem for the most part related to what the literature has explored in terms of optimization of business functions and processes, and in terms of measuring and accounting for sustainability. It resembles too what Beier et al. (2020), in their critique of the Industry 4.0 literature, or Piscicelli (2023) in her overview of how scales of impact of digitalization are not fully analyzed, describe as a focus of industrial stakeholders on the benefits of digital technologies without providing a systemic or holistic sustainability overview. This is not to mean that they, as facilitators, their organizations and firms, or the firms they interact with, don't have, or use this holistic overview, as in the other themes I explore the context where they nuance their examples and show awareness of the tensions. Still, the descriptions are related to what Brenner & Hartl (2021), as well as Klymenko (2021), characterize as implementation of digital technologies being driven mostly by economic gains and with sustainability goals as secondary objectives (the exception being perhaps the biodiversity monitoring applications).

While I decided to include in another theme their perspectives on whether optimistic framings can obscure the understanding of the negative impacts, or the net balances, in the subtheme of values and purpose, I am including in this first theme of positive applications and description what I consider is the optimism in their tone when describing the actual benefits and potential applications that can be expected in the future. I am not examining in my thesis whether those specific examples offered are indeed positives, neither am I using content analysis of their discourse as a method, but I had asked them about the potential they saw for digitalization and sustainability, and the further reflection on their

own views on techno-optimism was an interesting difference for me in exploring their perceptions. In this instance, in different degrees they all link the necessity to invest in or develop digital technologies in terms that seem closer to policy goals, like the green shift mentioned in the Background, acknowledging the existence of a climate crisis. And while all point to specific examples of positive benefits in terms of dematerialization, optimism for future developments is specified about healthcare through personalized medicine. However, their views on AI (except for one facilitator who said she didn't know of debates around its risks or ethical concerns), also provide degrees of caution in their appraisal. One facilitator says there are traps here and there, but another also considers that given the state of the world it is worth the risk.

2. Tensions of sustainability and digital technologies

While I found this theme indeed prevails in their descriptions, there are important distinctions in how they describe this happens and can be separated in four different categories or locations of these tensions: perceived in specific negative outcomes and risks to infrastructure; perceived in the structural barriers that firms face; perceived in the gaps of alignment between sustainable values and purpose of digital technologies; perceived in the difficulty of defining sustainability. This third section includes questions of consumption, design stages, responsibility, and techno-optimism are contained in the third part of alignment gaps. I decided to also separate their discussion of artificial intelligence, but as a subtheme, given that it touches on all the other aspects discussed around tensions, but also elicited important comments by the interviewees that distinguishes it from other digital technologies discussed.

Tensions perceived in negative outcomes and risks

They all seem to acknowledge tensions in relation to some negative social and environmental impact in general, such as the energy consumption of virtualized services and digital devices, which is explored by many authors like Howson (2019), Tamburini et al. (2015), and others, and one instance is described as being due to the excessive copying of stored data (which has been explored by Monserrate, 2022; and Castronuovo, 2022). Interestingly, one of the facilitators, seems to imply than rather this being an issue of the number of digital devices or the computing of technologies like AI or blockchain, this is

located on the side of end users and the batteries of their devices, with a possible implication of a shared responsibility with consumers. One of them also mentions the rebound effect directly (which has been explored by Kunkel & Tyfield (2021), and Kopp & Lange (2019), but only when prompted about indirect effects. None of them mention what different authors have studied in terms of extraction of rare-earths or the management of electronic waste. With the exception of one who mentions that in the future the energy needs of digital technologies will be very challenging, neither mentions the net impact in terms of emissions that have been debated in the literature.

Infrastructural threats due to cyberattacks to data and data-related infrastructure, which has been explored by Popkova & Gulzat (2020), among others, was mentioned by two of them, and one elaborated on the future implications of risks of data storage across different countries in unstable geopolitical scenarios. Besides the potential risks specific to AI, the risks are mentioned in general appraisals of complex challenges, or in the possibility of a more divided society due to data literacy gaps among the population, as has been studied by Carmi & Yates (2020). Despite the challenges, one of them says that the balance is overall positive. Another topic mentioned was the digitalization divide between countries, which has been studied by Dong et al. (2022).

While it could be expected that they may not openly discuss sensitive issues like social impact in global value chains (Loonam & O'Regan, 2022) in the context of the firms with whom they collaborate as clients or partners, It was interesting that none discussed at least in general this topic, given the relationship several had to manufacturing firms, though one of them said it was important to close the value gaps in the chains (but this is explored further down), and another said that the firms try to control supply chains as a strategy, but that they are unable to do so in reality.

Tensions perceived in structural barriers

Beyond specific negative outcomes and risks, the majority of tensions are described as not being intrinsic, decoupled from the digital technologies themselves, and experienced from the perspective of structural barriers faced by business firms in their industrial environment. Tensions in these cases seem to be attributed to these barriers specifically, or to the complex interaction of them, rather than being intrinsic to the digital technologies. All of them contextualize first the, perhaps evident, market pressures of firms having enough technical

competencies for competition, which has been studied by several authors, like Hadjimanolis (2019). One of them, also nuances this challenge as one of having good business models (for sustainability) where firms can actually profit.

One of the facilitators who has expertise in circular economy implementation comments however, on the maritime companies in her cluster being knowledgeable on how to perform environmental LCAs but not necessarily competent in measuring the social aspects, which relates to what Durmaz & Budak (2021) have studied about companies having insufficient technical expertise, as well as Neri (2021), Rizos (2016) and others regarding the lack of regulatory and cost-effectiveness incentives of adopting those capabilities. This is also similar to what Yip et al. (2023) and others have found in manufacturing processes, which are much less involved in the social dimension of sustainability, but apparently in part due to what Boiral et al. consider the lack of internal capabilities of knowing what and how to report.

Nevertheless, Klymenko et al.'s 2021 study of Norwegian manufacturing, where companies use tools like LCA to define responsibility in the product's life cycle, while not necessarily in their own manufacturing processes can be another interpretation of that perspective. Especially in the example given by one facilitator of the way in which an oil & gas customer is aware of how using different types of metrics in their definition of LCA parameters has different implications for their responsibility.

Several comment on the challenge of having inadequate regulatory tools. While I was expecting to possibly hear the portrayal of regulation in terms of being a constraint for business, in terms of costs and auditing (as is implied in the discussion of the facilitators that are not part of the NICs or the catapult), it was very interesting to hear some detailed explanation of situations where sustainability regulations can have, perhaps unintended effects on discouraging circular economy practices, such as the impediments of EU regulations on reusing waste products for energy, the very high indirect cost of renewing ISO certifications for medical devices that require recertifying designs, or the uncertainty created by not knowing whether classification societies would approve of the quality and safety of repurposed components in maritime vessels. This is related, but not exactly, what George et al. (2016), describe of uncertainty barriers created by regulations. Kirchherr et al. (2018), have studied the barriers to circular economy in practice and have found that most are normative/cultural (including risk-averse corporate culture), as in the last example,

and other authors had described regulatory barriers in terms of lack of policies and tools for incentivizing circularity, which is a different angle.

Locating the tension in norms, a couple of examples relate to its complexities, for example in the competing economic incentives of multiple stakeholders who interact with how a strictly regulated industry like healthcare reinforces unsustainable work behavior even when sustainable practices had been intentionally "purchased," and this has been mentioned by or in the description of a Norwegian culture that does not take care of values created (in this case, meaning goods and services). The second point, to my knowledge is not fully explored in the English language literature. But, perhaps, this can also be contextualized on the very high levels of consumption of Norwegian households that I mentioned in the Background.

Another perspective offered by two facilitators whose work with firms seems more closely related to big data analytics, also characterized as a challenge a Norwegian approach to data that has siloed many datasets and systems, which was manifested in part in the regulation of GDPR (though this is European in origin), and as a lost opportunity of exploiting these rich datasets within ethical boundaries. I also didn't find this in the literature, though perhaps it is a language access issue. However, a somewhat contradictory perspective was offered by one of them later on when he discussed how exploiting deep data of such a historically homogenized population would have such bias that it would be inappropriate for contemporary uses in healthcare.

Several of them seem to agree on the role of regulations as drivers for sustainability, as seen in their positive expectations for the landscape that the Transparency Act, the EU Taxonomy and the AI Act, contextualized in the Background of this thesis, would create because they would reduce uncertainty and pressure many actors to comply due to the auditing requirements that mark a difference with voluntary standards that can lead to greenwashing (ranging from superficially engaging with cherry-picked SDGs, to checking social impact beyond LCAs). Another description of drivers is offered by one facilitator's definition of sustainability as a hygienic factor, with an implication that working for companies that are sustainable has become the norm for employees in some places, and it would be undesirable to work for an unsustainable firm, similar to what some researchers like Kiefer et al. (2019), have explored in the literature of drivers. Another side of normative drivers was offered in an interviewee's mention of the pressure of ESG expectations and

obligations both in his own consulting firm and the many firms who engage their services in the context of competitive markets, which recalls Wang et al.'s description of ESG as a systemic pressure, and digitalization being a powerful tool to deliver optimizations in those fronts seems related to what Cort & Esty (2020) have found related to the need of precise frameworks by both investors and firms. But also, in his description of the demands of consumers for more sustainability, as discussed by Meyer (2023) and others.

The description of barriers in the governance systems was mentioned in passing by one of them after elaborating on the adequacy of standards and later on to the geopolitical instabilities, which led to considering how digital technology isn't able to solve issues that our political systems haven't been able to do anyways.

Related to market barriers, the lack of sufficient workers who are competent was discussed by the two facilitators who seem to have the most experience in leading business firms and reflects what the business interest organization IKT Norge (2022) has also publicly aired as a country-level challenge of competitiveness. However, none of the facilitators' positions this, or a similar critique, in terms of not having enough experts in sustainability or ethics, even if they all nuance the need of having decision-makers who put sustainability issues on the table. Nevertheless, the fact that they participate in projects with intermediaries may signal that they are willing to expand knowledge capabilities (even if mostly for the innovation aspects and necessarily not strongly oriented towards sustainability). These issues are closely related to the thematic pattern of not knowing how to define sustainability, which is something that the literature has explored in many settings beyond manufacturing firms.

Overall, their varied descriptions of the complex interactions of barriers and drivers, is more in line with what Kiefer (2019) and others say about the multidirectional dynamics at play in terms of eco-innovations and firms, but it was interesting that most of the descriptions of tensions were placed in the regulatory and normative settings, perhaps due to their experience in working with these topics every day. But when prompted, the interviewees all offered different perspectives on other sources or location of tensions as is discussed below.

Tensions perceived in the alignment of value and purpose

All provide nuanced views on the relationship between alignment of sustainability values and the purpose for which the digital technologies are used, though not all make this explicit and it is mostly shown in the discussion of practical examples, and this touched on different questions related to consumption, responsibility, the misalignment of values and purpose, and the importance of the design stages of digital technology.

When one of them links this to data ontologies, which has been explored by Bonacchi & Krzyzanska, (2019), and related to the following subtheme I found of the difficulty of defining sustainability, she says we can have the right data, but we need the right systems. The same interviewee is who says that the issue is not viewing digital technologies as tools, but rather as goals, and that AI in particular is not a neutral technology. However, she also said that sometimes these issues are out of the hands of developers. Her tone and the context of her answer implied that this was a matter of knowledge, rather than shared responsibility that is diluted (as Hon et al., 2012, say can happen in virtualization) between stakeholders who collaborate in a value chain. Nevertheless, it is important to consider, as has been discussed by Fritz & Binder, 2020, that different stakeholders, in part due to their positionality, have different sustainability priorities, and motivations, possibly related to their knowledge.

Regarding the effects on consumption levels, only after the question was prompted, all of them agree to some degree that digitalization can have a negative impact in terms of increasing levels of consumption, with half of them saying this is a difficult dilemma or challenge, though they don't discuss whether this requires questioning the optimization in production in relation to systemic consumption patterns as has been explored by Bengtsson and others, or through the framing of digital technology as being an optimized version of doing business as usual, as Niehoff (2022) says. One of them goes on to explain that the problem is the existence of a market for our personal data, with the implication that device users have been set up to let their data being used and commercialized, which resembles the debates around data extraction by Sadowski (2019), or the corporate domination of digital platforms that rely on pattern data (Campbell et al., 2020; Dahl Andersen et al., 2021). Two offer views describing marketing as a dilemma always. This could be interpreted as the difficulty of firms to rein the possibility of ever-increasing optimization possibilities of targeted marketing, and from the consumer perspective this is seen in Panizzut et al.'s (2021) exploration of consumerism as a lifestyle, as well as Hodder's and

other's conceptualization of production-consumption patterns that are very hard to change as they are deeply embedded with habits, history, culture and norms. Nevertheless, one facilitator exemplifies how this dilemma can be managed with how marketing targeted towards children has been more strictly regulated in Norway. Beyond these situations, none of them reflected on whether the current levels of consumption (and particularly in a highly digitized and developed economy like the Norwegian one) need to be seriously questioned, or the overall rebound effect of digitalization (not only in energy, but accelerating extraction as has been studied by Dauvergne (2022). While one of them did mention the rebound effect as a possibility, she did not elaborate further, and seemed to reject the proposition because she said digital technologies are enablers of sustainability, not their own enablers.

However, these prompts about consumption also led in some interviews to discussions about attributing responsibility. One of them said that when a person's life is hurt then the digital solution was not fully functional, which is an interesting choice of attributing responsibility to the dysfunctionality of the technology, rather to the decision-making process and the persons deciding about the purpose or the values within. I'd argue that this rhetorical distancing is related to how Lenz explored the normative discourse of digital technologies in sustainability as happening around modernization, transformation, and control. When discussing the use of tools like LCAs, and how some firms don't know how to account for social impact, responsibility was not mentioned by one of them, related to Weidema et al.'s (2018) study, but another did say that an oil & gas firm was aware of how measuring LCAs in different ways would assign their responsibility at different stages. However, in two interviews this also led towards the previous topic of structural barriers, in which they covered the incomplete information that consumers have about life cycles (about electric vehicles, or palm oil), and how this can lead to normative pressures on firms, or even greenwashing.

However, when talking about the limits of digital technology, and later on specifically with AI (where it was mostly described in terms of ethics), three of them did say that digital technology cannot solve the deliberative and intentional act of placing sustainability goals at the center of decision-making. Even when some of them don't describe the goal-framing process of paradox thinking elaborated by Hahn (2017), or later by Wannags & Gold (2020), in these situations, they all also imply there is a general challenge in putting sustainability concerns on the table, on mindset and management as one said, and this

cannot be done by digital technologies themselves. In these scenarios, this recalls the critique of van Bomel & Rasche (2023) who have linked this to the financialization of values, which turns the social and environmental aspects into factors with a market value within the business models.

This was usually the point where I also prompted the question of whether they thought these issues were more relevant at the design stages of digital technology, as has been discussed by Ferati et al. (2021), and they all agreed to different degrees. One of them said that at every stage, from design, to deployment, to escalation; another linked this to the business models. All of them reflected on this, either from the ethical perspective, or from the practical side, as seen in the examples of material costs and experiments in the testing sites, or in the design of medical devices who get locked in due to the high verification costs.

Their perspectives on whether an optimistic framing of digital technologies was a problem for weighing negative aspects of digital technology seemed divided. This has been explored in different ways by Dwivedi et al. (2021), Brenner & Hartl (2021), and Mouthaan et al. (2023), among others, where the discourse of technological promises of solution for entrenched sustainability issues can reduce these problems due to deterministic views, and sometimes convenience, in not fully appraising the holistic impact of these technologies. Seele & Lock (2016), for example, also discuss how impact can become unseen by the virtualization or dematerialization processes, and another related perspective, as mentioned above, is van Bomel & Rasche's (2023) argument that the value-capturing purposes of digitalization can lead to pursuing them regardless of tradeoffs. Only one of them said that she didn't think this was the case. Another said that optimism and risk is in the blood of every entrepreneur, and this was going to be challenged by the worries of policymakers and regulators.

Artificial intelligence

In relation to artificial intelligence and machine learning, almost all the practitioners discussed how AI/ML models were being used with significant gains in sustainability related examples, and they were also aware of the risks related to explicability of decision-making in the models and their potential impact in societal systems or individual harm (only one said she hadn't heard of this). However, this was not done at the same time, the

positive examples came about organically during the interviews, and the risks specific to AI were prompted by my questions separately. As Kopka & Grashof (2022) as well as Dauvergne (2022), have explored in the literature, the efficiency benefits have not been discussed much side by side with the significant risks and actual consequences documented for AI.

However, one says this related with retail consumers, not necessarily their particular industrial segments; three others say ethical concerns are significant, especially around the issues of less control, transparency, and explicability in models that self-develop (blackbox), as has been debated by several authors (Hasan, 2021; Dwivedi et al., 2021; Landers & Behrend, 2023). Of these three, one facilitator says that if it is not possible to explain how they work, these models should not be used at all, but that as long as the EU and Norwegian regulations are followed, there should be no problem. While Fukuda Parr & Gibbons, in their 2021 evaluation of frameworks, several industry-led, had criticized some of the ethical frameworks for accountability because they leave out enforceability and participation, this may not reflect the status of upcoming AI Act provisions (2023-2024), and my interviews took place in 2022. Another interviewee said the AI Act would provide needed governance because it would make all actors in a value chain responsible, but she cautioned there were many traps here and there, that these challenges are real and being experienced today, and that the bias started from the data collection stages (as has been covered in the literature by Martinez-Martin et al., 2018; Bonacchi & Krzyzanska, 2019), and this makes AI a non-neutral technology (Shadikhodjaev, 2021).

Interestingly, one of them rejected the perception of these issues as risks of AI development, transferring the responsibility to users too, as she said that as should be obvious to anyone using a chatbot, these are flawed tools that are biased, the same way one should be skeptical when we consume news media, but that she remains optimistic about their medical promises (she had also previously seen positively the evolution of Industry 4.0 policy paradigm towards a more human-centric Industry 5.0 paradigm). And she said this should have been obvious too when AI tools were used for hiring purposes (the case of Amazon work recruitment, analyzed by Hunkenschroer & Luetge, 2022). In the end, she said, digital tools need to be used to be improved, which is something espoused in different technical fields (Turchin, 2018). The same viewpoint of the need to use technology to develop it was given by another interviewee who went on to describe how we didn't need to fear a Robocop (perhaps reflecting the debate of the race to develop an AGI, as explored

by Grace et al., 2018) but that there are serious issues of AI around weapons, financial risks, human risks, governance of databases in uncertain geopolitical scenarios, extreme surveillance in China that could leak into European practices, and political divisions in the US & UK (König & Wenzelburger, 2020; and others too). He had said, paradoxically in my interpretation, that while technology hasn't helped in improving our governance systems of these issues, it was worth the risk given our current climate emergency.

Tensions perceived around defining sustainability

Sustainability seems to be acknowledged as a concept with multiple aspects and meanings, though their direct or indirect allusion to this varied throughout the interview. In relation to the previous discussion of misalignment of values and purpose, they seem to perceive as a challenge having knowledge and agreement of what we measure and for what reason (O'Brian and Sygna, 2013). This was the first topical question I asked in the interview, and they offered perspectives that included variations on the three main pillars, but in a business context When asked about it in a business context, except for 2 of them, they seem to reflect and say it can be tricky or hard to define, or that their network may say it is only an environmental question, but they operationalize them around the three Ps (Joyce et al., 2015) business models that consider sustainability (Schaltegger, 2013), the TBL, or ESG paradigms (Clement et al., 2023) and their descriptions of tension in defining it involves examples in practice with other firms. Several mention later that there are many dimensions.

They mention the SDGs when discussing the different standards and certifications, and they characterize them as good or necessary overall, but hard to put in practice by business (which has been an important scholarly critique of this paradigm). None of them included in this point, or later in the interview, definitions explored in academic debates and communities of practice that relate to different paradigms (such as the planetary boundaries, the doughnut model, etc.), the intergenerational aspect, or relational aspects that directly frame them in terms of justice or ethics. None used definitions that challenged economic growth. Most of the examples linked to sustainability tensions related to the environment, and the social or human aspects, or questions of ethics, were usually explored in relation to artificial intelligence. These were closely related as areas of concern, but implied to be separate from the environment, or even sustainability. This in part is suggested by the work

of Klymenko et al. (2021) that says the social dimension is usually the least understood and operationalized when manufacturing companies try to implement sustainable models. Interestingly, one of the interviewees who would usually provide detailed explanations during most of the interview and seemed to be quite familiarized with the state of the art of digitalization and sustainability, said right at the outset that it was a very tricky question and that it's a common challenge in their practice.

When they discussed issues around impasses, dilemmas, or difficulties in achieving sustainability, in most cases there is an implication of a clash of norms, values, purpose, or knowledge about what a sustainable outcome looks like, what should be evaluated and why. This is so, even in the cases where they discuss mechanisms, governance or having to use the right mindset for decisions around sustainability, and this relates to what O'Brian and Sygna (2013) say about the lack of clarity of what, why, how, and in whose interests would sustainable transformations need to happen. Another implication is that sustainability is performative, as Hallin et al. say (2021), because the definition the interviewees can offer to reply a static question may query their values or an abstract layer of how they see their work, but it is definitely a more nuanced, changing definition, with several stakeholders who contest it in practice, when seen through the lens of a particular example that reflected a clash even if none of them make a reflection of how these interactions change the notion of sustainability, as for example is explored by Markard, Raven, & Truffer (2012) who consider it a continuous process of transformation. However, some of the examples do seem to show the perspective of how different stakeholders can have legitimate claims from their position in a situation, which has been debated by Haack & Rasche (2021) and Fritz & Binder (2020).

3. Managing the tensions

In the examples the interviewees gave of how firms focus on different business functions, or use specific strategies, including certifications and standards, beyond the discussion of barriers explored in the previous themes, another pattern that seemed common was that firms engage with the strategies that seem the most feasible to them in terms of those barriers of market dynamics, regulatory pressure, consumer expectations, or systemic interaction with their industrial networks, and in turn this seems closely connected to the

cognitive and cultural barriers to implementation of circular practices explored by Kirchherr et al. (2018), and Ranta et al. (2018).

While the facilitators did not directly say (when discussing strategies used by the firms) there are multiple definitions of circularity, they did point to a variety of practices related to circular economy that is similar to what Hazen et al. (2021), Clement et al. (2023), Kirchherr et al (2023) and Hou et al. (2022) say about there being multiple definitions of sustainability within manufacturing, and within firms that claim to use circular practices, including those that manage structural barriers by adapting to the possibilities of their industries.

They all portray the use of standards with caution and their perspectives seem to reflect what Zerbini (2017), and Neri et al. (2021), also says about certifications being used to increase reputation and ease some of the normative pressures. One of them explained that one of the reasons some certifications are not appropriate, is because they may not be useful input for sustainability decision-making in the present (as they are snapshots of the past), and digital technologies aim to reduce that knowledge gap. None of them discussed tools or reflective postures in regards of what the literatures on stakeholders' perspectives and initiatives explore about co-creating meaning and finding inclusive solutions in settings like supply chains, as has been discussed in many different ways by Dahan et al. (2015), Perez-Aleman & Sandilands (2008), Kruger et al. (2018), Woiwode et al. (2021), or the intentional, proactive, use of reflective research and innovation practices (Sovacool et al., 2020).

Nevertheless, there are degrees of reflective practice with nuances, by themselves and the firms, and part of this may be related to their intermediary work. I didn't ask in the interviews, nor did any of them elaborate on the specific practical aspects of what the literature of intermediary organizations has characterized as the roles of innovation diffusion and knowledge brokering in innovation systems in the context of sustainability transitions (Kivimaa et al., 2019a; Kivimaa et al., 2019b; Sovacool et al., 2020). They did, however, offer plenty examples of situations where, in my interpretation, they provide those services, in particular when they discussed how they engaged in knowledge and learning work in practice that helped firms understand the use of applications like the digital twins in a learning environment (catapult), the measuring of KPIs, the relevance of circularity tools like LCA, or digitalization aspects of ESG strategies, as well as awareness of the

regulatory environment, like the EU Taxonomy, and socialisation of expert knowledge on other digitalization and sustainability topics. The two interviewees who work in business-to-business firms seem to describe their activities in a related fashion, but their answers also reflect a scope that is more concerned with the client relationship that may determine the extent to which they are asked to, or are willing, to challenge the views of their clients with a vision that expands sustainability knowledge. However, the NICs and the Catapult facilitators, while not always describing their engagement in purely open-innovation terms, did seem to have that orientation, in part perhaps due to the very purpose of their industry organizations which are tasked to do that for their members.

Implications

Some scholars have focused on the positive applications of digital technologies, while others have questioned the net benefits of digitalization from a variety of fields. Other scholars have studied the barriers to implementing sustainable business models and practical frameworks like circularity, and the framing in decision-making by firm leaders, while others have contested the very utility of these frameworks. Furthermore, some have explored whether the use of digital technologies improves our accounting and measuring of sustainability, and some question their utility for attributing responsibility in supply chains and other manufacturing settings. Some of these debates have even revolved around the challenges created by unclear definitions of digital technologies, circular economy, sustainability, and the lack of comprehensive approaches to sustainability impact across a range of fields. Many of these scholars call for research that bridges many of these interconnected topics, but not enough attention has been devoted to how these two large trends of digitalization and sustainability plays out in very specific settings, such as the intermediary organizations' work in Norwegian industry (sites and actors that seem highly influential on how digitalization is adopted by other firms). Because of this, exploring the perspectives of practitioners who may be sustainability-oriented and through their position facilitate digitalization can provide valuable insights on how these tensions are characterized.

Looking at the range of answers that the facilitators suggests that all the interviewees seem to perceive tensions in sustainability and the use of digital technologies or digitalization in their industrial settings, with important nuances in relation to how these technologies are

described and where these tensions may be located: at the outcome in negative impact related to energy and other environmental aspects, or in terms of the risks to infrastructure or datafied systems; in the structural barriers that firms face from regulations, the market, norms and culture; in the gaps between sustainability values and the purpose of these technologies; in the difficulty of defining what sustainability is and how to measure it. It seems too that the intermediary organizations' work in industrial clusters also help firms expand their capacity to deal with these tensions beyond their own toolkit of strategies, especially in those settings where open-innovation practices like knowledge brokering and innovation diffusion is sustainability oriented.

The theoretical implications point towards how barriers to sustainable practice in industrial firms may be perceived by innovation facilitators to be initially located in external structures (in market pressures, regulatory tools, norms and expectations, culture and habits), but how all of them, in different degrees, also seem to imply that there are deeper layers of tension at the core of digitalization that have to do with how decision-makers arrive with sustainability mandates and incorporate them in the design of digital technologies, the business models that bring these tools into reality, and the technical systems and social structures that rely on these technologies. The need to align sustainability values from even before data-generation processes seems to be implied directly and indirectly in their answers, as they all offer a range of views where digital-technologies cannot by themselves self-align or provide a sustainability purpose that was not there from the beginning. This seems to be particularly poignant in the use of artificial intelligence models that through their escalating properties can have significant positive and negative impacts. All these practitioners' perspectives offer valuable examples of positive applications of digital technologies, but they also characterize a complex interaction of factors that seem to suggest that our understanding of the net social and environmental impact of these technologies is incomplete, and the case in point may be found in how focusing on the optimization benefits of digital technologies may exacerbate production and consumption patterns.

The practical implications of this exploratory study are related to reflection on the innovation system (the public and private actors), on whether MOIP policy tools (like the NIC and Catapult programs), and the current digitalization and sustainability regulations, could be better geared towards addressing some of these tensions, or whether intermediary organizations and their firms can be better equipped to deal with these tensions, perhaps

through capacity-building activities that facilitate reflective R&I frameworks, or to evaluate whether the digitalization and green shift policies can take into account their perspectives. Examining how these issues play out in open-innovation settings seems important because, as the perspectives suggest, digital technologies and sustainability are not easily defined, their impact is not easily defined, and Norway is a highly digitalized country, with an economy that is characterized by very high levels of consumption, where decarbonization is still a challenge, and where there are strong governmental commitments to sustainability goals.

Limitations

As mentioned in the methodology chapter, generalizability of the results is limited by the nature of semi-structured interviews (including the knowledge gaps I had when embarking on this study), the possible gaps in meaning and knowledge between me and the participants (including confounding aspects related to our understanding of these complex topics, where definitions are not set in stone), using English language for non-native speakers, and the reflectivity of these practitioners, that among other things, may not fully represent the cognitive frameworks they use in their everyday settings.

Some limitations are related to the very specific setting of this study: the small size sample, selection of practitioners (whose job tasks, descriptions and industries are quite varied), the time and resources available to conduct it, the period and place (December 2022 in Norway). The questions regarding "business functions, strategies, and standards" (the slides) were only used to prompt the conversation, not for analyzing these from a literature perspective, and their answers are also likely very contextual to their particular industries.

When doing thematic analysis, the choices taken imply at times sacrificing topics of research, and the scope of the study also imply that I am not examining in detail the policies and regulations, the NIC or the Catapult program, other type of intermediators.

Validity

Nevertheless, these limitations, the results are still valid because my aim was to conduct exploratory research of the perspectives of leaders of intermediary organizations who can

provide valuable insights about the tensions of sustainability and digitalization in a Norwegian industrial setting.

Conclusion

This thesis aimed to explore the perspectives that innovation facilitators had about tensions of sustainability and digitalization in Norwegian industry. The objectives of this study were: first to collect through semi-structured interviews the answers of selected managers or leaders in specific organizations and firms (that have an industrial innovation intermediary role, who work with digital technologies for enabling purposes, and who have a degree of sustainable orientation); and second to thematically analyze the perceptions in these answers about tensions, and briefly discuss these themes considering the academic literature. The purpose of this study was to answer the exploratory research question of how innovation facilitators perceive tensions in sustainability and digitalization in Norwegian industry.

It can be concluded that all seven of the interviews perceive tensions in sustainability and the use of digital technologies and digitalization, with nuances on how these technologies and their positive applications are described, and where these tensions may be located: in negative outcomes related to energy and other environmental aspects, or in terms of the risks to infrastructure or datafied systems; in the structural barriers that firms face from regulations, the market, norms and culture; in the gaps between sustainability values and the purpose of these technologies; in the difficulty of defining what sustainability is and how to measure it. Their perceptions raise also important questions around consumption and responsibility that may be obscured in part by the benefits that these technologies bring through virtualization. Artificial intelligence seems to be a flash point where these issues converge. It seems too that the intermediary organizations' work in industrial clusters also help firms expand their capacity to deal with these tensions beyond their own toolkit of strategies, especially in those settings where open-innovation practices like knowledge brokering and innovation diffusion is sustainability oriented.

Engaging with these topics requires navigating blurry boundaries in theory and practice about what these topics mean (sustainability and digitalization), and these semantic complexities seem to be part of the issue that creates important gaps in the discursive and material reality lived in the current climate emergency. Regardless of complexity, it is

important to engage with these topics from transdisciplinary perspectives, particularly in the context of the rapid digitalization of our social and economic systems, a technological change that may happen even faster through artificial intelligence and other enabling digital technologies, whose promises have not yet delivered in terms of carbon emissions, or the equitable and just provision of societal needs both here and in those geographies across the world where our digital life may be inescapably connected to.

In the context of the highly digitized Norwegian economy, with significant consumption levels compared to other developed countries, it is important to examine these topics. This exploratory thesis aimed to shed light on the specific setting of individuals' perspectives, whose position as leaders of innovation intermediary organizations is considered influential, as they seem to have a wide reach that includes other business firms who engage their services for strategic reasons, including enhancing their competences in technological and sustainability aspects. The examples discussed by these professionals include the industrial use of digital applications such as artificial intelligence models, Internet of Things networks, digital twins, among others. While some of these uses had the explicit goal of improving sustainability outcomes, others can also be perceived as claimed sustainability benefits after economic capture was prioritized first (not alongside environmental or social benefits).

The exploratory nature of this study was deemed appropriate given the scarcity of research dedicated to the complex interaction of these two major shifts from the perspective of innovation practitioners in mission-oriented intermediary organizations. Even less common have been such studies in Norway, despite the abundance of calls for research in the overlapping areas between sustainability transitions, innovation studies, and digitalization; and despite the seeming prominence that public funds and industrial innovation policy in Norway has been dedicated to developing these kinds of organizations and their projects. One of the limitations of this exploratory approach is methodological, preventing generalizations about the results. Nevertheless, the thematic analysis was appropriate to explore the richness of descriptions in these interviews, providing a nuanced view of these complex topics, which in turn point towards interesting avenues for future research. On a personal note, engaging with these issues for my master thesis has been highly rewarding even if challenging at times due to the specificity of some of the topics.

These findings suggest that further exploration of decision-makers in these settings, where sustainability and digitalization seem to be accelerated, can be useful to find deeper and perhaps more causal links to the potential decoupling of sustainable values and digitalization activities. This could include too other methodological designs, like targeted surveys to an array of stakeholders in these cluster organizations, their affiliated firms, or public agency officials who may oversee designing policy to foster innovation entrepreneurship. Regardless of the approach, engagement requires an intentional and reflective stand as the direction of our lives continue to be altered by the forces of digitalization and the climate emergency.

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Appendix A. Methodology Documents

A01. SIKT Assessment

Sikt

Notification form / Perspectives of digital technology corporate practitioners on the ... / Assessment

Assessment of processing of personal data

Reference number	Assessment type	Date
169712	Automatic	02.06.2023

Title
Perspectives of digital technology corporate practitioners on the paradoxes of sustainability efforts

Institution responsible for the project
Universitetet i Oslo / Universitetsstyret / Senter for utvikling og miljø

Project leader
Tanja Winther

Student
Rafael Andres Solis Moreno

Project period
23.12.2022 - 31.12.2023

Categories of personal data
General

Legal basis
Consent (General Data Protection Regulation art. 6 nr. 1 a)

The processing of personal data is lawful, so long as it is carried out as stated in the notification form. The legal basis is valid until 31.12.2023.

Notification Form

Basis for automatic assessment
The notification form has received an automatic assessment. This means that the assessment has been automatically generated based on the information registered in the notification form. Only processing of personal data with low risk for data subjects receive an automatic assessment. Key criteria are:

- Data subjects are over the age of 15
- Processing does not include special categories of personal data;
  - Racial or ethnic origin
  - Political, religious or philosophical beliefs
  - Trade union membership
  - Genetic data
  - Biometric data to uniquely identify an individual
  - Health data
  - Sex life or sexual orientation
- Processing does not include personal data about criminal convictions and offences
- Personal data shall not be processed outside the EU/EEA, and no one located outside the EU/EEA shall have access to the personal data
- Data subjects will receive information in advance about the processing of their personal data.

Information provided to data subjects (samples) must include

- The identity and contact details of the data controller
- Contact details of the data protection officer (if relevant)
- The purpose for processing personal data
- The scientific purpose of the project
- The legal basis for processing personal data
- What type of personal data will be processed and how it will be collected, or from where it will be obtained
- Who will have access to the personal data (categories of recipients)
- How long the personal data will be processed

- The right to withdraw consent and other rights

We recommend using our template for the information letter.

Information security

You must process the personal data in accordance with the storage guide and information security guidelines of the data controller. The institution is responsible for ensuring that the conditions of Article 5(1)(d) accuracy and 5(1)(f) integrity and confidentiality, as well as Article 32 security, are met.

A02. Consent form, interviewees

Consent Form

Request for participation in a research project about sustainability in digital technology

"Perspectives of corporate practitioners on the paradoxes of digital technology sustainability"

Purpose

This is an information letter for you about the research project and questions about whether you want to participate in it. You are asked to participate as an employee at a digital technology company, with job responsibilities related to sustainability, to learn about your perspectives on the potential paradoxes of sustainability in digital technology. You would be interviewed once (45-60 minutes) and can decide to be informed of the insights produced by the research upon project completion.

Background

Data and digital technology goods, services and platforms have become an inescapable driver of economic development and are also considered powerful tools for the improvement of social and environmental issues around the world. Research on sustainable development shows that most of these topics are closely interrelated and pursuing one or the other can directly and indirectly affect other goals in both positive and negative ways (for example, a green energy agenda could both increase desired decarbonization and exacerbate food insecurity or water scarcity, among different possible scenarios). This research intends to examine how people in charge of sustainability efforts within digital companies view the interrelation of sustainability goals and their potential paradoxes. The information collected in the interviews will be analyzed using interdisciplinary frameworks from the literature of sustainability transitions, corporate social responsibility, social psychology, and science and technology studies.

Who is responsible for the research project?

This project is carried out as part of the master's thesis on the study program "Development, Environment and Cultural Change" at the Center for Development and the Environment (SUM) at the University of Oslo.

Why are you being asked to participate?

The company where you work at is a member of one of the Norwegian Innovation Clusters (a state-funded industrial cluster program by Innovasjon Norge). These clusters are specialized in sectors such as construction, maritime services, energy, healthcare, among others. The core activities of most affiliated companies are related to the development or commercialization of frontier technologies, including digital tech. Among these companies, many explicitly work with an environmental or social mission that can be described as pro-sustainable. Your job responsibilities may include designing, implementing, or overseeing

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sustainability-oriented practices, programs, or policies (a balancing of environmental, social, and economic goals) for your company, with varying degrees of responsibility but clear involvement in decision-making. Ideally, you are the highest-level employee in charge of sustainability there.

What does participating mean to you?
I would like you to participate in an interview (1 hour approx.), so that I can obtain meaningful and descriptive data about how you understand a variety of concepts related to sustainability and digital technologies, sustainable strategies and certification processes, examples of positive goals, negative consequences and problem solving. The information I will collect will be mostly based around specific frameworks used at the company and your perspective and experiences related to these issues. I will make an audio recording and take notes during the interview, for which I will ask you to sign a consent form. You will be the only person interviewed at your company, and the project intends to interview 12-15 people in total (all in different companies).

Participation is voluntary
If you wish to participate, you can withdraw at any time without giving any reason of some or all your expressed views or data. If you wish to withdraw, this will not have any negative personal consequences for you. Nor will it have any negative consequences for your workplace. You can withdraw during the interview or by sending an e-mail or calling me. Information about you will be anonymised in the final publication.

Your privacy - how I store and use your information
Only information that has been agreed in accordance with the purpose of this letter will be processed. I process the information confidentially and in accordance with the personal data regulations. Information collected in the project will only be available to me and my thesis supervisor.

The personal data that I will collect for contacting purposes while the research is ongoing is: name, job position, workplace, email and mobile phone. The personal data that I will collect for carrying out the analysis of the perspectives according to the literature is: age, gender, and sound recording of your voice within the interview. The recording can provide valuable insight about intonation, pauses and other contextual information about perspectives, and it will also be very helpful in transcribing the interview accurately.

The data will be processed and stored with full confidentiality in a computer located at the University of Oslo and my own personal computer, and access to it will only be by me and my thesis supervisor. For this, each participant will be assigned an alias or a code within the research project and in publication instead of using real names. The published thesis will reveal which sector your company operates in, and will anonymize the name of your company, providing details of its business profile only to the extent agreed with you.

The project is scheduled for completion and publication by the end of May 2023. At the end of the project, all personal data and audio recordings will be deleted and other potential data identifiers will be made anonymous.

Your rights
As long as you can be identified in the data material, you have the right to:

- access personal data registered about you.
- to have personal data about you corrected.
- have personal data about you deleted.
- be given a copy of your personal data, and
- to send a complaint to the data protection representative or the Norwegian Data Protection Authority about the processing of your data.

What basis do I have for processing your personal data?
I process information about you on the basis of your informed and signed consent. Please contact me (Rafael Solis, 96821442, rafaelso@student.hf.uio.no) or my thesis supervisor (Tanja Winther, 22858915, tanja.winther@sum.uio.no) if you have any questions about the study, if you want to withdraw consent or if you wish to exercise your rights about your data.

Best regards,

Rafael Andres Solis Moreno

Declaration of consent

I have read the information document and understand the purpose of the project. I have also been given the opportunity to ask questions about any ambiguities. I agree to participate in the interview and I give Rafael the opportunity to process my information until the end of the project.

_____

(signed with name of project participant and date)

A03. First contact email for interviewees

Hi (NAME OF INTERVIEWEE),

My name is Rafael Solís Moreno, a master's student of Development, Environment and Cultural Change at the University of Oslo. I am writing a thesis on how people at digital technology companies understand the dilemmas of sustainability in digital technology. I would love to interview you for my research since you are ROLE AND COMPANY

Why do I want to interview you?
COMPANY NAME is one of a few CLUSTERS/COMPANIES that I have identified as a very relevant actor for my research questions. Because of your role, your responsibilities may include understanding or decision-making related to sustainability (designing, implementing, or overseeing sustainability practices, programs, or principles), or your position has given you a perspective on these issues that is relevant to explore in my research.

Why am I doing this?
Digital technologies offer unprecedented opportunities to help solve the problems of the current climate emergency. As we go deeper in understanding these issues, we have learnt that they are interconnected in complex ways and can create conflicting scenarios (for example, green energy efforts can have both positive and negative impacts in other efforts related to food, inequality, or security). Because of their transformational impact across industries, it is important to learn how digital technology companies deal with the paradoxes that unfold when trying to be more sustainable. I am particularly interested in finding out how these issues are understood and practiced by the people who work in data and digital technology.

What would this require?
A one-time voluntary remote interview lasting 50-60 minutes at a time of your convenience (preferably in December, but it could possibly be in January). I could also meet you in person if you happen to be in the Oslo region in the next couple of months. You would receive an information letter and a consent form. I would like to record the audio (not the video) of our call as it facilitates my work later. I will ask about opinions and experiences on a variety of concepts related to business, sustainability, and digital technologies. The conversation will be confidential, and your personal data will be anonymized.

What do I offer?
While I don't have money to compensate for your valuable time, I would love to share or discuss in more detail the insights of my research when I finish! :)

Please let me know if you would like to participate or whether it would be better to contact someone else at NAME OF COMPANY. If you have questions, I'd be glad to write in more detail or call you back anytime.

Kind regards,

Rafael
Tlf: XXX-XXXX

A04. Interview Guide

	Warm-up conversation and presentation. I will read a brief disclaimer introducing myself, explaining the research objectives, their rights about their data, reiterating that it will be anonymized, that I will share with them the insights, and asking if they consent to being recorded.
1	First, I would like to know what you think about a few concepts. Even though they are widely used now, these concepts don't have a strict, clear-cut definition. Some specialists have a narrow interpretation and others offer a much wider scope. So, I'm interested in how different people in your industry understand them. What does sustainability mean to you in a business context? *[for questions ahead, I will note whether they focus only in environmental, or whether they include other dimensions like economic, social aspects, cultural, etc.]*
3	How would you define digital technology?
4	Can you please tell me what *[their company's name]* does?
5A	Talk me through the responsibilities of your role.
5B	*[only if they don't mention impact and or sustainability in their role]* …To what extent, if at all, your role in requires you to consider aspects of sustainability?
6A	All companies have areas responsible of compliance with regulations on quality, safety, industrial standards, and other aspects. In addition this, some companies also carry out research on the direct or indirect impact of their products on people, the environment, or society. If this is done by your company, can you please walk me through how this research on impact is done?
6B	*[only if they don't mention specific policies, guidelines, frameworks]* Are there specific guidelines or frameworks to help employees detect or understand these impacts?
7	Let's say there is a new idea you would like to implement to make things more sustainable, can you walk me through how you would do that? For example, is there a specific process in place, metrics that you need to show, or key people or areas you need to convince?
8	I will show you a diagram with topics related to business strategy. Not all these topics may be relevant to your role, to digital business, or to your company. Some may overlap or others may be missing. Please mark down those where your company actively tries to improve processes to make them more sustainable. Feel free to mention any others • SLIDE "AREAS WITH INCREASED SUSTAINABILITY FOCUS"
9	Now I'd like to show you a list of current strategies especially focused on sustainability, grouped by their overarching goal. They can apply to specific processes, or across all areas of a business. Just like before, not all of these may be relevant to your role, digital technology, or your company. But please mark those actively used here. Feel free to mention any others: • SLIDE "STRATEGIES FOR SUSTAINABILITY"

10	Which of these, if any, do you think can have the biggest impact on sustainability in your company or elsewhere and why?
11A	Companies like to communicate how much effort they put in sustainability, so they certify themselves and report on this. Please of the following tools and standards you know, tell me if you have worked directly on them and feel free to mention others: • SLIDE "SUSTAINABILITY STANDARDS"
11B	*[If they have worked directly with any of the tools]* To what extent do you think these tools you have worked on are adequate for measuring what they are supposed to measure? *[If they ask for clarification: "For example, if they are intended to certify best practices across the whole supply chain, do you think they are able to do that, would some things slip away, do they need much improvement in how they measure?]*
12	Now I'd like to ask you about the intersection of digital technologies and achieving sustainability. In your opinion, what role does digital technology play in helping improve sustainability in *[THEIR SPECIFIC INDUSTRY e.g. energy, food, healthcare, maritime, construction, etc.]*
13	Can you give me some examples of breakthroughs achieved or issues that have been solved by digital technologies?
14	What are the obstacles that restrict the full potential of digital technology? *[If they ask for clarification: "For example, in terms of natural resources, energy, infrastructure, regulation, culture, business environment"]*
15	What are the limits in this domain, what problems do you think cannot be solved by digital technology?
16A	What would you say are the risks associated with increased use of digital technology?
16B	*[if they don't mention Machine Learning or Artificial Intelligence in the risks]* When talking about the risks, the focus of some debates seems to be in artificial intelligence. Have you heard about this?
16C	*[if they don't mention bias and associated harm in Artificial Intelligence]* Debates about artificial intelligence sometimes ethical concerns around bias. What are your thoughts about this? *[If they ask for clarification of bias: "for example, research suggests that facial recognition seems to work best for lighter skin tones, and voice recognition seems to work best for male voices, and this has been documented by Google ex -employees who helped develop these technologies"]*
17	To what extent should ethical and other impact concerns be considered in the design stage of digital technology, if at all, compared to other stages of product development?
19	What are your thoughts on how digital technology can be used to increase consumption patterns and practices of itself and other products? *[Do you consider this a dilemma, if so, can it be solved?]*
21	In the case of digital technology, to what extent do you think that seeing it in mostly positive terms (for example, as strategic enabler of innovation) could make it harder for both companies and users to detect or prevent unwanted consequences?
	Closure. I will ask if they would like to add anything, thank them again for their time, confirm my contact details for any questions they might have and tell them I'll gladly keep them posted about the insights or any other development.

Areas with increased sustainability focus

Sourcing & Procurement

Energy
Raw goods
Labor
Critical resources
Technical-technological components
Suppliers
Outsourcing
Purchasing processes

Partnerships & Customer Relations

Supply chains
Logistics
Chambers & networks
Business ecosystem
Customer satisfaction
Customer behavior enablers
Other stakeholders

Value Proposition

Function & form
Quality
Design
Consumption patterns
Product life-cycle

Value Creation

Core business
Manufacturing
Enabling technologies
Marketing
Material ownership

Finances

Expenses
Investments
Substitutes
Subsidies
Sustainability premiums
Advantages
Price structures
Revenue models
Funding

Reporting

Financial
Environmental
Social
Corporate governance
National standards
International standards
Industrial standards

Channels & End-of-life

Marketing
Communication
Distribution
Use
Care & management
Product disposal
Recycling

Others

(Please name them!)

Strategies for sustainability

Circular Economy

Product as a Service
Product Refurbishing
Rematerialization
Industrial Symbiosis
Collection Service
Local Loop
Modularity
Trash to Cash
Upcycling
Remanufacturing
Product Deconstruction
Closed-Loop Production
Rent instead of buy
Circular Supplies
Unlimited Warranty
Innovative Product Financing
Repurposing of Excess Capacity

User Behavior

Nudging
Reduce Consumption
Daily Habits
Modification
Pay per use
Repair Encouragement
DIY

Lean Practice

Miniaturization
De-materialization
Lean Production
No Frills & Frugal Innovation
Drop shipping

Physical to Virtual

Digitization
Virtualization
Predictive Maintenance
Remote Maintenance/ Service
Internet of Things

Open Innovation

Open Source
Make More of It
Corporate Asset Sharing
Crowdsourcing

Sharing Economy

Consumer Product Sharing
Consumer Resource Sharing
Consumer Extended Value Chain
Fractional Ownership
Social Franchising

Stewardship Models

Differential Pricing
Inclusive Sourcing

Production Alternatives

Local Grow and Sell
Produce on Demand
Waste to Storage (Carbon Capture)

Others

(Please name them!)

Sustainability Standards

Reporting Initiatives, Frameworks, Certifications, EcoLabels

Miljøfyrtårn
The Ecolighthouse

The Nordic Ecolabel
The "Nordic Swan"

BREEAM NOR
Building Research Establishment Environmental Assessment Method, Norway

GRI Standards
Global Reporting Initiative

Integrated Reporting
Sustainability Accounting Standards
Climate Disclosure Standards
Carbon Disclosure Project

Task Force on Climate-Related Financial Disclosures

IASE Certifications for ESG
International Sustainable Business (ISB) / International Sustainable Finance (ISF)

Principles for Responsible Investment

The EU Taxonomy Compass

ISO 14000
International Standard for Environmental Management Systems
Other ISO standards and voluntary guidelines for sustainable practices (20400 Sustainable Procurement, 26000 Social Responsibility, 14064 Greenhouse gases, etc)

B-Corp
Certification for Social and Environmental Performance by B-Lab

The UN Sustainable Development Goals (SDGs)
SDG Impact Standards
The UN Global Compact
Other SDG Reporting

Fair Trade certifications

Social or Environmental Life-Cycle Analysis
Environmental Impact Analysis, Life-Cycle Assessments, Cradle to Cradle, etc.

Other
Mandatory
Voluntary
Internal Policies

Appendix B. Quotations from the Interviews

Inf: the code assigned to each interviewee, as described in Methodology, Table 01.

Table B01. Definitions of digital technologies and digitalization

Row	Inf.	Quotation
A	*6*	*"… for us internally that would be getting data on our activities, all our projects, making that available through technology. So, dashboards, having charts and graphs and making that accessible to all the employees in (…). So, that is, at least how I see it. I don't work directly with defining them (…), so I just receive these kind of reports and links to dashboards so I can get information about how the company is improving their, their KPIs on this. And I see that it's the same among our customers, so they also have maybe someone internally that is responsible for sustainability. There's a lot of reports coming out. So, yeah, from that perspective I see that technology is helping kind of making information easily available to people in the company."*
B	*7*	*"…data is not longer just "data" because of the huge size of it and also how technology has helped us all using data in another matter. So digital and digitalization is more about helping data delivering the best way of taking decisions, not as it used to be. Technology used to be technology for itself, where data was like something that was just a component, not the substantial part of it."*
C	*1*	*"a tool for humans to be more effective or deliver products or services in different ways. But it's important that we look or we view digital technologies as tools and not a goal in itself, but it's a tool to make change or impact or something and we should do it the right way (…) we have to acknowledge that digital technologies are tools for achieving something and it's the something that has to be evaluated and of course you can discuss if this digital tool is the most effective tool we can use or do we have a different one that has better, or that takes into account sustainability for instance?"*
D	*4*	*"Enhancement and the solution for several of the, is it 17 sustainable targets we have, 17, 18 something. So, we need to use technology as a tool to solve a lot of those issues*
E	*5*	*(she asked if I meant digitalization for sustainability, yeah if you want) "it's important to do digitalization, to reduce the raw materials in a better way, for instance, as an example, in the process industry this is very important. If you have raw materials going into a melter for melting minerals metals whatever. And recycled materials will often have broader variation in your input material than mined raw material or virgin raw material, and you need to measure these variations. (…) that's why I like the industry 5.0, more than the industry 4.0, in industry 4.0 the forest you can say is the optimization and robotization, but industry 5.0 is collaboration between robots and digital technology, AND people. And I think that is, it's definitely the five, it's definitely a step above the four."*

Table B02. Describing positive applications of digital technologies

Row	Inf.	Quotation
A	*1*	*(…name of company) that they use AI to monitor biodiversity. So instead of scientists having to go on a boat and actual count birds for several weeks with a lot of error margin then you can use AI to monitor video of wildlife and to actually monitor biodiversity over time or when you have when you install like a windmill or whatever. (…) Also we have a company that works with value chain optimizing in the meat industry. Of course you can discuss if you want to make the meat industry sustainable but I think we do because it's cultural and we will eat meat. So I think it's a great effort. And then they use AI and actually save at least 3 percent of waste meat waste with AI. (…) Another is (…) that is actually situated in XXX that uses AI to monitor power lines. So instead of you doing it time consuming and dangerous work for people they use AI to monitor the power lines."*

B	*2*	*(prompted: biggest impact) "Definitely in healthcare definitely in various aspects it [digitalization] has the biggest impact. You know, lower use of resources, raw materials as such. It's lower transport needs. And it's a better utilization of current resources, human and material. So, I think the move towards digital health is by far the one that has the biggest impact."*
C	*4*	*(prompted follow-up: of those (digital technology or digitalization enabled process) you mentioned any in particular you think can have the most significant impact?) "Carbon capture is the most significant. Of course, digitization is extremely important. Virtualization is important. Internet of Things are really important. And why? Because we're going to solve a lot of things with digitization and virtualization." (prompted on which has biggest impact) "dropshipping is more sustainable for some companies. This goes directly from the producer to the end customer. It doesn't go into a warehouse or storage for them to be sold further.*
D	*5*	*"from a production perspective, of course, the digital twins is definitely very important because being able to make a digital twin of your whole process line production line, and then you can do it on the computer to see how to optimize the line before you do it in practice, or not to mention for instance building digital prototypes in one of the other (...) you have raw materials going into a melt for melting minerals, metals, whatever, but recycled materials will often have a broader variation in the input material than mine raw material or virgin raw material. If you then have (...) some spectroscopy technology, which is an inline measurement of the chemical composition of raw material coming into the mouth, and then you can adjust the mouth, according to the raw material stream. When you have the data processing you can use A.I. to then calculate how you should adjust or lower for instance the temperature of these specific variations in your instrument."*
E	*7*	*"We use as a rule of thumb that digitization is in itself a sustainable contribution to the world. So I think that we think in itself that you're saying that with digitalization, and optimize the use of all the platforms and tools available when it comes to features like A.I., machine learning and other stuff, features are in itself a contribution, a contribution to that. Without thinking of the value chain around it, but that is basically what we say is important. Of course, I could go into this because I also know the economy. But as a company, I can say that we more officially say that digitization is important to consider for being more sustainable because its effectiveness is higher, the results are much more effective. But of course, could be other factors that could contribute to it in other way, of course. We know that, too, but we have landed on that. (prompt: biggest impact) "things go fast and slow at the same time. So what could have been a big change six months ago wouldn't be anymore now. Yeah, for me… it's a little bit intricate, but using machine learning algorithms for optimizing is extremely effective. So, for instance, one of those huge trends nowadays is how so expensive the power utilities are, the electricity in Norway. We see that, for instance, balancing the surplus of energy and electricity around cross-countries, cross-regions, electric grids in US and so on, we see examples where we can optimize it significantly using the right type of technology, machine learning, A.I. So there is a revolution now for data engineering using the features from more technology platforms available. That is not easy to discover unless you are very much into it. And then that is obviously double digit efficiency gains on using those types of technology. (...) when you have a scarce resource like electricity like you are nowadays. If you optimize the use of it during time or region or other dimensions, you don't get more of the same resource, but you can use it better, which then gives you a chance to not using more energy, which is good for sustainability. So every gain you get into a sort of industry or area like that is good, basically. (are the gains better for the companies or the consumer)? The user. So electricity is the best example in this case because it's so easy to see that energy is energy. If you should have more than you need more gas, which you don't want. So*

		optimizing, for instance, the electric grid is extremely important. And we have just started. Many would think that we have control over that area. We don't."
F	*2*	*"huge amount of work going in digitalization towards virtual reality and augmented reality to, you know, avoid long travels of patients, to increase capacity of existing surgeons for example that can do remote surgery, to increase the training of personnel, increase therapy that it can be done at home. So if you have, you know, mental health disorder or even a physical disorder you need rehabilitation. So, you know, there's augmented reality solutions or virtual reality solutions to help you recover. (...)…one of the areas that is gaining a lot of attention is personalized medicine and drug development. So making drugs (...) specific, not to a specific condition but to a specific condition in the person a specific person right. You know, we have more or less the same body structures ...[but somebody else who is].. a lot thinner than us, (...) or a woman (...) or an older person, they need a different type of drug. [in cancer therapy] only 30% of the drugs that you take actually have a strong effect. So most of the drugs, they're either not doing anything, or then they're counterproductive so [work] being developed will alleviate or will improve that quite a lot [...] So, you're reducing the amount of drugs first, and then reducing the side effects. And improving treatment. So you're reducing the use of raw materials you're reducing the need for the hospital to provide all that treatment and follow up. You're improving the quality of life of the of the patient. You know, extending their life span, most likely. So, you know, environmental, sustainable and societal impacts…"*
G	*7*	*"..we are just seeing the start of a huge industry that will have investments in the world, I think like five thousand trillion dollars or something when it comes to the green shift. We need to replace fossil energy with more sustainable energy. And we know that the new way of producing this efficient energy would require maybe as much as 50 percent of the investment into digitalization. So then you have two aspects of it. The one thing is that you will not have a green shift in itself unless you use the best way of using technology and digitalization. And the other way is actually seeing what kind of technology you put into this. And if you use that optimally with the best way of using machine learning, AI and other efficient ways of predicting and using and optimizing beyond the human capacity at all, we can see further how we could do the green shift.*

Table B03. Tensions related to negative outcomes and risks

Row	Int.	Quotation
A	1	*"Some of the problems are on the use of data and the environmental threat that excessive copying of data might mean because the data centers and all the data stored in clouds, it really demands a lot of energy. (...) but also how you use technology and for what purpose. (...). Energy will be a huge limitation for technology in the coming years."*
B	7	*(prompted about consumption dilemmas) "...I'm not sure if it can be solved, but I was actually a little bit surprised for what I mentioned before about where the largest CO2 footprint is, of using technology. most people in the world would actually think that it is producing the algorithms running the technology using data centers, storing data. But actually, most CO2 consumption was done in the end user level because the sheer number of devices was so huge. And that got me to think about that this is not an easy dilemma to solve. So what we need to do is to make the inner clients and easier clients and everything around that running data centers and. Centralize how we do that. I think that is necessary. But I would not recommend to use all the data centers to make bitcoins, for instance. But there are aspects of how we actually use the technology."*
C	4	*"the only things we have ever discussed there in different kinds of companies are "okay, we're going to use a server who is in a place where there is electrical power from water and the environment part of it with how we're going get rid of the old equipment that we have." That's the only two kinds of discussions I've ever been in*

		regarding sustainability within IT more or less. (...) But we also see that there's a lot of companies like (name withheld) who will help other organizations to become more sustainable regarding reporting on sustainability. We also have (name withheld) with their own solutions for sustainability reporting, etcetera. So, there is more and more focus on sustainability and that we are going to use the technology to become more sustainable, but not the technology sustainable in itself (...) Of course there will be some negative impacts. We see that technology is sometimes reducing the employment, the staff. We have done something, we have created some RPA solution. That means that five people have to go into a knob and get social. But mostly we see that the effectiveness created is positive. The company I mentioned, showed you just before here, they can have a revenue on twice the amount now with the same people, because the technology saves workload. Yeah. So, but mostly I see that technology is used for good. Yeah."
D	5	*"the only risk I can see is a more divided society, if you're not able to make sure that digital technology is something just as basic as mathematics or languages that you learn at school. You can get a divided society. "*
E	3	*"Cybersecurity. Everyone talks about that. That's where I kind of got that. I think the data itself. I can also talk about the data and maybe data privacy risk. Yeah. Because like, for example, with the sensors, like I talked about, you have to agree with the customers. Otherwise they'll say, no, we don't want you to know or get hold of our data. Other risks with this technology is maybe cyber security and then the data privacy."*
F	2	*"I'd say risks on data breaches. So, cybersecurity in everybody's agenda. Data being leaked and some people's private life being hurt because of digital solution not being fully functional."*
G	4	*"Cybersecurity is clearly an issue. Routines and code standards that are creating security. That's always a risk. And there are always companies or individuals that trying to destroy or do harm. And that's a big challenge"*

Table B04. Tensions related to competence or market pressures

Row	Int.	Quotation
A	4	*"I mean, the greatest problem for all industry is in Norway is competence, both on the strategic level, and for the developers, we need developers. We need developers, we need to have the technology is there, but we can't hire, recruit developers. It's a shortage of developers."*
B	7	*"what we normally see when working with emerging technology is that the barriers often are about who is making the decisions and where this takes place. And lack of insight into what technology actually could do. So it's quite common that those handling decisions related to the cost of implementing or using that type of technology, if they lack the competency or lack the will to actually get that competency, that will be that is a huge barrier for using optimized technology to help on sustainability."*
C	1	*"companies are struggling because it's hard to make great business models that really they can profit on."*
D	7	*"I read somewhere that the problem with the CO2, what is called climate footprint, is not always about the data centers and the production and the use of technology. It's more how many end users you have with their own devices. So if you're looking into that, it is one example, which is not common to think about. I would think that the challenges are also adapting to the ESG requirements from the market itself and their customers in the right way? I would say it's the big challenge because they are trying, and some are good. Most are not. So I would say that for an FSI industry, they are more adaptable to obey or to align to the sustainability requirements if they get even more pressure from the market and their customers"*
E	3	*"There's this company that I've told you that they've taken some of the products back. I think this company as of today, they're more like in the middle, they don't know whether they should take back more of these products or not. They're not by today, they*

		should market but also they realise that when they've taken back these products, it was a lot of work, more than they anticipated. So, you know, these products, they have a lifespan of 50 years. So, they were just experimenting. This is more like piloting for them. They took back these products and then they realised that they were extremely dirty and they had to do the cleaning inside the factory where they produce new products. I remember when they mentioned it to me, I was like, yeah, it's just cleaning but when I went to see it, I'm like, oh my goodness, this is a lot of work. It was dirt, grease everywhere and they were not prepared for that but also actually because they didn't check the conditions of these products before they brought them back, they realised that some of them, they can't do anything about it so they have to get rid of them again. So, for them, I think for now, they're more like, okay, what's the best way to go about it? Should we continue taking back or should we not take back or should we find a solution where we can maybe go to the scrapyards ourselves and then check the condition of these and get them cleaned there and bring them back and how about the costing of sending the service agents abroad and their missions. So, I think I would say maybe this is an example for now that they still haven't found a solution, sadly. "
F	2	*"The other aspect is how hospitals are funded. So, if you have a private hospital, they, or they talk with the private insurance, and it's a private insurance paying for the healthcare service. The insurance has all interest to deliver the best care possible to reduce the readmission of that patient, right. So doing it one time, it's a lot cheaper than doing it, you know, two times if you get you know a bad surgery and then you have to come back, it costs a lot more to the insurance. In Norway, the hospitals are paid by the number of patients that comes through the door. So, let's say you go to the hospital, you have surgery or you got whatever treatment, you go home, you get sick, and you come back to the hospital, and the hospital is paid twice. So, you know, you can see what I'm getting, there's very, you know, I'm exaggerating, of course, people want to do a good job and everything, but there is not a great incentive to innovate and bring together more practices to reduce the number of patients that come through the door. So, you know, you can see what I'm getting, there's not a great incentive to innovate and bring together more practices to reduce the number of patients that come to the hospital. To improve the quality of treatment that is delivered because of the way they are paid, right."*

Table B05. Tensions related to regulations

Row	Int.	Quotation
A	3	*"I think it's because of their production strategy, which is engineer to order. It's mostly because of that, because most of these companies, they're suppliers to the shipping industry. So the requirements are very strict, because I mean, these are some of the components that would be on the oil and gas industry or that would be on the vessel. So the barriers that I think have come across so far is the class societies, like for example, the DNV, those guys. Because what happens with these companies is, for example, if they have to reuse something, it means the class society is just doing what they do with the new products too. They have to come and validate or verify that, "yes, this is good and it fits with the requirements that this product or component is supposed to be on." So the challenge for these companies now is that they are worried that the class societies might not approve these reused components or products. And the other thing was the market for them. Like, for example, this (...) is a company that has already taken back some of the products. They have them, they've refurbished them, but now they're just sitting in the factory because there's no market for them yet. So those were more like, I think, the major obstacles that we've encountered with these companies so far.*
B	2	*"...When you talk about healthcare, if you have a medical device, you lock the design and locking the design is all the materials, all the quantities all the components the manufacturing process, everything. You cannot change it. So if you're going to change*

		it. You need to re certify your product and that's, you know, sometimes a couple million euros. So companies are not going to do that. So they don't focus on the product as such to improve their environmental sustainability. They may focus on the supply chain. So, you know, a better distribution system or less packaging, or on the use the type of use of their device, which is not necessarily covered by any or most of these standards. 14,000 covers the use phase, but then, you know, companies are not looking into it (...) So you cannot, for example, reuse a lot of things in the health care domain. You need to have everything individually packaged and you cannot go around that because of regulation. So it's not because of the lack of will, it's just regulation (...) also, if you need to certify a new device, you need to have the CE mark. And to do that you need a clinical trial or two or three sometimes depending on the type of medical device. And then two months after you think I could, you know, investigate and reduce the use of this material or instead of this plastic, I could use this other material that is a lot more sustainable. You cannot do that. If you don't research, if I, right. So when you're putting a device on the market, you are locking it, and you cannot improve it for the next, you know, few years, because it's basically not financially sustainable."
C	5	*"I think one problem are the EU regulations of how something is classified as waste. You're not allowed to use it as a raw material. In many cases, for instance, if you have car tires, you can use car tires as a source of carbon in and burn them in to get heat for the process industry, instead of coke. But if you do that, it's not allowed to do it, because then you release the CO2 from the tire, of course that you also do that with coal, but tires are products and classified as waste (...)(...) when you have an industrial process, you will always have waste in your process, some, some scrap production, some part of raw materials that you cannot use and so on. (...) for instance you often have to pay money to get that into landfills (...) if you can use that scrap as a resource, if you can put it back into your product line. If that material could be a raw material something that's your waste could be a raw material for another company, then you can sell it, or at least give it away for free, instead of paying to put it in landfill. (...) "(if a company is extracting) ...minerals and then you get what you want to have, and the rest is dumped in the fjords or whatever you know and it's not only not good for the environment, it's also not sustainable because we can use that as a replacement into concrete, we can use it as raw material for other processes, and that's, then this is not scrap it is, it is raw materials, it's valuables."*
D	2	*"So GDPR is preventing a lot of hospitals to facilitate innovation and adopt innovation, because, you know, they want to follow certain standards, and to not share data from their patients, and if it's anonymized, they will need the consent. And in many cases when they started the data collection, they did not ask for consent. And then it's a mess to go back and ask the same patient for consent, or if you ask consent for one study that has been done now, but you know in in five years ago 10 years ago nobody thought about asking consent for this study, and subsequent studies. (...) another barrier can be the ethics regulation, because there's a data protection officer and there is an ethics committee, but the ethics committee also looks at the sharing of data, right, is not just looking at the, you know, the unproduced groups or the bias or the ethnic bias or whatever, they're looking at the whole thing. (...) And so I think a medical device regulation, GDPR, and then ethics issues, certainly hinder innovation. So, you have a lot of data, a lot of material, a lot of opportunities to develop innovation with existing data that are just not possible because of, you know, data protection and or ethics issues."*
E	7	*"Well, it's very important. Yeah. Since we are a listed company, we are aware that ESG is one of the drivers for the values, putting value in the company. We also know that our customers use ESG as more and more of a criteria and our employees look up on us how we do it with the ESG agenda. And we are, of course, concerned about it ourselves. So we are concerned about the whole sustainability agenda in the world.*

F	4	*"regulation that is not appropriate for all the processes, that's a big obstacle, but it should also help digital technology go farther… but from that side, I think that it's hard to classify specifically what process can be digital and what cannot be "*
G	3	*"Reporting… Now this is a lot that we're dealing with now. The, not the financial, but more the environmental and the social as well (…) if we put the ESG and international standards, because most of the companies, most of the customers for these companies also of course they are not Norwegians but most of those international standards, especially from USA that are putting pressure on these companies. And of course the industrial standards. (…) but I don't think the companies can do it themselves, to be honest. The life cycle assessment, of course, it's a tool that really captures the environmental impact really well as of today. But even the corporate sustainability reporting directive. What I'm saying is because now there will be those mandatory audits because before, you know, companies would just write sustainability reports and then publish on the website to send to everyone. But there were no mandatory audits on it. But now with the corporate sustainability reporting directive, though, there will be audits that will be mandatory. So it's not just something you just guess or just you just done once. It will be something that will be checked for verification and validation."*
H	5	*"I think with the EU taxonomy I think it's, it's a very important tool to push the industry in the right direction. It's having regulations that are actually possible to fulfill. That's important."*
I	1	*"The EU taxonomy is really exciting but I'm of course a bit worried about because they say that capital will naturally flow towards the sustainability choices but I don't know what the US will do or China will do and then you will just lose out in the EU. So I'm really excited to see what the future holds for the taxonomy compass but I hope that the other continents will follow for sure. So I think that can be very useful if the rest of the world follows."*
J	6	*"So, the EU. Taxonomy. Yeah, I think that's when they, the customers are struggling a bit so it's more hmm okay, I've heard this "how would that impact on our business and what do we need to do fair trades". Yeah"*

Table B06. Tensions related to voluntary standards

Row	Int.	Quotation
A	1	*"What about the fact that you have now in Norway the Miljøfyrtårn which has been the most used, but we're not sure that this provides continuous development towards more sustainability (…) we started the process with Miljøfyrtårn and then we realized that there might be other options (…) So I think the ISO standards are quite good. It's more challenging for small businesses of course."*
B	2	*"ISO 14,000 it, you know, I think 15 years ago 20 years ago. It was a huge hype around it. Now, much less. I don't know any company that has actually ISO 14,000 certified so they have 1001 or 9000 series, and then many of them the 1345 so the quality assurance for medical devices, and the 6661, which is for software or solutions that have a software component. But that's it. (…) I've worked with the ISO 14,000. You know, few years ago. At the same time that I work with 50,000 so the energy one. And I think, you know, they are there for the continuous improvement. Thinking that the ISO series is very good but underutilized in in health. And the reason is the regulatory aspects so for most of these, maybe not all. But most of these will focus on the continuous improvement you need to improve from one year to another. From one audit to another right. (…) Miljøfyrtårn the first one on the left it's present, but yeah, not much in healthcare. Nobody has heard of in Norway of the TCFD and the EOSA, they, I think most companies on my cluster they never heard of it. (…) Yeah, they're more common in some other industries or companies that work also in other countries, some countries continents adopt much more some trends."*

C	6	*"Miljøfyrtårn (...) the Nordic Swan, I kind of relate them to consumer goods. (...) That's also interesting because we see that the industry is quite familiar with these types of standards. So, that's kind of how we have work processes or we are used to handling new types of standards that come into technology that comes into effect for different parts of what we are doing (...) these types of standards would be kind of easy to, maybe easier to integrate in parts of what we are doing than adapt to sustainability. But I haven't heard anyone kind of use them for sustainability really. And there's, of course, more on the internal part again, so clients ask "how do we report our sustainability KPIs."*
D	7	*"In my personal opinion, I think they are important, but how… to what degree they are actually measuring the right thing. That's what I must say, they never been actually so. But I think they are a good driver. I think it is nice that we have them. I think, for instance, this Nordic Swan, I would say that is the one I would put most trust into here. But to what degree? I don't know. Should I put a number on it? I don't know. No, no. That's obviously a perception thing. (prompted on why he singles out the Nordic Swan) the Nordic Swan has been around so long. What I have personally experienced into the market, I would say that it seems that they would have not existed for that long if they wouldn't have been that good. (What about the SDGs?) they are to me not something I would put into like a measurable part. I mean, you mean the SDGs, the 17s and 164 of them? (indexes?) yes, I personally haven't seen them used in that way, actually. So for instance, it is more a stamp of recognition, especially the SDGs are a way of categorizing the world. Maybe in the EU or globally others are using it that way. But I'm not familiar with that."*
E	1	*"UN SDGs of course those are very useful but they're not easy to make concrete in companies and it's very easy to use them for greenwashing and it's really easy to interpret them as it suits you. So, it's easy to forget that when you come to the points below the top heading, then it's more about what goes on in less fortunate countries and what we can do there and not so much about how one company can make things better in Norway. So I think practices that really activates the SDGs is key to make this and I know that there has been some practices that have been released in the past years but it took some time for Norway to try to understand what this means for Norway and other businesses and still I think there's some greenwashing."*
F	2	*"I think the Sustainable Development Goals are too general (...) the SDGs are the one that everybody will mention. Because they're kind of obliged to right? but when you start talking about it with them, most people do not know what the sustainable development goals are and how to report on them right, but it's by far the one that they will mention the most. And I think then it depends on the type of product"*
G	6	*"It's interesting to see that this kind of sustainability reporting is also becoming a business. It is definitely true. Yeah, so I can't say that I know all of this, but the UN sustainability goals have become so. I see a lot of customers have chosen a handful maybe two, three, four, five of them, and then says, like, use that in their strategy work, or in their corporate presentations when they explain what they do. So a wastewater customer that would be "yes we help ensure kind of safe and healthy water for everyone." Yeah, so that's kind of how I see that come to use in from customers side."*
H	4	*"Not in this project. We are using the sustainable UN sustainable goals in quite a lot of other projects. And (...) company is developing a solution for the EU taxonomy compass, they are translating this into a digital tool. (prompted about adequacy) I don't know. I was chairman of the board in a product development company, and they use the sustainable goals, but this is a product company making this product and developing interior products. And they are using the UN's goals, and I see a lot of companies do that."*

Table B07. Tensions related to norms and culture

Row	Int.	Quotation

A	1	*"I think culture matters. So in AI projects it is said that more than 80 percent of AI projects fail. Some people say it's because of culture, because we are poor at adopting technology and to take care of the values that we create. So, we have to have a plan for the value you create when you use technology. (...) another challenge is that in the mature digital society such as Norway we have built a lot of proprietary systems and silos. So breaking the silos and really be able to share data on a higher level that's something we need to do to solve sustainability issues. Because it's all about the value chains and how we use resources. So that's one challenge with siloed data that already exists and not a culture for sharing company data openly…"*
B	3	*"our members are more interested in product refurbishing or refurbishment, not just on the product but in its component level as well. When it comes to the refurbishment, they know some things. They are interested in leasing, they really want to adopt leasing but it's more complicated. They are in the process of trying to figure out how they can make it happen, but they're not there yet (...) and the maturization as well, industrial symbiosis, they are not there yet, even though we've mentioned it several times that actually this can work because most of these companies actually they are in proximity to each other. But the problem is, you know, they don't like to share in those terms, some of them are competitors or maybe it's a supplier to the other. So, I don't think it's happening. It's not like they have to share every kind of information, most of the sensitive ones are left out. And with the industrial services, it could work with these companies a lot, because most of them are in the marine, the maritime industry, but I feel like maybe it's not their focus yet…*
C	2	*"think, you know, the conservatism of the sector. So, maybe, so digital technology is at the same time a problem and a solution for what I am going to mention as a problem. If you go and ask in the environment, or the community of healthcare, and ask what's the biggest challenge, the biggest obstacle to adoption of innovation in the hospitals, most people are going to tell you that is the staff. (...) they have very tight protocols and processes that are very difficult to change. So, you need to bring them on board quite early and, you know, really massage them to think about the value that they will get from adopting a new digital solution or changing the current process or having a new way to do clinical validation."*
D	7	*"I would think that I sound like a technology optimist. I'm not particularly that. The world alignment on politics is something I don't think technology will help at all. So, the big issues when it comes to sustainability and, for instance, the climate part of it, I would say that how the world cooperates together is the biggest challenge to get agreements that actually work. I'm not sure if technology is a big thing there. (...) in some industries digital works really well. But where? I would say it's working in finance and insurance and energy sector industry and then quite a lot of other industries. But the main two are FSI and energy."*
E	2	*"…actually, a lot of the problems underlying are not maybe related to digital technology, or maybe not made worse by digital technology, you know? I think that's in the blood of every entrepreneur. So, you know, I work with entrepreneurs, so the brilliant guys that just see the opportunities, and they don't see the risks, they don't see the challenges, or they see the challenges, but the challenges are an opportunity for them. So I think they have a strong bias to believe in the positive. (...) so in the end I think you have the innovation segment that is looking only at the positives, and you have the more, let's say, political or policy regulation driven stakeholders that look at the negatives and the challenges…"*
F	3	*"I don't think that being optimistic about digital technology can prevent companies actually from also seeing the negative aspect of it. I think for technology being an enabler, I mean, it's one of the enablers, it's not their own enabler. But I think it's good for companies to really know so that they can also make use of it. But I don't think that can stop them from seeing that, OK, yes, this is an enabler, but also there can be*

		some negatives or negative effects associated with it. I don't think it has that effect, no."

Table B08. Tensions related to the alignment of value and purpose

Row	Int.	Quotation
A	1	*"I also think it's what we use the values for. So I think the economic system might be a barrier for creating value and that doesn't not just go for technology but it goes for everything we do. Because if we don't have incentives to produce other value than monetary values then we won't, I think solve these problems. (...) so, we have to make different business models profitable like reuse, repair, you know all these kind of closed loop circles so that companies start to push these business models to the customers to be profitable and so they can make a profit. (...) Or maybe we need to have a business model that makes sure that when we have increased the revenue at the same time we generate less CO2 emissions, or yeah you know, something that is relevant for sustainability. We have to focus more on the end goal and the impact because digital technologies have to be used as tools and not as a goal in itself so business owners have to have the discussion so we want to increase revenue by so and so and so and if we increase revenue by pushing more products what kind of impact will that have on sustainability?"*
B	1	*"but also the data ontologies because there are different measures everywhere… So the challenges there start with the ungenerated data, because we have to be really conscious about how we both develop the data assets, how we develop the models and who developed the models and how we deploy them because you have different obstacles in each section. So this is something we have to address… so there are so many obstacles here and traps there. (...) So, you can solve a lot of problems with the technology but we need the right system.""*
C	2	*"bias I think that's an issue very present in Norway's data, so Norway has some of the largest data banks and biobanks in the world, I think the databases, the health records we have, you know, some of them go back 50 years, 70 years. If you go to the home study, I think is now 5000 variables for, you know, hundreds of or tens of thousands of patients. So that's unparalleled in the world. "*
D	4	*(prompted about limitations of digital technology) "This is mindset and management. There is knowledge, competence building activities, but putting it on the agenda, those are things that technology itself can't do if people don't do it. Otherwise, I think that with technology you can solve a lot of the different issues and challenges. But it always starts in the mind with the management and the board."*
E	5	*"we do some working with robots, I think robotics, robots that do welding, you know, and what we see what we show to the welders is that their competence is still necessary because they have to guide the robot and tell them the materials the input, all the technical information, and, and not just from a data sheet but based on their experience."*
F	3	*"Well, one thing is it will never replace human beings. That's one thing. But of course, I think of another example from an experiment that we had It was more on the industry 4.0 side with a company that produces castings that we were trying to look for, if they can use a cobot in throwing the ingots in the furnace without the cobot being burned. You have to place it very close to the furnace. So the problem is, you know, for you to throw in the furnace, you have to get very close to it to also avoid the splashes which bring air in between and then the product will be damaged and is wasted. But the cobot [which is used to reduce exposure for worker] cannot go close because it's going to get burned because most of the parts are made in plastic. So in some sense a limitation will be the materials that these technologies are being made of themselves. Because if this cobot maybe was made in a certain material which can be resistant to*

		heat, then maybe that can work. But as of today, most of the robots and cobots, they do have some plastics which are not recyclable or biodegradable, by the way
G	2	*"I think it goes back to (...) rather regulatory boundaries that I mentioned. We have several companies that start developing their product unilaterally so they don't look and talk too much with their customer, they don't talk with the regulatory expert. And when they get to the stage of talking to the customer, and they realize they have to document all the design considerations, all the ethics considerations, all the GDPR considerations that they need to meet the regulation. Sometimes they need to go back to the beginning of product design. So, I think, definitely as early as possible into the product design. "*
H	3	*"I think from the very beginning. And I would even add not just environmental and social, but the economic as well. All these aspects have to be actually added or implemented in the very beginning of the designing of these technologies. So, yes, to a really, really, high extent, they have to be added to this from the design phase, starting from the design.""*
I	5	*"Composition function for design for quality, design for recycling, is very much an issue for us. How do you make products that's easy to recycle that don't blend materials together, that's hard to separate, for instance, composites are at the moment very hard to recycle (...) sometimes, or in older models, decisions are considered after the fact right? like almost like how to solve things that are already there. The designed part is where it's the most appropriate. You need to consider all the input that you give it to your machine. It's the same as, for instance, if you do sensors, and you change one part of your production line, and you use data you had from before you changed the production line, the sensors, the big data analysis will be wrong, because you use outdated data. So it's definitely, it needs to be thought of in the design phase. And you have to be careful what kind of input you used. It's the same when you read an article in a newspaper you need to know who has written it what is his or her intention in writing this article, this debate."*
J	7	*"Yeah, definitely in the design phase, obviously. And that is something we are also aware of. So we are, as many others, of course, working hard to convince customers and others that we need to always take a step back in the design phase. For several reasons. It could be, of course, sustainability. It could be optimizing the cost of the running cost later. It could be the risks and all parts. Yeah. So, we all know from experience over the years that rushing the design phase is not very smart or profitable."*
K	6	*(prompted on adequacy of voluntary standards) "Oh, I don't know if I have the competence to answer that. (That's OK, if you don't feel like commenting it's fine but if something comes to mind later feel free to comment) " I don't think I dare to make a statement about that but, at least my reflection related to it is that you need to start somewhere. So, trying to, as we do try, to get insight into okay per project, what is the actual CO2 emission that we can track back to this specific project, and it may not be 100% correct. And I have heard that there's different ways of calculating this. And depending on, okay, do I see my responsibility from here to here or is it only here, what kind of impacts a lot on the numbers. Actually I heard a presentation about this last week from one of our customers who was presenting different ways of how they have calculated and reflected also on what would kind of give the different results, and the difference in how beneficial each of these would be to them. Depending on if we measure from here to here, we take the whole lifecycle of this equipment that we bought, so from actual production to end of life, or if we measure only the actual time that we use it in the field. This was some large equipment they have purchased. I don't have any insights to how you should measure and how you can, how you can ensure that the numbers are in fact correct. But, hopefully, these kind of standards and guidelines will help us along the way, so it will probably get better. So, just starting to get insight into the numbers would be good, I suppose. And then, if you actually*

		have an honest will to help, to actually get insights and trying to use that data to actually improve, then it's good. I assume that someone would probably kind of misuse the maybe reporting numbers as well maybe, but hopefully that would only be a small part of. I don't think any kind of serious company would allow for that so I think if you can discuss what would be the best way to actually track and calculate these KPIs but hopefully it will get better and those that are doing it now probably will learn a lot."
L	1	*"some of the times it's out of the hands of the developer because it's when you apply it, then of course, ethical risks are there, can be built in already in the solutions. But it's when you apply it and really the value is created or the harm is created."*

Table B09. Tensions related to increased consumption

Row	Int.	Quotation
A	5	*"Well, marketing (...) it's always a dilemma I mean. We've banned marketing that specially targets kids in Norway. And I know that it's been a discussion on the Norwegian web pages, perhaps also in the EU, if it should it be legal to say "oh you like this item then perhaps you also like these, or these, or these" just because we would like people to use less. And in the regulation, again, what should be allowed? what should not be allowed? So it is a dilemma yes. (...) sometimes the company has some idea of what is more sustainable in the long term, but want something short term, so they say for example "I know that students move and they watch movies and all this stuff and so on, but I can have a way of collecting so that they can send it back to me and they get one, they get some cool new one if they send it back to me, and then I can watch it and this emphasizes that we can sell it as used with a lower price." Um, and that sounds like a good idea right yet, but how many students will actually do that? Not many, you know, so it's more like, the company making a product has to see okay what is the customer behavior and how can I expect them to behave, so that in total, there will be a good and sustainable solution."*
B	3	*"Oh, that would be really a debate, isn't it? Because at the end of the day, it's how to reach a balance. Because, yes, actually, I wanted to also say, with sustainability, we are also encouraging or discouraging actually overconsumption, the rebound effect kind of stuff. But how to reach that balance? Honestly, I don't know. It's hard to just sit here and discuss this. But at the end of the day, of course, there has to be a balance. But how? I really have no idea. Because everyone talks about it (...) maybe a part of this, a part of that. (...)* *(prompted on whether choosing between sustainable options can be a dilemma too, considering consumer behavior and whether a plastic or a metal drinking straw is better), for me, I wouldn't go for either the plastic straw or the metal straw, but I would go for the plastic straw that's made of bioplastic because if you make it out of bioplastic, it doesn't matter whether you use it once or use it 100 times because it will decompose anyway. But anyway we have to find an even better solution to solve this dilemma because it doesn't have to be A or B. In so many situations, we end up seeing A or B (...) but most companies, It's always conflicting ideas like, okay, if we do this, this is what's going to happen if we do this, what are we going to do then."*
C	2	*"it certainly can be solved, but we cannot expect technology to solve it. you come on the metro every morning, and you see people, more than half, they're glued on their phone, reading stuff that is sometimes completely superfluous. And why do they do that? Because, you know, the companies that sell information, they know what you want, and they kind of stimulate that vicious circle. They just keep consuming more, more information, but then of course more materials, more devices. So, I don't think it's, we cannot expect digital solutions to solve that problem. Digital solutions are being used to enhance the problem. I think it's, you know, human behavior change or behavioral change that needs to be affected in the right direction. (...) but I also think typical greenwashing can happen because the average consumer doesn't understand the life cycle implications (...) electric cars, there's a lot in Norway, but if you look at*

		the life cycle of an electric car, if you use it for less than 300,000 kilometers, in most cases, they will not be the most sustainable option. That's very clear. And I think in healthcare, so there's one company that produces a component that used to be discardable, and they produce something that can be reusable, but their customer, they're buying it but using it as a discardable one. So instead of reusing it, they're just using it and throwing it away. Even though they could, you know, sterilize it, clean it and reuse it. So this is, you know, the old problem of the work flows, the established workflows inside the hospital. And the producer knows that this is happening and the consumer knows that they could reuse it. But I guess it's an incentive to keep selling them more of this in terms of the company, as long as they tell them you can reuse it, but they don't intervene farther on. Yes, but think about it. The guys that are buying the products are not the ones that are paying for it. And they're not the ones that are using it. So there are three different types of things."
D	6	*"in technology I can actually see that clearer from a consumer perspective. I saw that you have "nudging" on one of your slides. So, consumption (of retail goods) consumers are maybe easier to impact, to bait, by using technology to impact on consumption from consumers. But that's harder with other businesses that are customers. I haven't seen any in digitalization, you clearly see that consumer business to consumer kind of leading that. And then industry is trying to follow, so I assume that we will have a similar discussion or seeing how we can use technology to impact or reuse or in that sense, because later you have the same discussions as you have in business to consumer markets."*
E	7	*"I'm not sure if it can be solved, but I was actually a little bit surprised for what I mentioned before about where the largest CO2 footprint is, of using technology that most people in the world would actually think that it is producing the algorithms running the technology using data centers, storing data. But actually, most CO2 consumption was done in the end user level because the sheer number of devices was so huge. And that got me to think about that this is not an easy dilemma to solve. So what we need to do is to make the inner clients and easier clients and everything around that running data centers and. Centralize how we do that. I think that is necessary. But I would not recommend to use all the data centers to make bitcoins, for instance. But there are aspects of how we actually use the technology."*
F	1	*"we often stand in this dilemma where digital technologies can be used for increased consumption and that's how it's been used a lot the past years. So how do you really control the impact of the technology in terms of sustainability? Because it can be used to optimize value chains and make them better and more effective, but you can also use it to push more products or make people want more, like marketing in a more effective way. So it's a two-sided story, it's a challenge."*

Table B10. Artificial Intelligence

Row	**Inf.**	**Quotation**
A	3	*"No, I haven't. I know there's someone here who is like an expert in machine learning, but I haven't heard anything about the risks of this company concerning that. So no, I haven't heard anything."*
B	6	*"Yeah, of course I know there's discussions about the risks, but I see that at least with the customers that we serve and talk with, digitalization hasn't come that far. So, the concern is more about, okay, can I access data that I have here that's part of some critical process. Can I do that in a safe way. That's maybe more the question, and then the debate that we have around machine learning, artificial intelligence is related to consumers, it's not industry specific to us (…) so we haven't really gotten to that point that if I use machine learning to optimize my process, then maybe the machine learning algorithm would just kind of shut down the whole plant. Yeah. But, I see now*

		that maybe digitalization hasn't really advanced to that level in this industry, it's on a much more flat curve. It's really simple problem solving what we are doing."
C	2	*"I don't see a big risk so far. A lot of people think that we will have an ethical use of artificial intelligence. So, I think in healthcare everybody has, seems to have, good intentions, and we're doing everything for the benefit of the patient. But then comes the other side of the coin that pharma companies for example, they will know a lot about the patient, and they will be able to exploit that. Basically make more money out of a patient or a cohort of patients by having access to a lot of data and putting an AI engine being able to process that in real time and taking advantage of that. So that's a risk that many people are discussing."*
D	5	*"I don't think it's a threat, but everybody that's used a chat bot knows that it has limited capacity, its limited kind of thinking when it's thinking about people, I hate chat bots because they never answer what I asked them to answer. And, of course, you see that in the same way as we get biased. It's more obvious when you see it on a computer and AI that they're biased for instance you probably heard about the issues with recruiting? (Hm, do you mean the Amazon scandal in the US? Of these AI models used for hiring based on previous successful candidates?) "yes. so you should never underestimate the complexity of the human brain, you can do artificial intelligence, but still, it will be limited to certain areas that they've been trained in (…) just by developing the technologies they will get better. And it's the capacity to do much more, for instance in medical, it's the capacity to process. In that matter it's [impressive], I really expect breakthroughs in the coming years. I'm so I'm optimistic."*
E	4	*"…We are not talking about sustainability within our approach [towards adopting A.I. in cluster firms] What we are trying to do... we try to inspire people and create a bit of panic by showcasing different kinds of AI solutions so that we encourage them to start using machine learning or the kind of cognitive technologies within their organization to try to solve challenges. (prompted further about AI risks), "there's a lot of problems within AI. It is from bias to black box. We don't know what's happening here. And as long as we use the Norwegian government or the EU guidelines for governance on how to develop AI, it should be no problem. But whenever we make a black box solution, we don't know what's happening in here. It isn't tested enough. It develops itself and we can't explain why this is happening. That's a real, real danger. (…) You have to use guidelines for developing machine learning and AI. If you can't explain it, you shouldn't use it. But that is, again, it's up to us as people to do that, there will always be companies and people that are using technology for bad, not for good."*
F	7	*(prompted to elaborate on the risks of AI besides surveillance) "Basically, we know how the neural networks, for instance, work in AI systems, which is then, it's not always traceable how a decision is taken, for instance. And you can look at AI robots and weapons and so on. We know that there will be decisions, but we don't know what the reasons were. So that's a huge risk because then you can get the wrong AI, but we don't need to see Robocop that way. We can also see that it creates biases, which is risk in itself. It can have financial risk, human risk, whatever, but there are risks. So that's the basic thing, I would guess. But then you have this long term AI risks we know going forward, where it even gets even more scarier when you see what AI actually can do. And we haven't yet decided what we should use it for and the limitations, but that's years to come.*
G	7	*"…There are lots of risks there, of course. We all know about those risks. We see them if we misuse AI, lots of examples already when it comes to biases, less transparency, less control. So basically every aspect around AI is high risk. I would say all the risks are this cross-border information problem where we store data in*

		other countries and we don't really know if they are friends at all in 10 years or whatever. And nowadays we can actually see risks on the physical level when it comes to what you call those cables for transporting digital signals across seas. They are actually laying along the gas pipes. There are lots of risks connected to surveillance, like in China. That's really scary. We see lots of risks when it comes to how we run our governance, politics, in the US, UK. (...) And also on a smaller level, as a society, I'm not sure if technology in itself always helped that much. (prompted to elaborate on surveillance) "it's easy to see regimes that use AI, for instance China now, where there is extreme surveillance of their own people. Of course, they couldn't have done that without AI. And as they go along, they develop their AI probably at the same pace as we do with open AR (augmented reality) and others. So, it's not hard to see that in 10 years what we then would have to use AI on that area. And they will probably export their systems to lots of other countries. We will gradually adopt it here as well, but then in bits and pieces for surveillance with good intentions, of course. But in the end, we are all in part of a big surveillance. So, I might be worried. (...) But if you keep on looking at sustainability, I think reaching the goals we have set on temperature on this planet, I would say that we really need technology and take that risk. So, for technology related to sustainability, I don't know if there are that many risks, but in general, I would stay on those risks I already said."
H	1	*"I think for sure ethics are a risk and we are already experiencing it (...) because the technology is scaling the impact so much so it can generate really large ethical problems. (...) So, we know that, you know, data science was not regulated in the same way as other sciences when it comes to ethics. It was only in 2017 I think that you had a checkpoint where you investigated the ethics of the research actually before publishing the model or the results. (Prompted on which stage of technology development has these issues) "How you collect data, what kind of data you use, do you train the model on historical data for instance and then you will have a lot of bias. Take for instance DALL-E, When I asked DALL-E to show me pictures of a "caretaker feeding a child" it only showed me women feeding children, and not men because we have inherited the bias in our data. And it's not because of the model but because of the data. (Prompted about whether techno-optimism could be an issue) "...that's a problem too when you don't have the right information, you don't have the right knowledge, and someone decides what society should do or because it's a trend or it's you know. So, I think this is a very valid question, but I think the solution is more open information. (Discussing the use of AI for sustainability problems) "...it's complicated because we see that if you take like the SDGs and you take AI as a technology, AI is not a neutral technology at all, and it impacts ethical and moral and environmental factors (...) the AI Act is also pointing towards that. It will make all the actors in the value chain responsible if the system is unethical or it produces harm to some groups of people. So, it's not just the company that has developed it. (...) we have to see that of course the countries that are not as digitized as our countries, they will also not be included both in the technology but also in the data sets."*

Table B11 Defining sustainability

Row	**Inf.**	**Quotation**
A	*1*	*"this has so many dimensions and so many flavors (...) I'd like to hear more about how you narrow it down in your research because it's a challenge and we see this all the time." "the holistic understanding of sustainability (...) it's varying a lot between businesses and companies (...) in the past years it's been economical sustainability that has been the main focus (...) I think that the understanding of system sustainability is much wider now (...) both people and planet are taken into the mix." "...in some businesses sustainability values are hygienic factors already..."*

B	*2*	*"hmm that's a very tricky question (…) …if you ask the environment we have here [the companies] I guarantee 90% are going to say that sustainability is about having financial revenue that is sustainable (…) having a model that generates cash and keeps the company running. I think there's more and more awareness of the environmental aspects, but still very little…"*
C	*3*	*"you got me thinking… because when I think of sustainability (...) you're trying to maintain something at a certain rate or level, right? So when we kind of apply to the business concept, it's more like the ability for businesses to maintain various systems or activities and processes, environmentally, socially and economically over time."*
D	*3*	*"we do have actually some companies that already check or measure the impact, especially from the environmental part, not the social that much.*
E	*4*	*"…in a business context, sustainability means economic. That's first of all. And second of all is the environment. (…) I have worked with different kinds of brands in nearly 25 years as a consultant [in ICT] and only the couple of last, the two, three, four, five last years that sustainability has become an issue within these companies. And we have seldom discussed the issue and we have seldom discussed sustainability within the IT and technology part."*
F	*5*	*"…it is about how can we take care of, of people, the planet. In a way that still makes business, because you have to earn money. But as we see, that they're not kind of contradictions… being more sustainable often also means better economy…"*
G	*6*	*"Maybe resource efficiency, I would say. That's the way that I kind of, yeah, that's the way I see it that makes kind of sense to the work that we do. So, yeah, we need to, to ensure that we use the resources that we have in the best possible way. But, yeah, it's complex. And also maybe a difficult subject, but it's a license to operate for many of our customers (...) they need to take sustainability and really tell the world that they actually are try trying to help to drive in a more sustainable direction."*
H	*7*	*"for me, sustainability in a business context is about succeeding in business, making money (...) it should be profitable to be thinking about sustainability in business."*

Table B12. Managing the tensions

Row	**Inf.**	**Quotation**
A	2	*"So if we go to sourcing and procurement, I think the raw goods is raw materials, right? that's definitely one. I think outsourcing, but then again, because of the procurement, so the customer asks the company to source sustainable materials and they will go out and outsource sustainable materials or work or whatever. And partnerships and customer relations. So it's the logistics aspect, packaging and supply chain management. So having production close to source. (…) customer satisfaction is, I think, the biggest driver here for the sustainability focus. On the value proposition. The product lifecycle. So again, here the raw material use, packaging, etc. recycling at the end of life. Value creation, the same thing, manufacturing. But also a big thing in terms of finance, the funding aspect for their projects. (…) for my companies is extremely difficult to go behind the firewall of a hospital to have access to patient data, and this is because of regulation so GDPR and patient protection, of course, and ethics and issues. Of course, they need to be there. And, but I think they're, they're, you know, very difficult to go around for the small company that has very little resources so open innovation does happen in small clusters, so we have here and hospital that is sharing the office with us, precisely because they want to do more open innovation so they got one of their units outside of the hospital. They're sitting here, and basically they can work with companies they can develop things already they go inside hospital."*
B	7	*(asked on which strategies are used the most) " I guess it depends on how you see it. Mostly here. So in physical to virtual because we are using working digitalization, all*

		sorts of it. Predictive instance is about machine learning, A.I. using data, data analytics, using the Internet of Things. So, yes, for us, this is mainly the physical to virtual part. And also we have experience department and they are working with the nudging theories. Yeah. And also I know that we have some projects around circular economy as well, but it's not the main business for us. But so this is the main part. Physical to virtual. (…) but when it comes to customers. I have not the full overview of all our customers, hundreds of them, so but I know for sure that Miljøfyrtårn is quite common. We are not very much into manufacturing and retail. So fair trade is I would expect we could have had customers if we had that industry, but we don't have much there. So, no. Yeah. And these two. Mostly. (prompted whether when they work with them, part of the consultancy is helping them get on the path of certification? Or is that an optional thing?) It depends on whether they have that. Yeah, then we need to go into a little more specification here, because if we have we have customers where we work with them on a strategic communication level, it also includes sustainability. We definitely go into whatever they have, because that's part of the strategic communication. If we are working more on realization, programming, developing, using DevOps, implementing quite heavy data and technology and digitalization technology. We are not very concerned about these standards at all. (…) (when discussing the visual aid of business functions)… "in the last three years, value proposition, reporting and value creation. Those places we are closer to the core business, of course, then we help them on that reporting. Yes, indeed. We see that more and more of our way of treating data and presenting data is about also looking into sustainability reporting, ESG report. And I would guess many of our employees, the consultants and also those working with cloud application services, they help our clients in the process of working together with their clients or customers, achieving their goals. We are putting sustainability into the process, like, for instance, quality assurance and design and way of producing using effective production methods during the digitalization. Yeah. So digitalization is probably closer to the core hypothesis here for us is sustainability itself (…) Since we are a listed company, we are aware that ESG is one of the drivers for the values, putting value in the company. We also know that our customers use ESG as more and more of a criteria and our employees look up on us how we do it with the ESG agenda. And we are, of course, concerned about it ourselves. So we are concerned about the whole sustainability agenda in the world."
C	6	*(considering sustainability in your everyday job tasks) "sustainability, I would say, but yeah, it's maybe more kind of indirect result from what we are doing in most cases but in some cases we also have kind of very specific request from the customer saying that we want you to look into. If we do this and this, would that result in reducing our CO2 emissions or flaring or, yeah, those kind of things or issues that you have in oil and gas, for example. But reducing flaring is that, yeah, it's sustainability but I think you can argue that when you work with oil and gas customers, maybe not so good from a sustainability perspective. Yeah, I don't know, it's a tough subject, I would say. (…) So customers are quite aware that when they have this big installations they have so much equipment that needs to be replaced, or are not going to be in use anymore they actually shut down the whole plant. So in some cases there's kind of complete oil platforms right that go to end of life and needs to be handled in some way. But also, um, yeah, just old equipment that needs to be handled in some way that are responsible so trying to see can we ship this to someone that actually can take care of it. And I think in most cases they do. It's not us that gets the old technology that has been replaced or are just removed but yeah. I don't think no one would consider just throwing things away. (…) (about value creation) I haven't seen that. So, that would be quite interesting if, if the department actually became more involved in the actual kind of value creation process of what you're actually producing and delivering. And of course, some companies that we work with have sustainability as their kind of core*

		value proposition, like producing biogas, we also have some that that are handling old plastics and making it into new. Partnerships are quite revenue or profit focused so I haven't kind of seen the sustainability elements in that. (…) what we actually offer to our customers that may be more on the physical to virtual box. So, predictive maintenance, remote maintenance service. So, again, so sustainability being part of the equation so if we can have data available in the cloud and help and do service remote. We don't need to fly out to offshore sites and so in that sense, it has an element of sustainability to it, as well as you can. I hope it's physical to virtual. Maybe but that's because that's what we do. Also, I haven't said anything about the production alternatives that you have. I know it that could be relevant to me is carbon capture (…) There isn't a lot of those projects around the world, but I think the few that are, we are. I think we are part of those projects, maybe in Europe, at least half of them. So, so that would be kind of the next step in terms of oil and gas moving, maybe closer to circular economy or kind of reusing the infrastructure that is already there. So that I think that would have kind of large impact."
D	3	*"But we've had, you know, examples of companies where they've done a lot of, you know, life cycle assessments, carbon footprint kind of testing and all that to check how much emissions of carbon footprint they produce when they're producing the products (…) Product disposal. Yeah, I'm interested in not disposing of the product, but more of taking it back. So it's going to be reused you know remanufactured, circular, recycling, it's not much, they still do it, but it's really at a low level now even though that's I think easier for them and the focus is on that one. (…) Design it's mentioned here, because as I said this company's mostly there from my engineer to order production strategy so also the design engineering part, it's also important for them, like how they can change their designs or the engineering to fit in with the circular economy sustainability practices. So we have another company for example they produce castings, you know, made of nickel, aluminum and bronze, but when they work in the foundry they had a lot of waste. So therefore instead of them throwing it away they send it to another company that they use it also in producing whatever projects that they do. So at first it started like that, you know, they always becomes food for this other company, but then it ended up that company being more like a spin off for this company. (…) modularity yes. Most companies are now actually working with this. So though I mentioned that most of these they're from this, if you're, you know, engineer to order kind of strategy but now they're actually moving from that to configure to order, because of this modularity issue. Down cycling. That's the focus for most of them so they are kind of moving from down cycling to up cycling now. So, manufacturing, I can't mention a company that we have in a given that I've started with this, but we've mentioned, and I think that there's one company that kind of might start with experimenting on remunerating very soon. So it's more like this company produces heavy machinery and then the supplier of that component that they use is also in this region. So the agreement is like this machinery company will take back some of those components and then send them to this supplier. And then they can remunerate and then sell it again to them like that. So that kind of process so by experimenting because this company has really taken back some of the products. As we talk, they are the factory and they're doing the you know the restorations and repairs and stuff but it's the refurbishment that they're working on. But it's a lot of work. I think maybe I can go for the last one which is circular supplies. Many companies, they've started doing it. Of course they're focusing on the renewable energy in the production but also the recycled materials in the production. So as of today, it's not like it's 100%, but they're kind of combining. So they're using maybe I wouldn't mention the percentage I think that would be wrong, but I know "one particular company, they're using 80% of the materials and 20% of the recycled materials. So they've started experimenting with that" but of course they said the aim is to at least go 50-50 and then eventually, maybe to keep increasing. (…) They do the predictive maintenance because actually they make more profits not by selling the*

		products but from this after sales services. So they do a lot of, you know, so they go for their, scheduled maintenance and you know that they do once in five years or every year and some, these shipping industries if they can just call them they go right away and stuff like that. So some of them they're working of course with the Internet of Things and some are working with the sensors that they put in the product. More like to, to try to check the condition of the products and stuff. Some, they're in the process of doing that. (…) So but the thing is, of course, you know, all these products, they were the sort of customers that are not the customers anymore because they don't do product as a service yet. So they don't own these products. So what but what they do is they have more like an agreement with the customers, some of them that are willing to share the data. So they put the sensors in these products so that they can check the condition of the products. But also when they reach the end of life, they can easily look at them where they are and also check the condition before they bring them back. And then they can do all sorts of, you know, circular economy strategies under that. So, of course, by doing that, they reduce production costs in terms of the production in itself, but also the materials because they're able to reuse some of the materials from this product. But also, you know, instead of them checking back something that they can't use and then they have to get rid of it, which is an extra cost. That means that will be avoidable. there's a certain company here where they have this scheduled maintenance. And that means they have to go to do maintenance regardless of the condition of the products. So with the sensors, what that means is even if they agree to say, hey, we come once in five years and the time comes. But if they check in the data through the sensors that maybe the product is still working as it should, then there's no point for them to even go into maintenance. Then the product can still running. So they also save, you know, a lot of costs in terms of the traveling costs and, you know, all the toolbox they have to carry with back and forth and all that. And another thing is the 3D printing. We do have companies that have also started working with 3D printing stuff. So instead of them, of course, you know, carrying all these parts for maintenance and stuff, they can just 3D print just on demand, right, when they need it. So by doing that also they're saving in terms of the hoarding costs, the inventory costs and what have you. Yeah. (…) Stewardship models. They're kind of working on it, but not much either, you know, they want to take control of the whole value chain, the companies themselves. They are talking about it, but if they have started and they're doing that, I really don't think so."

Table B13. Intermediaries' management of tensions

Row	**Inf.**	**Quotation**
A	*1*	*" that's a problem when you don't have the right information (about developing technology), you don't have the right knowledge and someone decides what society should do or because it's a trend or it's you know. So I think this is a very valid question but I think the solution is more open information," (prompted about consumption dilemmas) "we have to focus more on the end goal and the impact because digital technologies are used as tools and not as a goal in itself so business owners have to have the discussion so we want to increase revenue by so and so and so and if we increase revenue by pushing more products what kind of impact will that have on sustainability? " this is something we work on internally in the company, but we also work with these problems together with our partners from private sector. And there's multiple dimensions to it."*
B	*2*	*"they have very tight protocols and processes that are very difficult to change. So, you need to bring them on board quite early and, you know, really massage them to think*

		about the value that they will get from adopting a new digital solution or changing the current process or having a new way to do clinical validation"
C	*3*	*"then we ask them what are the pressing needs for your company right now with whatever is happening? Like environmental issues or the regulations, you know, when it comes to competition and then they'll tell us, like, you know what, we want to learn about this, this, and that. So for now it's more of the industry 4.0 and the circular economy that's really like companies are really interested in.*
D	*4*	*"We also try to help them solve their issues by using technology, building proof of value, building MVP [minimum viable product] solutions. Then we put different resources into that project and we build the AI solution together with the company so that they are capable to build the project, the application further on to start using it and they can further develop the AI solution. We also have a sandbox where they can come in with their own data. We will help them with third-party data sets and we also throw in a data engineer and a data scientist so they can develop it themselves… (…) We are trying to help another company and in their project they want to get rid of emissions and letting these targets to be more sustainable. I think that's a very important part of the project with them. Emission and letting these targets, giving them the tool to reach the targets of sustainability. This is within oil and gas."*
E	*5*	*"So let's talk about virtual, we have made all our labs, and also made our 3d version of them. So that when we are doing work for our customers that can follow our work on their PC instead of coming visit us. …but mainly we see that it's not always more costly [to find sustainable alternatives]. And that's always our goal. And us compared to a research technology, a research technology company is perfect for developing new things, but we also have the industrial competence that the research companies have in general, which means that when a company comes to the center, and say we would like to use more recycled plastic into our product, we can ask them.. and tell them… (…) when you have an industrial process, you will always have waste in your process, some, some scrap production, some part of raw materials that you cannot use and so on. (…) for instance you often have to pay money to get that into landfills (…) if you can use that scrap as a resource, if you can put it back into your product line. If that material could be a raw material something that's your waste could be a raw material for another company, then you can sell it, or at least give it away for free, instead of paying to put it in landfill. (…) "(if a company is extracting) …minerals and then you get what you want to have, and the rest is dumped in the fjords or whatever you know and it's not only not good for the environment, it's also not sustainable because we can use that as a replacement into concrete, we can use it as raw material for other processes, and that's, then this is not scrap it is, it is raw materials, it's valuables."*
F	*6*	*"…So, we internally do a lot on sustainability as well as trying to help our customers. So, that's kind of two perspectives. So, one is looking at ourselves and seeing what are we doing. And then you have helping customers and the business related to customer activities on the other side. So, that is kind of how we measure ourselves and I see that also, most of our customers also have that perspective also. (…)"*
G	*7*	*"We are probably in it every day, I would guess [factoring sustainability at work]. I just might need to start thinking about if we are in a workshop with a leadership group about potential solutions. We would, of course, present those dilemmas all the time (…) if we are working with leadership, helping them and advising them to take the right decisions around either technology or strategic communication or whatever it is, we would present them for the same dilemmas. You can either choose this or that. I would guess that the answer is in "this is the way of working." It's really dependent on, and we know that it is really dependent on what is the context of our time. For instance, we know that just a year ago, if you had to choose to prioritize a sustainable solution versus, for instance, pure security, you would choose sustainability because*

		the ESG was more important for the value of the company or for the product or for the perception at the end customers. Now we see that security, data security or other kinds of security or whatever kind of security goes in front of sustainability (…) It's looking at technology as I said before not just look at technology in itself. Now we ask them "where is your data?" We start there, then "what is the data, how many points, how can you extract it, process it?" You should value as a company your data, before you didn't do that because you had no ways to work with it. (…) So we have a department here with data scientists, data engineers, tech strategists and everything that looks into these things now (…) For some industries it is a journey that is huge because many are not there yet, and they see it, and linking it all together with sustainability I think people start realizing that it is a longer journey even.