INSTITUTO
UNIVERSITÁRIO
DE LISBOA

# Digital transformation and sustainability. Linking ESG and IIoT driven new technologies in the industrial rubber sector

Elisabeth Maria Rentto

Master's in Management of Services and Technology

Supervisor: PhD Isabel Duarte de Almeida, Invited Assistant Professor ISCTE Business School, Department of Marketing, Operations and Global Management

September, 2023

BUSINESS
SCHOOL

Department of Marketing, Strategy and Operations

# Digital transformation and sustainability. Linking ESG and IIoT driven new technologies in the industrial rubber sector

Elisabeth Maria Rentto

Master's in Management of Services and Technology

Supervisor: PhD Isabel Duarte de Almeida, Invited Assistant Professor ISCTE Business School, Department of Marketing, Operations and Global Management

September, 2023

# Acknowledgments

I am beyond happy and excited that I am delivering my master dissertation. However, first I want to thank everyone who supported and helped me along the way.

I want to express my gratitude to Isabel Duarte de Almeida for her continuous support, feedback, and encouragement during this writing process. Thank you Isabel, for all your help and effort towards my dissertation. With your expertise and insightful suggestions, you provided me with great directions during my dissertation writing process.

I would also like to thank you, Reka Rubber, and its employees for their valuable time and contribution towards my research. Their willingness to share their experiences and ideas was instrumental in shaping my study's accuracy.

Additionally, a special thank you is due to my family and friends, especially my brother, for his excellent thesis assistance and support calls whenever needed. Lastly, I want to thank my partner, who always pushed me forward with this thesis writing process.

# Resumo

Os resultados da dissertação indicam um reconhecimento crescente da importância do ESG para promover a sustentabilidade e a inovação no setor industrial da borracha. O setor enfrenta vários desafios no seu caminho para a sustentabilidade, e a transformação digital e a Internet das Coisas Industrial (IIoT) podem ajudar a alinhar as práticas da indústria com a sustentabilidade.

A pesquisa utiliza um estudo de caso e metodologia qualitativa que consiste em entrevistas semiestruturadas com funcionários de uma empresa industrial de borracha. A pesquisa utilizou uma abordagem multimetodológica para conectar pesquisas existentes e obter conhecimento relevante. A abordagem temática na análise dos dados possibilitou examinar a implementação das metas ESG, destancando a praticidade e a transformação digital por meio da adoção de novas tecnologias no setor industrial da borracha.

Os resultados da investigação revelam que o setor da borracha industrial evoluiu a sua consciência sobre os fatores ASG. No entanto, a implementação ainda é inicial e a indústria enfrenta desafios para tornar os objetivos uma realidade. Além disso, o estudo explorou os benefícios e as barreiras relacionadas com adoção de novas tecnologias emergentes trazidas pela IIoT.

Concluindo, a dissertação aborda o papel do ESG no setor da borracha industrial. Explora a intersecção entre sustentabilidade e transformação digital através da IIoT. Também fornece informações valiosas sobre ESG, tecnologia e sustentabilidade no setor. Além de contribuições teóricas, a pesquisa fornece conhecimentos práticos sobre a integração ESG e sugere direções para futuras de pesquisas.

**Palavras-chave**: ESG, sustentabilidade, transformação digital, Internet Industrial das Coisas (IIoT), setor industrial da borracha

**Códigos de classificação JEL:**

Gestão de Produção M11

Q01 Desenvolvimento Sustentável

# Abstract

The dissertation's results indicate a growing recognition of the importance of ESG for fostering sustainability and innovation in the industrial rubber sector. The sector faces several challenges on its road to sustainability, and digital transformation and the Industrial Internet of Things (IIoT) can help align the industry's practices with sustainability.

The research uses a case study and qualitative methodology that consists of semi-structured interviews with employees of an industrial rubber company. The research used a multi-methodological approach to connect existing research and obtain relevant knowledge. The thematic approach in the data analysis made it possible to examine ESG goal implementation emphasizing practicality and digital transformation through new technology adoption in the industrial rubber sector.

The research findings reveal that the industrial rubber sector has evolved its awareness of ESG factors. However, implementation is still early, and the industry faces challenges to make the goals a reality. Additionally, the study explored the benefits and barriers related to embracing emerging new technology brought by IIoT.

In conclusion, the dissertation addresses the role of ESG in the industrial rubber sector. It explores the intersection of sustainability and digital transformation through IIoT. It also provides valuable insight into ESG, technology, and sustainability in the sector. In addition to theoretical contributions, the research provides practical insights into ESG integration and suggests future research directions.



**Keywords**: ESG, sustainability, digital transformation, Industrial Internet of things (IIoT), industrial rubber sector

**JEL Classification Codes:**

M11 Production Management

Q01 Sustainable Development

# Table of Contents

# List of Figures and Tables

# Glossary

CPS: Cyber-physical systems

DT: Digital transformation

EC: European Commission

ESG: Environmental, Social and Governance

EU: European Union

EUDR: European Union Deforest Regulation

IBEYAS: IoT-Blockchain enabled Yield Advisory System

IIoT: Industrial Internet of Things

IoT: Internet of Things

I4.0: Industry 4.0

NR: Natural Rubber

ROA: Return on assets

ROE: Return on equity

RQ: Research Question

SDGs: Sustainable Development Goals

SF: Smart Factory

SR: Synthetic Rubber

SRS: Smart Rubber Scale

UN: United Nations

# 1.Introduction

## 1.1 Theme relevance

Sustainability is critical for every nation and organization to achieve the United Nations (UN) Sustainable Development Goals (SDGs) by 2030. Organizations are under unprecedented pressure to protect society's and the environment's interests because of global warming, climate change, pollution, emissions, and smog.

In 2019, the European Union (EU) launched the European Green Deal to make Europe the world's first carbon-neutral continent by 2050. The Green Deal, also known as the EU's growth strategy for a more sustainable economy, aims to implement the SDGs into the economy (European Commission, 2019). According to the European Commission (2020), the industry is essential in shaping the green and digital transition. As a result of this transition, the industry will become more sustainable, its carbon footprint will be reduced, and it will become more competitive globally (European Commission, 2020).

To achieve sustainable growth in the European economy, the European Commission states that this double transition relies on two pillars, one of them being investment (European Commission, 2022). It includes investment from the public and private sectors. The private sector is increasingly seeking companies supporting sustainability and following emerging regulations.

The concept of environmental, social, and governance (ESG) has gained traction as financial markets recognize the importance of sustainability outcomes (MacNeil & Esser, 2022). It has led to an increase in ESG investments (Boffo & Patalano, 2020). ESG metrics are used to assess an organization's sustainability level, allowing investors to make investment decisions based on the impact an organization has on different aspects (Peterdy, 2022). Financial market interest has been matched by an increasing commitment to ESG and sustainability issues within the industry.

Due to the growing need, digital transformation and Industry 4.0 have become an alternative to drive sustainable business development. Industry 4.0 contributes to the SDGs by providing opportunities for connecting technologies, resources, and skills to achieve sustainability (MacNeil & Esser, 2022). Furthermore, for organizations to address climate change, they must have tools and accurate data on their operations to understand what can be improved and why. If organizations do not have accurate metrics on their operations, making significant strategic decisions based on accountability is also challenging. Moreover, while data-driven sustainability is one of the most fundamental approaches to tackling climate change, there is little scientific literature on connecting these megatrends.

The research is relevant scientifically as it contributes to a deeper understanding of the relationship between sustainability and digital transformation within the industry and sheds light on future research possibilities. The subject is also crucial from a practical standpoint since sustainability and digital transformation are expected to grow massively in the coming years, and concepts like ESG and Industry 4.0 are already widely adopted by businesses. The dissertation will bring qualitative research into the current literature, but some limitations should be considered. The dissertation will focus on a rubber manufacturing company operating on the market. Due to the fact that the research will be based on a company and its operations, the external validity will be limited.

## 1.2 Research gap and research problem

While sustainability and the digital transition are seen together as having common goals and reinforcing each other, these trends are not automatically aligned. The research field for bringing sustainability and digital transformation together is exciting and very valuable however, there is still a lack of attention paid to this subject. Findings from published literature highlight a lack of research on how sustainability can be achieved with digital transformation in organizations and what impact digital transformation has on corporate social responsibility. In other words, there is an opportunity to conduct research based on the research gaps that have been identified.

As stated previously, little academic research connects sustainability and digital transformation. The spectrum of sustainability and digital transformation is comprehensive, and to focus the research, the dissertation will concentrate on one Industry 4.0 technology, the Industrial Internet of Things (IIoT). While sustainability can also have different meanings depending on the subject, the research will focus on the ESG framework, which is more specific and measurable. The research problem that will be addressed in the dissertation is:

"How can new technologies brought by IIoT help industrial rubber businesses achieve their ESG goals?"

The research aims to find a new approach to the academic research gap by exploring the possibility of integrating sustainability and digital transformation in the industrial rubber sector.

Due to the great importance of the industry becoming more sustainable in the European market, the dissertation will focus on a Finnish industrial rubber manufacturing company. In the European market, thousands of small and medium-sized industrial rubber companies serve various industries. As demand increases across industries, the market is expected to grow steadily in the near future. In recent years, sustainability has become a central concern, with efforts to preserve resources, preserve the

environment, and enhance social values. Regulations like the EU's Anti-Deforestation Regulation promote transparency and fairness in the rubber supply chain. Industry 4.0 technologies are also being adopted in production processes to reduce energy consumption and improve efficiency. Despite ongoing research into waste reduction and recycling methods, managing end-of-life rubber products remains a challenge. Sustainability and production efficiency must be balanced for the rubber industry to succeed in the long run.

## 1.3 Objective

This thesis aims to investigate the feasibility of linking ESG and IIoT in the industrial rubber industry using the "Digital Transformation and Sustainability" approaches. As a result, this study seeks to highlight the importance of Digital Transformation in the rubber industry to determine whether the utilization of emerging IIoT technologies would contribute to lowering risk and obtaining better terms for the company by improving ESG performance. On the other hand, understanding the link between ESG and IIoT can shed light on future research in the Academy.

## 1.4 Research questions

This research's objectives have been considered when defining the research questions. These research questions (RQ) help to focus the research on IIoT and ESG and provide a new approach to the defined problem. The research questions are as follows:

> **RQ 1:** How are ESG goals implemented and translated into practical, measurable, and trackable efforts in the industrial rubber sector?
>
> **RQ 2:** What are the advantages and hurdles in adopting new technologies to support rubber companies in ESG processes?
>
> **RQ3:** Do IIoT and ESG implementation processes contribute to SDGs in the Finnish industry rubber sector?

## 1.5 Methodology

The dissertation uses a case study and a qualitative methodological research approach. Qualitative case study methodologies allow researchers to examine complex phenomena within specific contexts in-depth. The study uses a qualitative research method because there is little previous research on the subject. Its purpose is to understand the phenomenon under investigation better and thus produce new information.

The case study is conducted in a Finnish Industrial rubber company, which allows us to deepen our knowledge and investigate a new approach to the academic research gap.

## 1.6 Dissertation Structure

This dissertation began with an introductory chapter examining the research topic's importance and relevancy. It is followed by a brief description of the study's objectives, research questions, and methodology used in the research. Following the introduction, a literature review is presented with a theory-based understanding of the studied phenomenon to answer the research questions. A summary of the literature review of the thesis is presented at the end of the literature review.

The methodology chapter describes how the research was conducted to fill the current research gap and answer the research questions. Afterward, the findings chapter presents and discusses the findings. After this, the discussion chapter analyzes, specifies, and discusses the research findings in relation to academic literature.

The conclusion chapter briefly presents the study's results and discusses the theoretical contribution, the managerial and social implications, and limitations. The dissertation concludes by offering suggestions for further research to increase knowledge and understanding of the phenomena.

# 2. Literature Review

The literature review investigates the research phenomenon by extensively analyzing articles from academic journals and books. The literature review can be used to develop research ideas, evaluate previous research, and interpret previous research results to understand better ESG and IIoT in the industrial rubber sector (Eriksson & Kovalainen, 2016).

## 2.1 Rubber Revolution in the European Market: A Comprehensive Overview

### 2.1.1 Overview of the industrial rubber industry

In Europe alone, more than 6000 companies produce rubber goods. Most rubber manufacturers are small and medium-sized businesses operating a highly integrated value chain to meet particular and niche needs (ERTMA, 2016). In addition, several industries depend heavily on the industrial rubber sector and its manufacturing capabilities. Moreover, Rubber has a significant application in the end-user industries, including automotive, manufacturing, mining, and electrical industries (Mordon Intelligence, 2021). But, the automotive sector accounts for over 65% of the production of general rubber goods. In addition, due to the rubber's resistance to chemicals and temperature changes, rubber products vary from hoses, tires, tubes, and pipes ideal for under-the-hood applications (ERTMA, 2016).

In other words, the rubber industry is a significant resource-based industry. The market is expected to grow in the upcoming years due to increased demand for rubber products in various industries. The global industrial rubber market growth rate (CARG) is estimated to be 5.8% until 2031 (Transparency Market Research, 2022).

Natural Rubber (NR) and Synthetic Rubber (SR) are the primary raw materials used for rubber manufacturing. The NR is derived from Hevea brasiliensis, a rubber tree that grows primarily in tropical regions like Southeast Asia, West Africa, and South America (ETRMA, 2019). On the other hand, SR products are petroleum-based, made from coal, oil, and other chemicals (AirBoss of America Corp., n.d.). Because NR is a renewable resource, SR poses no threat to NR production. At the same time, SR is made of nonrenewable resources and may become a scarce commodity in the twenty-first century. Due to the rubber industry's importance in the global economy, millions of people are employed worldwide, from workers in rubber plantations to employees in manufacturing facilities. NR production alone is produced by around 6 million smallholders (Monument, 2019).

### 2.1.2 Industrial rubber sector's journey towards sustainability

Considering the importance of the industrial rubber industry, sustainability, resource preservation, and economic and social value must be considered. The rubber industry companies are becoming more aware of the environmental consequences of their supply chain and are taking steps to reduce their environmental footprint. As rubber manufacturers invest in new technologies and processes and engage in dialogue with stakeholders, they create a more sustainable and socially responsible industry (AEG, 2023; Cottrill, 2021).

To some extent, NR, compared to SR, is more sustainable and competitive in the long term, but this depends on how the industry manages NR production. It will decide the direction of environmental, social, and economic impacts (Stanfield, 2019; Tanielian, 2018). In 2022, NR was added to the EU's Anti-Deforestation Regulation (EUDR) to address the sustainability issues of NR production. It requires companies operating in the EU to follow mandatory due diligence procedures (European Commission, 2022). With the EUDR, rubber supply chains are hoped to become more transparent, fair, and sustainable. Those companies that profit from rubber production must now mobilize resources to track supply, compensate workers fairly, and improve farm working conditions and environmental health (Ginger, 2023).

Several rubber manufacturing processes require a lot of energy, such as rubber vulcanization, which requires heating large presses (Wayne Rubber, 2021). Furthermore, energy costs constitute 50% of production costs in the rubber industry (ERTMA, 2016). It is recognized that energy optimization can be adjusted through investing in Industry 4.0 technologies, and CO2 reduction goals can be achieved. However, the industry continues to face cost pressures. In order to reduce costs, improve productivity, and improve product quality, rubber product manufacturers increasingly use automation technologies, such as sensors and wireless technology, to gather valuable data that increases efficiency, streamlines manufacturing processes, and reduces errors (Parker Hannifin Corporation, 2022).

Nevertheless, end-of-life rubber products pose a serious environmental threat since most end up in landfills. Due to the vulcanization process, rubber products, especially synthetic ones, are relatively resistant to natural degradation. In addition, rubber products' structure and composition include several components that challenge recycling (Molino et al., 2018; Sienkiewicz et al., 2017). New methods have been developed to reuse waste rubber, reduce resource use, and extend rubber's life, which could be potential solutions to the crisis. Such as using excess rubber as fuel in the cement industry or grinding the

rubber waste and converting it into granulates that can be used in asphalt mixtures (Asaro et al., 2018; Farina et al., 2017).

### 2.1.3 Summary of the sustainability efforts in the rubber industry.

Rubber products are still relevant and needed in various niche applications, so the demand for rubber products is expected to remain strong (Cernev & Fenner, 2020). With the high demand, the competition for raw materials will intensify, and as a result, rubber companies are looking for new raw material solutions. It can already be seen in companies trying to bring recycled rubber material back to the production process through mechanical or chemical recycling (Nikander, 2023).

Rubber manufacturers can work smarter while reducing their impact on the environment with the help of product and process innovations. As a result of digital technologies, vast amounts of production data are stored, and parameters are defined to increase plant safety, reduce overconsumption, and monitor product lifecycles (ETRMA, 2019a; Parker Hannifin Corporation, 2022)

Increased rubber production would inevitably result in more rubber waste, which could harm the environment if not handled or appropriately processed. For example, it can be perceived as an obstacle to achieving SDG 12, Responsible Consumption and Production (Cernev & Fenner, 2020). Sustainable development will likely be accompanied by cost-effective recycling, innovative degradation, and disposal options (Sarkar & Bhowmick, 2018). Recycling and reducing waste can help businesses cut production costs, reduce their environmental impact, and create new value-added products (AEG, 2023).

## 2.2 Environmental, Social and Governance (ESG)

### 2.2.1 ESG Definition

The United Nations Global Compact Initiative introduced ESG for the first time in 2004 with Who Cares Wins (United Nations, 2004). The publication Who Cares Wins by United Nations (2014) is based on the principle that conscious investments lead to a more sustainable society, and it also established a goal to enforce ethical dimensions into finance (United Nations, 2004).

ESG stands for Environmental, Social, and Governance, a framework for sustainable business. It is based on data-driven evaluation criteria. In addition to assessing the company's ability to manage its social and environmental impacts, ESG also evaluates its governance structures. Each dimension of ESG incorporates different issues and represents specific targets to assess (Peterdy, 2022).

The environmental dimension refers to the organization's environmental impact and risk management practices. It includes reducing carbon emissions, improving resource efficiency, and managing climate change risks. It represents the organization's resilience to climate change. On the contrary, the social dimension refers to stakeholder relationships. It includes employee diversity policies, workplace health and safety policies, and human rights protections. The governance dimension focuses on leadership and structure in a company. It is about managers' remuneration, leadership, board diversity, and other internal controls that promote leadership accountability and transparency (Billio et al., 2021; European Banking Authority, 2021; Peterdy, 2022).

Implementing ESG into corporate strategy and operations has benefits. According to Huang (2021), a substantial positive relationship exists between firm performance and ESG. Environmental factors influence corporate financial performance more than social and governance factors (Huang, 2021). Kim et al. (2018) stated that strategic decisions enhancing ESG goals and ESG performance could increase the company's value and improve its reputation (Kim et al., 2018). Another benefit of ESG is the ability to secure a loyal customer base and retain a more dedicated workforce, which affects companies' performance, like finance costs and risk (Albuquerque et al., 2019; Fatemi et al., 2015). Sustainability practices also increase financial variables such as return on equity (ROE) and return on assets (ROA) (Gupta et al., 2021).

### 2.2.2 ESG investment and ratings

In less than twenty years, the ESG movement has grown from a UN initiative to an international movement. Many investors are adding ESG attributes to their capital allocation processes and decisions as the importance of sustainability and ESG continues to grow, which increases ESG investing.

ESG's popularity is evident in the number of signatories and assets the Principle of Responsible Investment (PRI) currently represents. UN supports the PRI as an advocate of responsible investment and defines responsible investment by incorporating ESG. Over 4000 institutional investors, including pension funds, asset managers, and endowment foundations, have signed the agreement. These signatories now represent US$ 120 trillion of assets (2022). In 2006, they represented US$ 6.5 trillion; in 2019, they accounted for US$ 86 trillion. The increasing popularity of ESG investing since 2019 is evident from the amount of assets managed under it (PRI, 2022). It means ESG investing is growing strong, and its popularity has increased even more after 2019.

Increasing investor interest in ESG factors is due to the belief that ESG issues can affect a company's performance in the long term, thereby affecting its return. Therefore, ESG is given more consideration (Boffo & Patalano, 2020). Stark et al. (2017) state that investors with longer horizons favor companies with higher ESG profiles. Also, long-term institutional investors are more tolerant of short-term underperformance in enterprises with high ESG performance (Starks et al., 2017).

Risk ratings can rate an organization's ESG performance. A company's ESG ratings indicate how well it addresses and mitigates industry-specific ESG risks. A low ESG score indicates that a company indulges in sustainable practices (Gupta et al., 2021). Leading ESG index provider MSCI rates ESG performance based on exposure to ESG risks and managing capability. Their ESG rating ranges from leader to laggard, as seen in Figure 1 (MSCI, n.d.).


Figure 2.1 – MSCI's ESG ratings

### 2.2.3 ESG metrics and frameworks in the industry

Increasing recognition of the financial importance of ESG variables has led to the growth of ESG data providers and metrics (Zanten & Tulder, 2021). Identifying ESG metrics that matter most to stakeholders unlocks benefits for the company.

If an organization has identified its core ESG challenges, it may want to consult on a pre-existing framework for guidance on ESG opportunities and risks. ESG frameworks and standards may specify specific metrics on which a corporation should report and collect data (Bell & Llewellyn, 2022). The World Economic Forum (WEF), in collaboration with Deloitte, KPMG, PwC, and EY, addressed the need to harmonize reporting standards and metrics within the ESG performance and published a report converging ESG standards. In the report, 21 core metrics and 34 expanded metrics are outlined in alignment with the Sustainable Development Goals and organized into four categories (World Economic Forum, 2020):

| Pillar | Core metrics |
|---|---|
| **Principles of governance:** | Purpose of governance; composition of governance bodies; oversight of risk and opportunity, material issues, anti-corruption, ethics and reporting mechanisms |
| **Planet** | Greenhouse gas emissions (GHG) from Scopes 1, 2, and 3, monitor land use and ecological sensitivity, and implementing Task Force on Climate-related Financial Disclosures (TCFD) |
| **People** | Diversity, pay equality, supplier and employee well-being, employee training, wages, executive compensation, and employee training |
| **Prosperity** | Generation of wealth and employment, innovation investment, tax policy |

Table 2.1 – Pillars of ESG metrics and disclosures

ESG standard frameworks are also provided by other private institutions, such as the Sustainability Accounting Standards Board (SASB), Global Reporting Initiative (GRI), and others (Giner & Luque-Vílchez, 2022).

To standardize and transparently track ESG efforts, the European Commission's Corporate Sustainability Reporting Directive (CDRD) became effective in January 2023. It alters the existing Non-Financial Reporting Directive (NFRD) to ensure that firms in scope report consistent and comparable sustainability information. The new directive strengthens the rules concerning reporting social and environmental information, and it also requires organizations to set targets, select a baseline, and report progress toward them. Nevertheless, it affects a broader set of companies than before, which have now reported on sustainability under the new directive (European Commission, 2023).

## 2.3 Industry 4.0 and Digital Transformation

### 2.3.1 Industry 4.0 the concept and relevance to the industry

The world is currently experiencing the fourth industrial revolution and the digital transformation of businesses, often called Industry 4.0 (I4.0). I4.0 represents the technological evolution from embedded systems to cyber-physical systems (CPS). CPS are technological systems integrating cyberspace with physical objects to transform devices and processes into a network (Dalenogare et al., 2018). To reach I4.0, network and production connectivity are integrated through CPS and the Internet of Things (IoT)(Kagermann et al., 2013).

I4.0 includes a wide range of technologies and paradigms, but the technologies enabling I4.0 are presented in Table 2.2 (Alcácer & Cruz-Machado, 2019; Bortolini et al., 2017; Yang & Gu, 2021):

| Technology | Explanation |
|---|---|
| **Internet of things** | Enables the collection and transmission of information between devices, resulting in the identification, localization, tracking, and monitoring of objects |
| **Big Data** | Interconnected things generate large amounts of diverse data at a rapid pace. Big Data consists of structured, semi-structured, and unstructured data. Performing data analysis is the value of Big data, not data collection. |
| **Cloud Computing** | The broad term refers to computational services that provide scalable resources for various activities over the Internet. Databases can be stored on it, and resources can be outsourced. |
| **Cyber security** | With the increase in internet-connected devices, vulnerabilities are present that compromise information. Protecting, detecting, and responding to cyber-attacks requires technology and management. |
| **Simulation** | Simulation allows testing products, processes, or systems to understand their dynamics better. |
| **Augmented reality** | It enhances the surrounding environment with virtual reality. It operates in real time, allowing interaction with real and virtual objects. |
| **Automated robots** | Robotics with artificial intelligence allows production systems to be more flexible and adaptable. An autonomous robot makes decisions based on its environment. |
| **Addictive manufacturing** | Refers to technologies that enable "3D printing" of physical objects. Highly customized products can be manufactured without conventional surpluses. |

Table 2.2 – Industry 4.0 technologies

I4.0 utilizes wireless networking technology and IoT capabilities to connect machines, sensors, and other appliances to people who monitor production and efficiency. With I4.0, horizontal and vertical manufacturing processes can be integrated and connected to increase efficiency and performance (Dalenogare et al., 2018). The openness of the technologies allows a significant amount of real-time data to be collected, exchanged, and transformed into information (Fatorachian & Kazemi, 2018; Liao et al., 2017). Operational productivity and automation are expected to increase with I4.0 (Thames & Schaefer, 2016). It has also been presented as the solution to the manufacturing systems challenges (Alcácer & Cruz-Machado, 2019a).

### 2.3.2 The concept of digital transformation and its importance to the Industry

Digital transformation (DT) is the application of advanced digital technologies to complete the digitalization of businesses. DT is the process of integrating technologies across operations to achieve fundamental change. It refers to enhancing or creating new processes, systems, business models, and products or services. With DT, productivity increases, value is created, and social welfare is enhanced (Ebert & Duarte, 2018; Schwertner, 2017). DT allows an organization to evaluate a different operational perspective and change its cultural mindset (Imran et al., 2021).

With DT, the European manufacturing industry can create new jobs and economic growth, making traditional sectors more sustainable and competitive (Digital Europe, 2022). The digitalization of the industry has not only affected the service and product offerings of companies but has also changed how they operate (Vial, 2019). With digitalization, the industry can make more efficient and accurate economic and technical decisions in real-time. It can be seen as increasing competitiveness using advanced technologies (Korovin, 2021). The extensive implementation of digital transformation will provide better value-chain integration and new-market exploitation that positively affects the whole industry (Ebert & Duarte, 2018).

### 2.3.3 Opportunities and hurdles of digital transformation

Businesses must undergo long-term cultural and technological changes to use DT as a competitive advantage. As DT grows within the industry, it creates many opportunities but poses numerous challenges and hurdles.

By utilizing DT, a company can process large amounts of data more efficiently and make more informed decisions. Using new digital technologies, organizations can use DT to respond appropriately to economic conditions based on real-time information. It improves production and operations efficiency and avoids unnecessary waste of resources. Improving operation flexibility may encourage firms to invest in higher-risk projects (Tian et al., 2022). In addition to its value generation capacity, DT can create transparency and flexibility across the value chain (Imran et al., 2021).

Still, the new value added is not instant with DT investments. For this reason, ROE and ROA are affected negatively in the short term, but in the long term, they can maximize their performance (Jardak & Ben Hamad, 2022). It is expected that DT will increase revenues, but many companies struggle to use the technology to its full potential and, therefore, fail to surpass their revenue expectations (Gebauer et al., 2020). It is estimated that these failures within digital transformation range from 66% to 84% (Libert et al., 2016). This extensive percentage ranges from poor execution, adopting wrong metrics, and being over-optimistic with scope outcomes (Bonnet, 2022).

### 2.3.4 Industrial Internet of Things (IIoT)

The industrial application of IoT is called the Industrial Internet of Things (IIoT), which aims to connect industrial assets to the cloud over a network. The IIoT architecture can be defined in various layers and ways, but the basic structure follows. For the IIoT solutions to work effectively, these four main

components are required, as presented in Table 2.3 (Ambika, 2020; Ben-Daya et al., 2019; Hammoudi et al., 2018; Li et al., 2015):

| Layer | Explanation |
|---|---|
| **Sensing Layer** | It is the first layer of the architecture, called the "things" that are the visible part of the system and have a unique identity. It includes devices, sensors, and actuators that collect data from their surroundings. |
| **Network Layer** | The second layer is the Network Layer that supports the infrastructure. The layer transports data from the Device Layer to the Service Layer through the wireless or wired network. |
| **Service Layer** | The third layer handles enormous amounts of incoming data and pre-processing data to generate real-time alerts using middle technology to support required services and applications. |
| **Interface Layer** | The last layer is the interface, where data is used for end-user applications by generating reports and data analysis via different interfaces. It makes the managing and interconnection of IIoT easier. |

Table 2.3 – Key structure of the IIoT system

IIoT has emerged as a viable solution for improving productivity and efficiency in the industry (Bhaskar, 2022). Cloud platforms, smart objects, and cyber-physical assets are connected in the Internet of Things to create a new business ecosystem. With industrial IoT, processes, products, and services data can be accessed, collected, and analyzed intelligently and autonomously. The data enables companies to detect and resolve problems faster, thus also affecting the overall cost. For instance, data can reduce overall production costs by optimizing and shortening product delivery times, increasing productivity, and reducing labor costs and total energy consumption (Boyes et al., 2018; Khodadadi et al., 2016).

IoT enhances visibility and insight into a company's operations and assets by integrating sensors, software, cloud computing, and storage systems (Gilchrist, 2016). According to a survey conducted by Deloitte and the Manufacturer's Alliance for Productivity and Innovation (MAPI), over 80% of respondents believed that smart production facility initiatives would be the primary driver of competitiveness even though only roughly 50% were investing in IIoT implementation (Deloitte, 2019).

### 2.3.5 Case studies of IIoT applications in the industry and the rubber sector

IoT plays an increasingly important role in logistics and transportation within the industry. With the help of IIoT devices like RFID technology, customers and distributors can quickly obtain the tracking details to make the logistics more accurate during the entire supply chain. Blockchain-based IIoT can also prevent all transport data from being shared with third parties (Ahmad et al., 2018) .

Another application of IoT in the industry is industrial automation. An essential aspect of industrial automation is the automated execution of functions and tracking of performance speeds (Zhu et al., 2015). In addition, smart planning improves the interaction between automated devices. Technology makes all value creation possible, including purchases, commissioning, and production. Furthermore, IIoT can be used in an end-to-end platform to gather data from various sources to predict manufacturing defects and save time and money (Müller & Voigt, 2018).

Throughout the rubber industry, IoT is used from rubber plantation extraction to understanding rubber products' life cycle. Landowners of natural rubber plantations are currently facing challenges monitoring their entire plantations. Benedict et al. (2020) tested the IoT-Blockchain enabled Yield Advisory System (IBEYAS) to facilitate manual monitoring. IBEYAS uses blockchain technology and IoT-enabled sensors to inform rubber tree plantation yield-enabling procedures. IBEYAS collects soil moisture content, slope details, temperature, and latex yields from rubber trees to validate rubber latex yields. Manufacturers are also notified of anomalies and advised on rubber-yielding procedures based on the record (Benedict et al., 2020).

Moreover, the rubber measuring procedures are currently manual work, which consumes time, energy, and cost, and there is a risk of incorrect data. Ismail et al. (2020) proposed a Smart Rubber Scale (SRS) system to solve the challenges. The system uses an intelligent approach by using the Arduino platform and IoT. It facilitates employees to store the rubber's weight in the system automatically. The data is sent directly into the data storage, which prevents misinformation, and the information is available at any given time (Ismail et al., 2020).

As for rubber product life cycle analysis, many automobiles contain smart products with embedded computing features that interact with the surrounding environment and store and share information about their use. Several well-known tire manufacturers are using ioT-connected sensors and software platforms to measure and monitor the entire life cycle of tires (Arcidiacono et al., 2019).

## 2.4 Sustainability

### 2.4.1 United Nations Sustainable Development Goals (SDGs)

All UN Member States adopted the 2030 Agenda for Sustainable Development in 2015. The 2030 Agenda is a shared action plan that mobilizes efforts to eradicate poverty, fight climate change, and fight inequalities without leaving anyone behind (The Global Goals, n.d.). It establishes a framework for governments to implement policies and actions to achieve objectives by 2030. The 17 Sustainable

Development Goals (SDGs) are a foundation for global economies toward sustainable development by 2030 (United Nations, 2018). The SDGs have been regarded as the most comprehensive framework for addressing global socioeconomic issues.

Many topics are covered in the 17 SDGs, including poverty, food security, energy, well-being, and climate change. Goals have specific targets and guidelines that can be measured and achieved (United Nations Department of Economic and Social affairs, 2022). The goals recognize that eradicating deprivations requires economic development based on social equality and within ecological boundaries (United Nations Global Compact, 2016).

Governments, the private sector, civil society, and communities must act together to achieve these goals (UNDP, 2014). Private-sector solutions are essential, representing an expanding business innovation market (United Nations Global Compact, 2016). The industry has been highlighted as having a tremendous capacity to contribute to an extensive range of SDGs. Moreover, an industrial organization can contribute through primary activities by delivering goods and services that facilitate the achievement of SDGs (OECD, 2021). As can be seen, the SDGs and the industry are interconnected. In order to achieve the SDGs, the industry must adopt sustainable practices and contribute to sustainable development.

### 2.4.2 Linking ESG and SDGs

Investors and customers expect organizations to take responsibility for long-term prosperity. In the long run, businesses may have difficulty creating capital if natural, financial, or social capital is threatened (Alijoyo, 2022). SDGs provide a practical framework for addressing global social and environmental problems. The 17 SDGs have 169 specific and detailed targets (UN Global Compact, 2015). These detailed targets can help companies focus on their own sustainability goals. Sustainability risk will become a crisis if businesses do not engage with the SDGs (Alijoyo, 2022).

ESG is becoming a valuable tool for assessing SDG progress. ESG factors can all be connected to the SDGs; Social and Environmental factors can be easily aligned with SDGs, but the Governance factor is indirect (SustainoMetric, n.d.). ESG-based investment decisions aim to create long-term value for the business and society (United Nations Global Compact, n.d.). A constructive connection with societal demands and market potential for an inclusive approach is directly related to the SDGs' concept of creating shared value (Lev, 2021).

A growing interest in ESG and the requirement to disclose sustainability goals have led companies to align their ESG goals with the SDGs (European Commission, 2019a). In other words, the ESG acts as a

framework on the company level to support the implementation of the macroeconomic ambition of the SDGs in organizations and within the industry (ESGgen, n.d.). ESG factors integrate into broader social issues and global environmental goals, increasing the adoption of sustainable investing and promoting responsible corporate behavior. It makes the ESG and the SDGs a valuable framework for integrating sustainable development into the economy. Organizations that actively pursue the SDG Agenda 2030 are more likely to enhance their ESG score and discover new chances for growth and development (Lev, 2021).

### 2.4.3 Relationship between IIoT and sustainability and the importance of a smart factory

Global sustainable development relies on creating sustainable value in the industrial sector. International enterprises must take a proactive approach to sustainable value creation (Sergio et al., 2021). Manufacturing systems rely heavily on information and communication technology. Through the Industrial Internet of Things, big data, and automation, Industry 4.0 makes production processes more intelligent (Lu, 2017; Stock & Seliger, 2016). Sustainable manufacturing practices can be achieved through the underlying drivers and technologies of I4.0 (Tiwari, 2015).

Smart Factory (SF) features high adaptability, optimizing large and small-scale production and accommodating high-diversity batches. However, implementing SF also carries social and environmental implications (Jäger et al., 2016).

From a social perspective, SF reduces employee routine tasks since cyber-physical systems communicate with each other. Nevertheless, human involvement is essential for planning and controlling, creating demand for information technology skills (Wang et al., 2016). In terms of environmental impact, SF systems reduce waste, overproduction, and energy consumption. Also, it facilitates ordering raw materials on demand and leverages energy surpluses to plan energy-intensive tasks (Wang et al., 2016). However, these intelligent systems require massive data centers that consume much energy.

SF initiatives can contribute to a company's digital transformation and sustainability efforts by providing the ability to track outcomes, provide feedback, and coordinate efforts. A synergy between SF and ESG frameworks drives the industry's sustainability efforts to deliver long-term revenue and protect stakeholder value (Kneib Negron, 2020).

### 2.4.4 The Linkage of IIoT, ESG and SDGs

As IoT offers the chance to digitize various operations, it can contribute to combating climate change and protecting the environment. IoT addresses or can address 84% of the UN's SDGs, which will help

companies improve their ESG performance and enable more sustainable operations (World Economic Forum, 2018).

To better understand an organization's sustainability level, I4.0 technologies such as IoT and blockchain can enable real-time, authentic, transparent, and structured data about ESG factors (Saxena et al., 2022). Furthermore, by consistently collecting valuable data, IoT can assist the UN and its partners better understanding Sustainable Development variables in their environment. As a result of data enrichment, insight analytics tools can be enhanced to support and improve development programs (Bothwell et al., 2015).

Decarbonizing economies and mitigating climate change are crucial to achieving the UN's SDGs, and I4.0 can help achieve them through digital sustainable operations within organizations (Ramakrishna, 2021). SDG Compass was developed by the UN Global Compact, the Global Reporting Initiative (GRI), and the World Business Council for Sustainable Development (WBCSD) to help businesses measure their contribution to the SDGs. It identifies over 1,500 indicators that can be used to measure sustainability in various ways (Armstrong, 2020). Ultimately, this provides a valuable platform for businesses to track their progress toward the SDGs.

## 2.5 Summary of the literature review

There are over 6,000 small and medium-sized enterprises in the European industrial rubber sector. Automotive accounts for over 65% of rubber production and is vital in manufacturing, mining, and electrical industries. Rubber supply chains are becoming increasingly transparent and fair thanks to environmental awareness and regulatory actions like the EU's Anti-Deforestation Regulation (EUDR). Technologies such as Industry 4.0 and automation address energy-intensive processes while recycling and waste reduction methods are emerging to reduce environmental impact.

ESG, the environmental, social, and governance framework, was introduced by the UN Global Compact in 2004. It evaluates a company's environmental impact, social practices, and governance structure. A company's ESG practices can improve its performance, increase its value, enhance its reputation, and attract loyal customers and dedicated employees. ESG principles are incorporated into investment decisions by over 4,000 institutional investors representing $120 trillion in assets. Several ESG metrics and frameworks are available to help organizations report and improve their ESG efforts, including the harmonized metrics proposed by the World Economic Forum and the recently implemented Corporate Sustainability Reporting Directive (CDRD) of the European Commission.

Known as the fourth industrial revolution, Industry 4.0 (I4.0) integrates cyber-physical technologies such as the Internet of Things (IoT), Big Data, cloud computing, cybersecurity, simulation, augmented reality, automated robots, and additive manufacturing. This approach aims to improve manufacturing processes, increase efficiency, and automate more, which will transform traditional industries. Digital transformation (DT) complements I4.0 by integrating advanced digital technologies into business processes, systems, and products. The European manufacturing industry benefits from DT because it increases productivity, value creation, and competitiveness. DT and I4.0 both offer significant benefits. However, they also present several challenges, including cultural and technological changes and potential short-term negative impacts on return on equity and return on assets.

The Industrial Internet of Things (IIoT) is a crucial component of I4.0. It connects industrial assets and processes to the cloud, improving the industry's productivity, efficiency, and cost savings. There are various applications of the IIoT in the industry, including logistics, transportation, industrial automation, and predictive maintenance. RFID technology and private blockchain-based IIoT solutions improve accuracy and data security in logistics and transportation. Industrial automation utilizes IIoT for automated execution, smart planning, predictive maintenance, and reducing downtime. The rubber industry uses IoT applications ranging from rubber plantation monitoring with systems like IBEYAS to automated rubber measuring with solutions like the Smart Rubber Scale (SRS). Moreover, IoT is being explored in tire manufacturing to analyze tire lifecycles and monitor tire performance.

The industry plays a significant role in achieving the Sustainable Development Goals (SDGs) of the United Nations. In assessing progress toward the SDGs, ESG factors are increasingly important, bringing together societal needs and market opportunities. I4.0 technologies, like the IIoT, enable more sustainable manufacturing practices. I4.0 technologies align with ESG goals and contribute to addressing global challenges like climate change and environmental protection and helping organizations monitor their sustainability progress.

# 3. Methodology

This chapter discusses the methodological choices made for the study and begins by discussing the research context. The chapter discusses the research method used in the study, followed by a description of the research choices related to the collection of data and its analysis.

## 3.1 Research Context

The rubber industry is facing increasing demand to operate more sustainably and pursue environmentally more accountable practices. Integrating Environmental, Social, and Governance (ESG) factors into business operations has become critical for long-term success. Then again, the Industrial Internet of Things (IIoT) has opened new opportunities for industries to improve their operations more efficiently.

The dissertation examines the role of Industry 4.0 in promoting sustainability in the industrial rubber industry. The research explores the feasibility of integrating the ESG principles with IIoT in the rubber sector by analyzing their relationship and impact on obtaining better market terms. The research can offer valuable insights into how IIoT can contribute to sustainable development within the industrial rubber sector and shed light on future research in the academy. It will also highlight the importance of digital transformation in the industrial rubber sector, which is essential for businesses to be more sustainable and stay competitive in the long term.

## 3.2 Methodological general issues

A qualitative research approach is applied to analyze and answer the scientific research questions of the dissertation. A multi-methodological approach is used to connect existing research and to obtain new knowledge and research results specific to the sector. Combining multiple methodologies assists the researcher in exploring multiple perspectives on the research problems, increasing the scientific merit of the research (Singhal & Singhal, 2012).

The first step of the multi-methodological research approach is a theoretical literature analysis. It is followed by the qualitative research method because there is little previous research on the subject. Qualitative research methodology aims to understand the phenomenon under investigation better and thus produce new information (Aspers & Corte, 2019). Eriksson and Kovalainen (2008) emphasize the importance of using a qualitative research method when there is little previous research on the subject (Eriksson & Kovalainen, 2008). Expert interviews were conducted to gain holistic insights into potential drivers, barriers, and motivations for implementing IIoT and ESG principles in a Finnish rubber company. The research design, process, specific reasons, and scope were targeted to the research questions that fit

the objectives. The discussion chapter uses the resulting findings to illuminate the research question further.

## 3.3 Research Design

Considering the premises and the object of the study, it is pertinent to explain the methodology chosen for the study. This study uses a case study and qualitative methodology to address the research problem. An inductive approach was used in this research strategy since it extracts more general statements from observed cases (Eriksson & Kovalainen, 2008). The inductive approach intends to condense data into a brief and draw explicit links between research objectives and the summary of the raw data discoveries (Thomas, 2006).

The research starts by analyzing the existing state of the art regarding the industrial rubber sector sustainability efforts and its current situation. Furthermore, since we want to deepen our knowledge of linking ESG and IIoT within the rubber industry and not test a specific model, a qualitative approach is employed during this case study's research and development process (Eriksson & Kovalainen, 2008). For this reason, a quantitative research method is not feasible. Moreover, qualitative data is exploratory, allowing a deeper understanding of theories, opinions, or ideas. Generally, qualitative research aims to collect qualitative data to build a rich understanding of a phenomenon through interviews (Saunders et al., 2012).

According to Stake (2003), a case study is a common framework for conducting qualitative research, and it can be divided into intrinsic and instrumental case studies. Instrumental case studies mainly provide insight into a more significant issue, whereas intrinsic case studies interest a particular case (Stake, 2003). The case study conducted in this research is instrumental since the thesis will enable us to determine how the Finnish rubber industry handles IIoT and ESG. The dissertation uses an empirical, methodological approach based on the literature review. Yin (2003) states that a case study is an empirical inquiry investigating a contemporary phenomenon in depth and within its real-life context (Yin, 2003). A case study on Reka Rubber Ltd. intends to gather information regarding the perspective and goals of the company regarding IIoT and ESG issues. As a result, we will be able to understand what can be done to improve the company's overall sustainability.

## 3.4 Data collection

The primary research data was collected by conducting semi-structured interviews with experts in Reka Rubber Ltd. Semi-structured interviews were chosen to allow flexible interaction between the interviewer

and interviewee and to target the questions within the proper context (Saunders et al., 2012). This data collection method was also chosen since it does not limit the interviewee's answers, enabling new and surprising things to emerge from the data collection process. For this reason, the method was chosen since it made it possible to investigate the phenomenon in the rubber industry. Also, semi-structured interviews can be considered the most appropriate way to collect empirical data for the research questions defined since the scientific literature is still scarce (Saunders et al., 2016)

The questions asked in the interviews were very open, and depending on the answers' scope, more detailed questions were asked. The purpose of open-ended questions is to get the interviewees to describe the phenomenon under investigation in their own words freely. The interview questions were divided into research questions and operationalized using keywords and key concepts from the dissertation's literature review. The purpose of operationalizing the interview questions is to clarify the interview process and to diversify the information obtained from the phenomenon under investigation. The interview questions can be found in Annex A.

All interviews were conducted remotely using Microsoft Teams. The interviews were recorded using the Microsoft Teams program's recording feature and the iPhone’s recorder application. The video feature was used during the interview to make the interview resemble a standard face-to-face one. The interviewees were contacted by email to arrange the interviews. The themes of the interview questions were sent to the interviewees before the interviews to have the possibility to prepare for the interviews. All interviews were conducted within May 2023. Before the interviews, the flow and the script were practiced several times and pre-tested on several people to ensure the interview questions' relevance and appropriateness to secure the smooth flow of the interview situation. After this, the actual interviews were conducted.

Single case studies are relevant to increasing knowledge (YIN 2009); therefore, Reka Rubber Ltd served as a single case study for this dissertation (Yin, 2009b). Interviewees and the number of interviews were selected better to understand this phenomenon (Yin, 2009b). Multiple employees with different positions were interviewed to ensure that the findings represent the whole company and are accurate since each person has their own experiences, beliefs, and knowledge that can contribute to a more comprehensive understanding. After the interviews were conducted, they were transcribed accurately and precisely.

To preserve anonymity and due to the company's small size, each interviewee was given a number code according to the chronological order of the interviews. Table 3.1 shows the interview code, date, duration, and location. All of the interviewees were told about the recording before the interview started. After the interviews, the interviews were transcribed in colloquial language and as precisely and accurately as possible. Filler words and phonemes such as "hmm," "so," and "in a way" were left out of the transcription, and other personal information was also left out of the transcriptions.

| **Interview ID** | **Interview date** | **Duration of the interview** | **Location of the interview** |
|---|---|---|---|
| Interviewee 1 | 9th of May 2023 | 53 minutes | Microsoft Teams |
| Interviewee 2 | 9th of May 2023 | 62 minutes | Microsoft Teams |
| Interviewee3 | 10th of May 2023 | 54 minutes | Microsoft Teams |
| Interviewee 4 | 10th of May 2023 | 56 minutes | Microsoft Teams |
| Interviewee 5 | 11th of May 2023 | 58 minutes | Microsoft Teams |
| Interviewee 6 | 15th of May 2023 | 28 minutes | Microsoft Teams |
| Interviewee 7 | 15th of May 2023 | 59 minutes | Microsoft Teams |

Table 3.1 – Interview information

## 3.5 Data Analysis

The research material is analyzed using a thematic approach. The thematic approach refers to dividing and separating qualitative material into larger subject areas that are seen to deal with the same issue. It allows comparing different themes in the materials (Saunders et al., 2012). According to Braun and Clarke (2006), data analysis methods must be precise so that the evaluation of the study and comparison with other studies is possible. The theme approach aims to organize and describe the research material in detail (Braun & Clarke, 2006).

The data collected for the study consists entirely of interviews. The material was manually categorized into themes. The transcription of the interviews was started right after each interview, during which a preliminary analysis was conducted simultaneously. Following the completion of all interviews, the actual data analysis phase was conducted. The transcribed interview materials were thoroughly and comprehensively analyzed. The different interviewee answers were compared to find similarities and differences. The dissertation's research questions were used to group the answers and analyzed separately. The summarized interviews can be found in Annex B.

# 4. Findings

This chapter presents this study's results based on the data analysis. As explained in the previous chapter, the research's empirical material consists of seven expert interviews. According to Table 3.1, the study's interviewees are referred to by interview ID numbers. The themes of the result chapter are built by identifying recurring themes from the interviewees' answers, also known as the thematic analysis approach. Thus, after a brief Company overview, the results will be presented in five distinct sections, enhancing the clarity and precision of the findings.

## 4.1 Introduction to the Case Study Company

Reka Rubber is the case study company studied in the dissertation. The company is one of Northern Europe's leading technical rubber product suppliers for well-known transportation equipment and mechanical engineering OEMs. The Reka Rubber group employs about 290 employees, and in 2022, the group's turnover was 30 million euros. Reka Rubber offers customers cost-effective solutions for their production needs through its long rubber expertise. The company has a unique position, long-term customer relationships, and experienced manufacturing engineering capability. Reka Rubber has a wide product range divided into four main product groups: molded products, rubber-metal products, heavy profiles, and shaped hoses. Products are mainly used in fluid solutions, anti-vibration systems, and various heavy-duty rubber-metal combinations. The company's production plants are located in Aura, Finland, and Dopiewo, Poland (Reka Industrial, n.d.). Data collection was carried out by interviewing Reka Rubber's employees at the Aura plant.

## 4.2 ESG implementation within the company

It was strongly evident from the materials that the company is at the beginning of its ESG process. Two interviewees prioritized introducing a clear ESG strategy so everyone knows what can be done by individually in the company regarding ESG. At the moment, the company has a somewhat ESG strategy that is not very clear. Because the company is at the beginning of the journey, interviewee 2 stated that the company should now start focusing on developing competence and raising awareness. With these aspects, the company could strongly begin the journey.

When analyzing whether the company believed that ESG would bring a competitive advantage or innovation to the company, answers were divided between interviewees. Three interviewees did not see that ESG would bring a competitive advantage. They saw it as a must for the company and that if it does not implement its ESG factors in the next couple of years, it will drop out from the competition. On the

contrary, four interviewees saw that ESG could bring a competitive advantage to the company. The company is involved in developing low-emission and electric vehicles that create opportunities for innovation. Also, it was seen that using the ESG perspective in marketing can give a possibility to stand out from the competition. ESG can create an opportunity to rise in the competition since the customers put more emphasis on ESG, which puts all the suppliers in one line from a customer point of view.

The interviewees had different opinions on how the company handles investments regarding ESG implementation. Two interviewees stated that ESG investments aligned with sustainable development had been supported with priority. These prioritizations come from company owners who positively pressure the company to change the operation to be more sustainable. On the contrary, four interviewees stated that the company does not invest with an ESG-first approach and focuses more on manufacturing needs regarding processes and machines. The interviewees expressed and agreed that the company's financial situation has affected the number of investments and investment opportunities. Interviewees had different ideas on how and where to spend the money once the company can invest.

From the data collected, it was recognizable that the company faces challenges regarding the implementation of ESG. All of the interviews named multiple challenges that the company is confronting. There is a lack of resources and people concerning the ESG department. The paperwork that comes with the ESG approach has increased. For example, the customer interface already consumes much time and deducts resources from ESG implementation in the company. In the analysis, there is a strong emphasis that the competence the company has regarding ESG knowledge is very thin. Interviewee 2 stated that there is a need to expand expertise regarding all areas of ESG, both in the manufacturing facility and in the office. Another three interviewees stated that there is a need for ESG training to raise awareness and understanding throughout the entire organization.

> ***Interviewee 6:*** *"The top level is clear of ESG, but how you can influence it and your role in this ESG implementation is unclear."*

Interviewees stated that the knowledge and skills with ESG have not spread throughout the entire organization, reflecting that only one person runs the ESG department and has limited capabilities.

> **Interviewee 4**: "*There is too little knowledge in the company to make concrete and big decisions. The biggest challenge is getting ESG to our strategy work, which needs to be there. It is nominally already included, but in reality, it is not included there yet."*

Also, multiple interviewees stated that they have doubts regarding the communication of ESG internally and towards customers and how to make it a competitive edge before it is the minimum requirement. It can be concluded from the analysis that the company lacks resources and needs to expand its ESG expertise. It is evident that improved internal communication and guidance regarding the company's ESG objectives and individual responsibilities are needed.

Even though ESG needs much knowledge to be implemented, it also brings another challenge: costs regarding implementing ESG factors within the company. The respondents mainly saw that working around ESG increases direct costs, which does not necessarily reflect an increase in sales. The company has started to use a new reporting system that brings additional costs. There is a growing need for ESG, CO2 calculations, and reporting in the customer interface, which has consumed more employees and increased indirect ESG costs in the company. Also, lately, the carbon footprint calculations and installation of solar panels on the production plant's roof have brought additional costs.

> **Interviewee 3:** *"The question becomes who pays these costs because we are supposed somehow to put these costs into the customer's prices, and what if the customer is not ready to pay these prices?"*

## 4.3 IIoT and Technology within the Company

The analysis emphasizes that the company is not at the frontier with technology installations. All interviewees stated that the company has old machinery with technology implementation restrictions. The company will invest in new machinery once the old machinery is not fixable anymore. Replacing new machinery will bring the possibility to predict maintenance and better monitor production in the future. In some machine replacements, it is already possible to see the opportunities new machines will bring in the future.

> **Interviewee 5**: "*When machines have been renewed, it has been noticed that the production values improved, even though they were not supposed to do so. It has allowed for more consistent quality."*

Even though the company has old machinery, the company has implemented some different technologies in the production facilities. The latest technology implemented in the company is a steam measurement device to understand how much steam is produced in the factory to change the steam production method to a more sustainable option. Also, a smart water tool with real-time video has been installed to understand and have more data about the factory's water usage and detect water leakages.

Additionally, an extraction line spool has been ordered into one of the factories to reduce material waste and increase the quality of the products. Also, measuring devices for laboratories that bring more data and adjust the production quality have been ordered. Furthermore, solar panels have been installed in one of the production facilities.

Several respondents stated the potential of technology implementations that could facilitate future sales or manufacturing processes. It was mentioned that there had been some thoughts to use more industrial robots in production and to get a higher level of automation in manufacturing. Four interviewees stated that the usage of tags in the products could be more widely adopted to have the ability to understand more about the whole life cycle of the product. It could start from the product's production to the placement and usage of the product with the end user.

> **Interviewee 7**: "*For example, if you could track the product, the customer could optimize when to buy a new product according to production downtime and production patterns. It would be valuable information for us and the customer.*"

The analysis shows that there is inertia in the company to implement more technology. Regarding the automatization of the process, it halts since the company should be ready for a risky investment; according to the data, there has been little investment in the past. According to different interviewees, the company should be ready to acquire new technology to get new sales. However, since the company would have to acquire, i.e., robotics from intermediates, the investment becomes expensive. Also, several interviewees stated that every investment needs a payback plan. However, with some investment plans, it is hard to justify the investment decision or to calculate the investment payback plan easily.

All the respondents listed several advantages the implemented technologies bring and the opportunities they could bring for the company. It was evident from the analysis that the steam measurement device has brought interesting data and has allowed the company to understand more about the production levels and acknowledge its energy use. It was stated that with the smart-water tool, the company could identify a big water leak, which was suitable for environmental and monetary reasons since the company saved money in detecting the leak quickly.

The materials collected strongly reflected the advantages regarding the possible future IIoT implementation. If the company implements IIoT in the production processes, it would be possible to follow and monitor processes and consumption and place more measurements around production. One interviewee mentioned it would also create the possibility of measuring electricity consumption by each

production department and getting observations. IIoT would also help the company to understand how the company could improve and rationalize operations. Moreover, the company would better understand the product life cycle if IoT were added to the products. Two interviewees also stated that the more precisely the company could track products, the less waste and flawed products the company produces. Furthermore, this would show in competitive pricing, giving the company a competitive advantage in communication.

Even though these technology implementations have brought advantages to the company, all of the interviewees listed multiple hurdles that have come up regarding these technology implementations. In the interviews, the respondents listed several difficulties when discussing the steam measurement device. The device has not yet produced enough information to understand the company's energy use fully. Four interviewees described the installation process as extensive, complex, and expensive, from finding the correct device to installing the device. Also, the data collection has to be done manually since there are still problems regarding data log-in.

It was also mentioned that once a technology need has been identified in the company, it is not easy to find the exact device to satisfy the need since it operates in a particular market. This incident occurred with the steam measurement device. Three interviewees also identified that there are only a few service providers regarding technology implementation in the market and that these providers are also very costly. Moreover, sometimes, service providers cannot solve a specific problem. Some responders indicated that the company lacks resources, skills, and knowledge regarding the new investments.

In order to overcome these described technology hurdles, interviewees listed several supporting techniques for how the company could overcome these challenges. According to the materials, education and training would be helpful. Furthermore, for the training to be more concrete, they could be facilitated using real case examples to understand the problem and how a specific company solved it. Also, the company's maintenance department has grown, allowing the organization to go deeper into the technologies themselves. However, it was stated that the company still needs more resources in the technical development department. Since the company is a small organization, it would need more service providers within the market at a reasonable price so it would not have to invest in its resources massively.

## 4.4 ESG goals in the company

As stated before, the company is at the start of the ESG process and implementing strategic and practical goals in general. Still, all the interviewees knew the general concept of ESG, a more specific concept under the sustainability umbrella.

Nevertheless, the company still has some goals regarding all ESG factors. From the data it can be analyzed, the company has several targets that it is focusing on regarding the Environmental factor. The company has a goal that the company's carbon footprint should be zero by 2040. Currently, the company has conducted Scope 1 and Scope 2 calculations to understand the current carbon footprint of the company. There have already been efforts to diminish the carbon footprint, like changing to green electricity, installing solar panels, and having different options to change the steam production method in the future. Also, the lighting in one of the production facilities has been changed to LED lighting, which is more energy-efficient. To sum it up, the company has made practical efforts to get one step closer to its carbon neutrality target. The company uses primarily synthetic rubber in its production process, which is made from oil and other chemicals. Replacing the oil in the product requires the knowledge and cooperation of the whole industry to make rubber products more sustainable. Currently, no solutions are available to replace the raw material.

From the data, it was also found another goal regarding the environmental factor. The goal is to minimize waste in the production process. The company has tried to minimize waste in the past, but there is just one practical effort ongoing to minimize waste. There are no more practical efforts to minimize efforts because the production process makes it hard to minimize waste drastically. However, it was mentioned that this goal is in the company's focus area.

Regarding the social factor of ESG, the company has multiple goals and has made efforts to achieve these goals. One of the goals of the company is to have zero work accidents. The goal includes dangerous situations, accidents, sick days, and close situation announcements. The company has occupational safety training to achieve this target and focuses more on safety procedures in the production facilities. The company also has an equality plan. It was identified within the interviews that the company has room for improvement regarding gender diversity among employees. Also, job satisfaction is measured in the company. It is done by, for example, measuring employee rotation in the company. Also, the psychodynamic load of the work has been measured and analyzed.

Regarding the governance factor, it was identified that there needs to be more information on what can be done in the company. Within the interviews, the governance factor was the least known aspect, as what it holds and how it can be measured. The company has a whistleblower channel to ensure that persons who notice or suspect abuses during work can safely report the matter. Also, the company has had obligative training for the entire organization, like business ethics training.

### 4.5 UN's Sustainable Development Goals within the Company

All the respondents knew the UN's Sustainable Development Goals and their mission towards the world. Furthermore, based on the interviews conducted with the company, it appears that it has yet to identify, make a decision, or set goals concerning the SDGs to which it can or wishes to contribute.

Interviewee 4 doubted how a small company can contribute to the UN's SDGs since the global goals are so broad. However, Interviewee 1 stated that the company focuses on workplace equality, which is the 8$^{th}$ SDG. Also, Interviewee 7 stated that the company is contributing to SDGs by developing parts for electric trucks. Interviewee 3 saw that the company is indirectly involved in all of the SDGs since it fosters the customer's demands when the customers develop their products that lead to these goals. As can be seen, the respondents had divided opinions on how the company can contribute to the SDGs.

Nevertheless, interviewees identified possibilities regarding the SDGs. Two interviewees saw possibilities that SDGs could help to visualize and group ESG internally for the employees, for the management, and for the customers to understand more thoroughly what the company has done regarding ESG and what the company is going to do regarding ESG issues in the future. Interviewee 5 identified that the company could demand more from its suppliers regarding their sustainability with the SDGs. While the company has a general belief that sustainability factors with suppliers are in order, it is still essential to understand the fairness of the initial production.

According to the data, the company has now committed to the UN's Science Based Targets and to the UN's global compact, which forces the company to come up with targets that align with the targets. It allows it to be a framework for developing practical and effective ESG targets. It was clear from the data that the company does not yet measure its efforts toward the SDGs. However, Interviewee 6 stated that there is only talk and nothing concrete for these measurements within the competitors, which means that companies in the industry are also at the beginning of the process.

## 4.6 Current and future company's requirements' perception

The analysis found that the interviewees had a contiguous line regarding customers' requirements for reporting ESG processes and goals. The interviewees expressed that some customers have their own reporting and measurement metrics and tools, which is problematic since there is no single way to report ESG goals. It also creates more work for the employees. One interviewee also stated that small clients do not have ESG requirements and considerations for their suppliers. Currently, the reporting in the company is not at the level it should be, even though the company has done some work around sustainability. Among the interviewees, there is a strong belief that it is necessary to show and measure the ESG process more clearly to customers in the future.

It was found and understood that there have not yet been many changes in the external due diligence from customers. Now, the ESG has not yet influenced the purchase decision. The price is still the most essential factor for the customers, and there is much ambiguity around the whole ESG in the industry. Additionally, most customers have shared their goals and disclosed that they expect the same from their suppliers. It was evident that most interviewees thought that most customers would demand ESG disclosures in the future and that the company has to show its efforts more clearly.

The regulations the company might face in the future divided opinions among the interviewees. There were concerns about European regulations regarding diesel cars, which can prevent the company from selling some products. Also, the EU taxonomy regulation regarding sustainable activities might affect the company shortly since it is near the limit. Reporting is required if the company exceeds certain limits with the EU taxonomy. The EU is also planning to tighten the measurements of emissions released from production facilities significantly. It was also stated that customers set regulations by obligating specific certifications for the company regarding quality and environment.

As can be seen, there was no unified line on the subject. As mentioned earlier, addressing the lack of expertise and resources regarding ESG becomes crucial for the company to effectively assess, understand, and respond to future regulations. Allocation of sufficient resources can enable the company to build the necessary capabilities to navigate the evolving regulatory landscape successfully and proactively identify opportunities with future regulations and customer demands.

# 5. Discussion

The section aims to answer the research questions by explaining the data analysis results and linking them to existing theories and concepts.

## 5.1 Research question 1 - How are ESG goals implemented and translated into practical, measurable, and trackable efforts in the industrial rubber sector?

The result suggests that the company is beginning the ESG journey, indicating that ESG implementation and understanding are still in the early stages in the industrial rubber sector. However, there is recognition of the importance of ESG in the company and that it can foster opportunities for differentiation and innovation. The result shows a need to raise awareness and increase knowledge of ESG concepts and practices within the industrial rubber sector. The research expands current knowledge and brings new perspectives on the industrial rubber sector's ESG implementation efforts due to little previous research in the field.

The findings indicate that the company has focused on specific ESG goals related to environmental and social factors. The company aims for carbon neutrality by 2040 and has made several efforts to achieve the goal. Another goal is to minimize waste in production. Still, there are challenges to achieving these goals since some solutions are not yet available in the market. In the production process itself, it is hard to minimize waste drastically. Social goals include zero work accidents by focusing on safety procedures and occupational safety training. Klettner et al. (2014) stated that companies could learn from other organizations about best practices by benchmarking against peers within the industry (Klettner et al., 2014). However, according to the results, other industrial rubber companies are also beginning the ESG journey, which does not facilitate the implementation of ESG goals. In this context, similar results cannot be found.

Results recognized the need to break down long-term goals into short-term targets to make long-term goals more concrete and practical. It allows companies to progress toward their goals while staying realistic about their achievements (Beusch et al., 2022). So, this research findings do not contradict previous research. Still, the results indicate that the company faces challenges translating ESG goals into practical, measurable, and trackable efforts in the industrial rubber sector. These challenges include resource constraints regarding financial and personnel capabilities in the company. Limited expertise and resources in the ESG department were highlighted as the key obstacles to effectively implementing ESG goals in the company.

Also, difficulties like communicating internally and externally about ESG practices and integrating ESG into the company's strategy and decision-making were identified as challenges. The company also recognized that embedding ESG consideration into decision-making ensures that sustainability has priority in the organization (Eccles et al., 2012).

To address these challenges, the company should focus on developing competence, raising awareness, and management focus on ESG. To further implement ESG goals, a clear ESG strategy is needed that involves everyone in the company. As Storero and Barychev (2022) state, assigning responsibility to specific groups enables companies to oversee the implementation process better (Storero & Barychev, 2022). There is a need to invest in ESG training to ensure that all employees understand their responsibilities within the strategy to implement further ESG goals (Hahn & Kühnen, 2013).

There are also challenges in measurement and reporting relating to the ESG processes and goals outside the company's range. There is an increasing amount of ESG data requirement, with an absence of standardized frameworks and varying customer requirements, which require more human capital and technical software. Gitman et al. (2009) stated that companies with limited resource access will disclose less ESG data since they need to decide which ESG data is more valuable for the company. The study discusses the need for consistent and clear measurement metrics and improving the reporting capabilities to effectively track and communicate ESG efforts in the industrial rubber sector (Gitman et al., 2009). It was also revealed by Henriksson et al. (2019) and Kotsantonis & Serfeim (2019) that challenges caused by ESG data gaps dominate in ESG data collection and disclosure area (Henriksson et al., 2019; Kotsantonis & Serafeim, 2019).

## 5.2 Research question 2 – What are the advantages and hurdles in adopting new technologies to support rubber companies in ESG processes?

Results showed that new technologies could support rubber companies in the ESG process while presenting challenges. Data collection can be improved by understanding energy usage, detecting water leaks, and optimizing operations. Adopting new technologies can also benefit production processes, such as optimizing, monitoring, measuring consumption, and identifying opportunities through IIoT implementation. It also allows having an enhanced understanding of the product life cycle when incorporating IoT in products that would allow for better tracking, reduced waste, and improved product quality, leading to competitive pricing and competitive advantage in the rubber industry.

Boyes et al. (2021) and Khodadadi et al. (2016) found similar results in the literature review. They found that IoT data enabled companies to act faster, affecting overall cost, which aligns with the dissertation's findings. Also, Gilchrist (2016) found that IoT offers better visibility and insight into the company's operations, which was also seen in the empirical data as a potential benefit of implementing IIoT into the production processes. Davies (2015) also provided evidence that the digitalization of production facilities would increase product quality and decrease the number of defects and errors (Davies, 2015). This also harmonies the research's perception that new technology implementation has multiple advantages towards supporting companies in the ESG processes since all of these advantages positively affect the company's ESG process to become more sustainable. According to Osarenkhoe and Fjellström, implementing digital transformation increases operations to more effective and improves internal organization processes, which are the characterizations of sustainable firms (Moker et al., 2020; Osarenkhoe & Fjellström, 2021). It can be analyzed that the research brings out new information in the context of the rubber industry.

As new technology is implemented to support the ESG process, there are also hurdles to overcome. The results found several obstacles, like limited technology implementation caused by a lack of readiness and low investments in technology upgrades. Implementing new technologies has also become a challenge due to the high cost, estimating the return on investment, and complexity of the technology. Furthermore, in addition to this, the lack of resources in skills and knowledge relating to new technology implementation develops constraints. According to Koch et al. (2014), many companies face challenges regarding implementing IoT within the company due to high investment and unclear economic benefits (Koch et al., 2014).

Similar challenges were found by the World Economic Forum (2015), that the uncertainty of return on investment and immature technology present were notable barriers (World Economic Forum, 2015). OECD (2016) also pointed out that existing labor skills and knowledge are another challenge since companies can lack employees who understand IoT to monitor and develop the processes further (OECD, 2016). As it can be understood, the dissertation discovered similar findings as in the academic literature. Based on the academic literature and the research, it was possible to see how companies have multiple challenges in successfully implementing IoT in the manufacturing process, which also applies to the industrial rubber sector.

The empirical findings and the academic literature suggest that while there are clear advantages and potential benefits in adopting new technologies to support ESG processes in rubber companies like

the use of new technology and innovation decreases costs for sustainable companies (Hermundsdottir & Aspelund, 2021), there are still significant hurdles to overcome. The findings suggest that successful and effective implementation of technology-driven ESG initiatives will require training, resource allocation, collaboration with service providers, and investment planning. In other words, the research confirmed previous theories but expanded current understanding regarding the industrial rubber sector.

## 5.3 Research question 3 - Do IIoT and ESG implementation processes contribute to SDGs in the Finnish industry rubber sector?

The following correlations and patterns were identified regarding the contribution of IIoT and ESG implementation processes to SDGs in the Finnish industrial rubber sector. There is a lack of established goals related to the SDGs in the company. It suggests that there is a lack of clarity on how IIoT and ESG implementation could directly contribute to the SDGs and that the rubber sector is still in the early stages of understanding the SDGs initiatives.

According to the results, there is a mixture of opinions regarding the SDG's contribution possibility within the industrial rubber sector. In previous studies, IoT has provided numerous opportunities, both socially and ecologically, by integrating systems and people. Also, Industry 4.0 has enabled transparent and data-driven carbon footprint calculations, which are essential milestones in reducing carbon emissions (Storero & Barychev, 2022). To increase employee safety, IoT can also be implanted to avoid injuries and to interrupt machines in unsafe situations by tracking and merging employees' movements and machine data (Garrido-Hidalgo et al., 2018).

So, according to the previous research, there is a bridge between IoT and the SDGs. It correlates to the research that the industrial rubber industry is already contributing to the SDGs even though no specific goals are defined. Furthermore, the research starts a conversation in the industrial rubber sector since there are potential possibilities to leverage ESG and IIoT to contribute to the SDGs.

Additionally, the company has committed to the UN's Science Based Targets and to the Global Compact, which was identified as a framework for setting goals aligned with the global targets. Even though no specific targets are yet set, it suggests the industry's willingness to align goals with these global sustainability initiatives. These global initiatives will set the company's strategic direction and help align ESG targets with broader environmental and societal values.

In other words, this research confirms a strong need for strategy and long-term strategic planning to reach these goals (Storero & Barychev, 2022). As can be seen, the correlation between the UN's SDGs

and ESG has been studied in academic literature, but this research brings out a new context. However, further research is needed into how IIoT and ESG practices can be aligned with specific SDGs in the industrial rubber sector and the importance of adherence to global frameworks in driving sustainable outcomes.

# 6. Conclusion

The concluding section of the thesis summarizes the research problem succinctly, explains the purpose, and describes the objectives. It also explains the research findings and provides a comprehensive overview of their implications. This concluding section provides reflections on the methodology, explains the study's theoretical contributions and practical implications, acknowledges its limitations, and makes insightful suggestions for future research.

## 6.1 Summary of the research

This dissertation addresses the research problem of what role the IIoT can play in achieving industrial rubber companies' Environmental, Social, and Governance (ESG) goals. The main objective is to explore the prospect of merging sustainability principles with digital transformation in the industrial rubber sector, filling a notable gap in academic research. The central purpose of this dissertation is to explore the feasibility of interweaving ESG considerations and IIoT in the industrial rubber sector, using approaches from the field of digital transformation and sustainability. It aims to highlight the central role of digital transformation and whether IIoT technologies can help mitigate risks and improve ESG performance. To channel the research focus and to develop new approaches to address the problem above, the study poses the following research questions (RQs):

> **RQ 1**: How are ESG goals implemented and translated into practical, measurable, and trackable efforts in the industrial rubber sector?
>
> **RQ 2**: What are the advantages and hurdles in adopting new technologies to support rubber companies in ESG processes?
>
> **RQ 3:** Do IIoT and ESG implementation processes contribute to SDGs in the Finnish industry rubber sector?

The research used a case study and a qualitative methodological approach to answer the dissertation's research questions and collect empirical data. The researcher believed that an exploratory case study would enable rich insights into the critical elements of this research and enhance the knowledge of merging ESG and IIoT in the industrial rubber sector. This methodological approach allowed the researcher to gather opinions, experiences, and detailed insights regarding the phenomenon. Due to the research design, it was valuable to have the ability to examine the dissertation's research problem in

a real-life context. For this reason, the correct methodological approach was believed to be chosen for the dissertation.

The dissertation met some of its research objectives regarding the industrial rubber industry. The research explored the feasibility of linking ESG and IIoT in the context of the industrial rubber sector. The dissertation has discussed the implementation of IIoT technologies and their potential impact on ESG factors like waste reduction, energy efficiency, and employee safety. Furthermore, the dissertation has emphasized the impact and importance of digital transformation in the rubber industry by discussing the adoption of IIoT technologies within the industry. These technologies are seen as excellent opportunities for sustainable improvements and process optimization.

The dissertation showed that IIoT can potentially improve ESG performance. However, these improvements come with challenges and costs. Whether these ESG performance improvements would lead to reduced risk or better terms for an organization was not determined. Nevertheless, the research has made progress in providing insight into the link between ESG and IIoT in the industrial rubber industry. The research also discovered unexpected findings. The findings highlighted that there are concerns regarding future regulations for the rubber sector, like EU regulations and customer-imposed certifications. For this reason, it would be valuable to research the potential impact of these regulations and how IIoT and ESG together could meet these requirements.

## 6.2 Theoretical Contribution, Managerial and Social Implications

Findings from the research offer several contributions to linking ESG and IIoT in the industrial rubber sector. The research extends existing theories by providing a new context to the academic and provides practical recommendations.

Based on RQ 1, it can be concluded that ESG goals implementation is still at an early stage in the industrial rubber sector. Rubber companies recognize the significant importance of ESG principles but face challenges translating ESG goals into practical, measurable, and trackable efforts. These challenges include communication difficulties externally and internally, resource constraints, and integrating a clear ESG strategy to guide the organization forward. There is a need to expand ESG competence, raise awareness, and provide comprehensive ESG training to address the challenges. The management should also play a central role in fostering an ESG culture within the organization and aligning ESG considerations with strategic decisions. Nevertheless, a clear ESG strategy that involves all employees is critical. The strategy should include short-term targets to make long-term ESG goals more achievable and practical.

This study underlines the importance of a holistic approach to ESG implementation that includes awareness, competencies, strategy, and goal-setting.

When considering RQ 2, the findings revealed that adopting new technologies driven by IIoT can offer significant advantages in supporting ESG processes in rubber companies. Enhancing data collection capabilities, managing resources more efficiently, and understanding the product lifecycle are just a few of these advantages. The implementation of these technologies, however, does not come without hurdles. Many challenges are associated with implementing new technology, including the high cost of implementation, the uncertainty of return on investment, and the difficulty of technology adoption. In addition to financial considerations, integrating new technologies into manufacturing processes is also challenging due to the need for skilled personnel. Training, resource allocation, collaboration, and careful investment planning are all necessary to overcome these hurdles. In other words, the industrial rubber sector can potentially advance ESG goals through new technologies.

Concerning RQ 3, research shows that the industrial rubber sector lacks established Sustainable Development Goals, indicating an early stage in understanding and implementing the SDGs. The gap in SDG goal setting suggests a lack of clarity regarding how IIoT and ESG practices directly align with the SDGs in the rubber industry. In previous studies, IoT technologies have been linked to several SDGs, especially those related to social advancements and ecological sustainability. With IoT, for instance, employees' safety can be enhanced, carbon emissions can be reduced, and sustainability efforts can be transparent and data-driven. These insights indicate that the industrial rubber industry is already positioned to contribute to the SDGs through ESG and IIoT activities, even without specific SDGs in place. Furthermore, the UN's Science Based Target and Global Compact underscore the commitment to align with societal and environmental values across borders. In other words, the research exposes the latent potential for IIoT and ESG practices to contribute to SDGs.

According to the research findings, ESG is still in the early stages of adoption by the industrial rubber sector, and it is consistent with previous research that highlights awareness and understanding of ESG concepts as initial barriers to adoption. Furthermore, the dissertation emphasizes the importance of breaking down short-term goals to progress toward long-term sustainability goals, which are in accordance with existing theories. It also confirms the challenges associated with ESG data reporting and resource constraints. The research shows that the industrial rubber sector cannot fully engage in ESG efforts due to financial and personnel constraints.

Furthermore, the findings suggest that while the new technologies have advantages and can support rubber companies in ESG processes, there are also several hurdles and challenges to overcome. It is consistent with previous research, which acknowledges the potential benefits of technology adoption for sustainability efforts while recognizing the barriers it creates, such as high cost and skill gaps. A potential link between ESG and IIoT in contributing to the UN's SDGs is identified in the research. Despite the absence of specific goals in the industrial rubber sector, IIoT and ESG practices can indirectly contribute to achieving global objectives.

This study also provides several practical contributions to corporate practice. This study highlights the need to increase awareness and understanding of ESG practices and concepts in the industrial rubber industry. Employees at all levels of organizations must understand ESG's significance and their role. It can be accomplished through training programs and other educational initiatives. The dissertation also emphasizes the importance of developing an ESG strategy that involves all stakeholders to ensure sustainability becomes a priority and that ESG considerations are incorporated into decision-making. The research also indicates that aligning ESG goals with sustainable initiatives such as the SDGs can provide strategic guidance.

## 6.3 Limitations

This research is subjected to some limitations. First, it is known that generalizing from a single case study is limited, even when considered exemplary (Yin, 2009a). In other words, the single case study limits the scope of the results, and the research generalizes the rubber industry with one company operating in the field. Also, data collected by conducting semi-structured interviews relied heavily on the interviewer's skills. For this reason, some of the questions could have been leading in their nature once presented in the interviews.

Another limitation of the research is related to the data collection of this dissertation. Because of the knowledge of sustainability within the case company, the interviews started to be repetitive, and no new data surfaced, resulting in fewer interviews. Due to the number of interviews conducted, statistical generalizations cannot yet be made on behalf of the subject matter. However, this qualitative study aimed to understand the investigated phenomenon analytically rather than statistically. Furthermore, some limitations were present in this study's data analysis section. As the language of the interviews was Finnish, some data of importance could have been lost in translation.

## 6.4 Suggestions for future research

The research findings concerning ESG, IIoT, and SDGs in the rubber sector have opened up several avenues for further research. In the future, researchers could conduct multiple case studies using a mixed methodological approach, utilizing experts in sustainability and IIoT to explore the further integration of IIoT and ESG. It would allow for more profound insight, determine possible success factors, and further discover the barriers and opportunities the sector could have. Even though the dissertation has discussed the implementation of IIoT and its benefits on ESG performance, future research could provide more comprehensive measurements and quantify these technologies' impact on ESG performance. Also, future research could research how IIoT and ESG practices could be aligned with specific SDGs in the industrial rubber sector.

# Bibliographical references


AEG. (2023, April 3). *Rubber Industry Trends 2023: What You Need to Know to Stay Ahead*. American Engineering Group Llc. https://www.engineering-group.com/rubber-industry-trends-2023-what-you-need-to-know-to-stay-ahead/#:~:text=Several%20companies%20are%20already%20utilizing,in%20temperature%20and%20road%20conditions.

Ahmad, S., Badwelan, A., Ghaleb, A. M., Qamhan, A., Sharaf, M., Alatefi, M., & Moohialdin, A. (2018). Analyzing Critical Failures in a Production Process: Is Industrial IoT the Solution? *Wireless Communications and Mobile Computing*, *2018*, 1–12. https://doi.org/10.1155/2018/6951318

AirBoss of America Corp. (n.d.). *Life Cycle Of Synthetic & Natural Rubber - AirBoss Of America*. Air Boss of America Corp. Retrieved April 3, 2023, from https://airboss.com/life-cycle-of-synthetic-natural-rubber/

Albuquerque, R., Koskinen, Y., & Zhang, C. (2019). Corporate Social Responsibility and Firm Risk: Theory and Empirical Evidence. *Management Science*, *65*(10), 4451–4469. https://doi.org/10.1287/mnsc.2018.3043

Alcácer, V., & Cruz-Machado, V. (2019). Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems. *Engineering Science and Technology, an International Journal*, *22*(3), 899–919. https://doi.org/10.1016/j.jestch.2019.01.006

Alijoyo, A. (2022, August 19). *SDGs and ESG - Overcoming the Sustainability Risks - CRMS*. Center for Risk Management & Sustainability. https://crmsindonesia.org/publications/sdgs-and-esg-overcoming-the-sustainability-risks/

Ambika, P. (2020). Machine learning and deep learning algorithms on the Industrial Internet of Things (IIoT). In *Advances in Computers* (pp. 321–338). https://doi.org/10.1016/bs.adcom.2019.10.007

Arcidiacono, F., Ancarani, A., Mauro, C. Di, & Schupp, F. (2019). Where the Rubber Meets the Road. Industry 4.0 Among SMEs in the Automotive Sector. *IEEE Engineering Management Review*, *47*(4), 86–93. https://doi.org/10.1109/EMR.2019.2932965

Armstrong, A. (2020). Ethics and ESG. *Australasian Accounting, Business and Finance Journal*, *14*(3), 6–17. https://doi.org/10.14453/aabfj.v14i3.2

Asaro, L., Gratton, M., Seghar, S., & Aït Hocine, N. (2018). Recycling of rubber wastes by devulcanization. *Resources, Conservation and Recycling*, *133*, 250–262. https://doi.org/10.1016/j.resconrec.2018.02.016

Aspers, P., & Corte, U. (2019). What is Qualitative in Qualitative Research. *Qualitative Sociology*, *42*(2), 139–160. https://doi.org/10.1007/s11133-019-9413-7

Bell, D. A., & Llewellyn, R. C. (2022, February 3). *Best Practices for Establishing ESG Disclosure Controls and Oversight*. Harvard Law School Forum on Corporate Governance; The Harvard Law School Forum on Corporate Governance. https://corpgov.law.harvard.edu/2022/02/03/best-practices-for-establishing-esg-disclosure-controls-and-oversight/

Ben-Daya, M., Hassini, E., & Bahroun, Z. (2019). Internet of things and supply chain management: a literature review. *International Journal of Production Research*, *57*(15–16), 4719–4742. https://doi.org/10.1080/00207543.2017.1402140

Benedict, S., Sibi, B. J., & Balakrishnan, V. (2020). IoT-Blockchain Enabled Yield Advisory System (IBEYAS) for Rubber Manufacturers. *2020 IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS)*, 1–6. https://doi.org/10.1109/ANTS50601.2020.9342839

Beusch, P., Frisk, J. E., Rosén, M., & Dilla, W. (2022). Management control for sustainability: Towards integrated systems. *Management Accounting Research*, *54*, 100777. https://doi.org/10.1016/j.mar.2021.100777

Bhaskar, A. (2022, August 28). *How IoT Is Transforming The Manufacturing Industry*. Forbes. https://www.forbes.com/sites/forbestechcouncil/2022/09/28/how-iot-is-transforming-the-manufacturing-industry/?sh=b38781e75d7a

Billio, M., Costola, M., Hristova, I., Latino, C., & Pelizzon, L. (2021). Inside the ESG ratings: (Dis)agreement and performance. *Corporate Social Responsibility and Environmental Management*, *28*(5), 1426–1445. https://doi.org/10.1002/csr.2177

Boffo, R., & Patalano, R. (2020). *ESG Investing: Practices, Progress and Challenges*. https://www.oecd.org/finance/ESG-Investing-Practices-Progress-Challenges.pdf

Bonnet, D. (2022, August 20). *3 Stages of a Successful Digital Transformation*. Harvard Business Review. 3 Stages of a Successful Digital Transformation

Bortolini, M., Ferrari, E., Gamberi, M., Pilati, F., & Faccio, M. (2017). Assembly system design in the Industry 4.0 era: a general framework. *IFAC-PapersOnLine*, *50*(1), 5700–5705. https://doi.org/10.1016/j.ifacol.2017.08.1121

Bothwell, C., Woodman, L., & Obradovich, L. (2015). *SDG ICT Playbook from innovation to impact*.

Boyes, H., Hallaq, B., Cunningham, J., & Watson, T. (2018). The industrial internet of things (IIoT): An analysis framework. *Computers in Industry*, *101*, 1–12. https://doi.org/10.1016/j.compind.2018.04.015

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Cernev, T., & Fenner, R. (2020). The importance of achieving foundational Sustainable Development Goals in reducing global risk. *Futures*, *115*, 102492. https://doi.org/10.1016/j.futures.2019.102492

Cottrill, S. (2021, December 16). *Rubber industry ramps up sustainability efforts*. Rubber News. https://www.rubbernews.com/sustainability/rubber-industry-commits-carbon-neutrality-2050#:~:text=Players%20big%20and%20small%20in,circular%20economy%20with%20recycled%20materials

Dalenogare, L. S., Benitez, G. B., Ayala, N. F., & Frank, A. G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics*, *204*, 383–394. https://doi.org/10.1016/j.ijpe.2018.08.019

Davies, R. (2015). *Industry 4.0 Digitalisation for productivity and growth*.

Deloitte. (2019, August 16). *2019 Deloitte and MAPI Smart Factory Study: Capturing Value Along the Digital Journey*. Deloitte. https://www2.deloitte.com/us/en/pages/about-deloitte/articles/press-releases/2019-deloitte-and-mapi-smart-factory-study-capturing-value-along-the-digital-journey.html

Digital Europe. (2022). *The future of industry*. Digital Europe. https://www.digitaleurope.org/futureofindustry/

Ebert, C., & Duarte, C. H. C. (2018). Digital Transformation. *IEEE Software*, *35*(4), 16–21. https://doi.org/10.1109/MS.2018.2801537

Eccles, R. G., Krzus, M. P., Rogers, J., & Serafeim, G. (2012). The Need for Sector-Specific Materiality and Sustainability Reporting Standards. *Journal of Applied Corporate Finance*, *24*(2), 65–71. https://doi.org/10.1111/j.1745-6622.2012.00380.x

Eriksson, P., & Kovalainen, A. (2008). Qualitative Methods in Business Research: A Practical Guide to Social Research . In J. Seaman (Ed.), *SAGE Publications Ltd* (2nd ed.). SAGE Publications Ltd.

Eriksson, P., & Kovalainen, A. (2016). *Qualitative Methods in Business Research: A Practical Guide to Social Research* (2nd ed.). Sage.

ERTMA. (2016). *Rubber Goods*. European Tyre & Rubber Manufacturer Association. https://www.etrma.org/rubber-goods/

ESGgen. (n.d.). *Sustainable Development Goals (SDGs) - ESGgen – The ESG accounting platform for SMEs*. ESGgen. Retrieved March 31, 2023, from https://www.esggen.com/the-science/sustainable-development-goals-sdgs/

ETRMA. (2019a). *General Rubber Goods Challenges*.

ETRMA. (2019b). *Natural rubber - ETRMA*. European Tyre and Rubber Manufacturers Association. https://www.etrma.org/key-topics/materials/natural-rubber/

European Banking Authority. (2021). *EBA report on management and supervision of ESG risks for credit institutions and investment firms EBA/REP/2021/18*.

European Commission. (2019a). Communication from the commission to the european Parliament, the european council, the council, the european Economic and social committee and the committee of the Regions, The European Green Deal. *European Commission*, *604(final)*.

European Commission. (2019b). *A European Green Deal | European Commission*. European Commission. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

European Commission. (2020). *Economic and social committee and the committee of regions - A New Industrial Strategy for Europe*.

European Commission. (2022, December 6). *Law to fight global deforestation and forest degradation*. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_7444

European Commission. (2023). *Corporate sustainability reporting*. European Commission. https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

Farina, A., Zanetti, M. C., Santagata, E., & Blengini, G. A. (2017). Life cycle assessment applied to bituminous mixtures containing recycled materials: Crumb rubber and reclaimed asphalt pavement. *Resources, Conservation and Recycling*, *117*, 204–212. https://doi.org/10.1016/j.resconrec.2016.10.015

Fatemi, A., Fooladi, I., & Tehranian, H. (2015). Valuation effects of corporate social responsibility. *Journal of Banking and Finance*, *59*, 182–192. https://doi.org/10.1016/J.JBANKFIN.2015.04.028

Fatorachian, H., & Kazemi, H. (2018). A critical investigation of Industry 4.0 in manufacturing: theoretical operationalisation framework. *Production Planning & Control*, *29*(8), 633–644. https://doi.org/10.1080/09537287.2018.1424960

Garrido-Hidalgo, C., Hortelano, D., Roda-Sanchez, L., Olivares, T., Ruiz, M. C., & Lopez, V. (2018). IoT Heterogeneous Mesh Network Deployment for Human-in-the-Loop Challenges Towards a Social and Sustainable Industry 4.0. *IEEE Access*, *6*, 28417–28437. https://doi.org/10.1109/ACCESS.2018.2836677

Gebauer, H., Fleisch, E., Lamprecht, C., & Wortmann, F. (2020). Growth paths for overcoming the digitalization paradox. *Business Horizons*, *63*(3), 313–323. https://doi.org/10.1016/j.bushor.2020.01.005

Gilchrist, A. (2016). Introduction to the Industrial Internet. In *Industry 4.0* (pp. 1–12). Apress. https://doi.org/10.1007/978-1-4842-2047-4_1

Giner, B., & Luque-Vílchez, M. (2022). A commentary on the "new" institutional actors in sustainability reporting standard-setting: a European perspective. *Sustainability Accounting, Management and Policy Journal*, *13*(6), 1284–1309. https://doi.org/10.1108/SAMPJ-06-2021-0222

Ginger, S. (2023, May 23). Why are rubber companies keeping investors in the dark over deforestation risk? *Ethical Corporation Magazine, Thomson Reuters.*

Gitman, L., Chorn, B., & Fargo, B. (2009). ESG in the mainstream: the role for companies and investors in environmental, social, and governance integration. *San Francisco, CA: Business for Social Responsibility.*

Gupta, A., Sharma, U., & Gupta, S. K. (2021). The Role of ESG in Sustainable Development: An Analysis Through the Lens of Machine Learning. *2021 IEEE International Humanitarian Technology Conference (IHTC)*, 1–5. https://doi.org/10.1109/IHTC53077.2021.9698939

Hahn, R., & Kühnen, M. (2013). Determinants of sustainability reporting: a review of results, trends, theory, and opportunities in an expanding field of research. *Journal of Cleaner Production*, *59*, 5–21. https://doi.org/10.1016/j.jclepro.2013.07.005

Hammoudi, S., Aliouat, Z., & Harous, S. (2018). Challenges and research directions for Internet of Things. *Telecommunication Systems*, *67*(2), 367–385. https://doi.org/10.1007/s11235-017-0343-y

Henriksson, R., Livnat, J., Pfeifer, P., & Stumpp, M. (2019). Integrating ESG in Portfolio Construction. *The Journal of Portfolio Management*, *45*(4), 67–81. https://doi.org/10.3905/jpm.2019.45.4.067

Hermundsdottir, F., & Aspelund, A. (2021). Sustainability innovations and firm competitiveness: A review. *Journal of Cleaner Production*, *280*, 124715. https://doi.org/10.1016/j.jclepro.2020.124715

Huang, D. Z. X. (2021). Environmental, social and governance (ESG) activity and firm performance: a review and consolidation. *Accounting & Finance*, *61*(1), 335–360. https://doi.org/10.1111/acfi.12569

Imran, F., Shahzad, K., Butt, A., & Kantola, J. (2021). Digital Transformation of Industrial Organizations: Toward an Integrated Framework. *Journal of Change Management*, *21*(4), 451–479. https://doi.org/10.1080/14697017.2021.1929406

Ismail, N.-S. N., Binti Mustafa, S. Z., Yunus, F., & Abd Warif, N. B. (2020). Internet of Things (IoT) Smart Rubber Scale (SRS) System Using Arduino Platform. *2020 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS)*, 45–50. https://doi.org/10.1109/I2CACIS49202.2020.9140209

Jäger, J., Schöllhammer, O., Lickefett, M., & Bauernhansl, T. (2016). Advanced Complexity Management Strategic Recommendations of Handling the "Industrie 4.0" Complexity for Small and Medium Enterprises. *Procedia CIRP*, *57*, 116–121. https://doi.org/10.1016/j.procir.2016.11.021

Jardak, M. K., & Ben Hamad, S. (2022). The effect of digital transformation on firm performance: evidence from Swedish listed companies. *The Journal of Risk Finance*, *23*(4), 329–348. https://doi.org/10.1108/JRF-12-2021-0199

Kagermann, H., Wahlster, W., & Helbig, J. (2013). *Recommendations for implementing the strategic initiative INDUSTRIE 4.0*.

Khodadadi, F., Dastjerdi, A. V., & Buyya, R. (2016). Internet of Things: an overview. In R. Buyya & A. Vahid Dastjedi (Eds.), *Internet of Things* (pp. 3–27). Elsevier. https://doi.org/10.1016/B978-0-12-805395-9.00001-0

Kim, K.-H., Kim, M., & Qian, C. (2018). Effects of Corporate Social Responsibility on Corporate Financial Performance: A Competitive-Action Perspective. *Journal of Management*, *44*(3), 1097–1118. https://doi.org/10.1177/0149206315602530

Klettner, A., Clarke, T., & Boersma, M. (2014). The Governance of Corporate Sustainability: Empirical Insights into the Development, Leadership and Implementation of Responsible Business Strategy. *Journal of Business Ethics*, *122*(1), 145–165. https://doi.org/10.1007/s10551-013-1750-y

Kneib Negron, M. (2020). *Intersecting Sustainability: ESG and Smart Manufacturing Trends*.

Koch, V., Kuge, S., Schrauf, S., & Dr Geissbauer, R. (2014). *Koch, V., Kuge, S., Geissbauer, R. and Schrauf, S., 2014. Industry 4.0: Opportunities and challenges of the industrial internet. Strategy & PwC*.

Korovin, G. (2021). Modeling the Digital Transformation of the Region's Industry. In V. Kumar, J. Rezaei, V. Akberdina, & E. Kuzmin (Eds.), *Digital transformation in Industry* (Vol. 44, pp. 49–55). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-73261-5_5

Kotsantonis, S., & Serafeim, G. (2019). Four Things No One Will Tell You About ESG Data. *Journal of Applied Corporate Finance*, *31*(2), 50–58. https://doi.org/10.1111/jacf.12346

Lev, H. (2021, October 29). *How the UN SDGs can help define & shape ESG outcomes*. Conservice ESG. https://esg.conservice.com/how-sdgs-help-shape-esg-outcomes/

Li, S., Xu, L. Da, & Zhao, S. (2015). The internet of things: a survey. *Information Systems Frontiers*, *17*(2), 243–259. https://doi.org/10.1007/s10796-014-9492-7

Liao, Y., Deschamps, F., Loures, E. de F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. *International Journal of Production Research*, *55*(12), 3609–3629. https://doi.org/10.1080/00207543.2017.1308576

Libert, B., Beck, M., & Wind, Y. (2016, July 14). *7 Questions to Ask Before Your Next Digital Transformation*. Harvard Business Review. https://hbr.org/2016/07/7-questions-to-ask-before-your-next-digital-transformation

Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration*, *6*, 1–10. https://doi.org/10.1016/j.jii.2017.04.005

MacNeil, I., & Esser, I. (2022). From a Financial to an Entity Model of ESG. *European Business Organization Law Review*, *23*(1), 9–45. https://doi.org/10.1007/s40804-021-00234-y

Moker, A., Brosi, P., & Welpe, I. M. (2020). How to digitalize inseparable service processes: the enabling role of internal and external support for innovation. *Business Research*, *13*(3), 1145–1167. https://doi.org/10.1007/s40685-020-00119-9

Molino, A., Donatelli, A., Marino, T., Aloise, A., Rimauro, J., & Iovane, P. (2018). Waste tire recycling process for production of steam activated carbon in a pilot plant. *Resources, Conservation and Recycling*, *129*, 102–111. https://doi.org/10.1016/j.resconrec.2017.10.023

Monument, A. (2019, March 29). *Sustainable rubber: setting the wheels in motion | by WWF | WWF - Together Possible | Medium*. WFF. https://medium.com/wwftogetherpossible/sustainable-rubber-setting-the-wheels-in-motion-fa9f83f5e859

Mordon Intelligence. (2021). *Industrial Rubber Market Size, Share, Growth | Analysis (2022 - 27)*. Mordon Intelligence. https://www.mordorintelligence.com/industry-reports/industrial-rubber-market

MSCI. (n.d.). *ESG Investing: ESG Ratings - MSCI*. MSCI. Retrieved April 5, 2023, from https://www.msci.com/our-solutions/esg-investing/esg-ratings

Müller, J. M., & Voigt, K.-I. (2018). Sustainable Industrial Value Creation in SMEs: A Comparison between Industry 4.0 and Made in China 2025. *International Journal of Precision Engineering and Manufacturing-Green Technology*, *5*(5), 659–670. https://doi.org/10.1007/s40684-018-0056-z

Nikander, S. (2023, September 20). *Suomalaisen kumiteollisuuden maailma on lokaalisti globaali*. Subcontracting Fair.

OECD. (2016). *The Internet of Things: Seizing the Benefits and Addressing the Challenges*.

OECD. (2021). STI Policy Note Industrial policy for the Sustainable Development Goals. In *OECD* (Vol. 2021). www.oecd.org/sti

Osarenkhoe, A., & Fjellström, D. (2021). The Oxymoron of Digitalization. *Journal of Information Technology Research*, *14*(4), 122–138. https://doi.org/10.4018/JITR.20211001.oa1

Parker Hannifin Corporation. (2022). *How Increased Focus on Sustainability and Digitalization Is Changing Industrial and Chemical Processing*.

Peterdy, K. (2022, August 30). *ESG (Environmental, Social and Governance) - Overview and Framework*. Corporate Finance Institute. https://corporatefinanceinstitute.com/resources/knowledge/other/esg-environmental-social-governance/

PRI. (2022). *Principles for responsible investment*. https://www.unpri.org/download?ac=10948

Ramakrishna, S. (2021). *Fourth Industrial Revolution Technologies for Progress in UN SDGs*.

Reka Industrial. (n.d.). *Reka Industrial - What we do*.

Sarkar, P., & Bhowmick, A. K. (2018). Sustainable rubbers and rubber additives. *Journal of Applied Polymer Science*, *135*(24). https://doi.org/10.1002/app.45701

Saunders, M., Lewis, P., & Thornhill, A. (2012). *RESEARCH METHODS FOR BUSINESS STUDENTS* (Sixth). Pearson Education Limited. https://gibsoncollege.edu.et/wp-content/uploads/2022/01/Research-Methods-for-Business-Students-by-Mark-Saunders-Philip-Lewis-Adrian-Thornhill-z-lib.org-1.pdf

Saunders, M., Lewis, P., & Thornhill, A. (2016). *RESEARCH METHODS FOR BUSINESS STUDENTS* (7th ed.). Pearson Education Limited.

Saxena, A., Singh, R., Gehlot, A., Akram, S. V., Twala, B., Singh, A., Montero, E. C., & Priyadarshi, N. (2022). Technologies Empowered Environmental, Social, and Governance (ESG): An Industry 4.0 Landscape. *Sustainability*, *15*(1), 309. https://doi.org/10.3390/su15010309

Schwertner, K. (2017). Digital transformation of business. *Trakia Journal of Science*, *15*(Suppl.1), 388–393. https://doi.org/10.15547/tjs.2017.s.01.065

Sergio, M., Franciosi, C., & Iannone, R. (2021). A model for the economic assessment of disassembly-line integration in traditional manufacturing processes. *Procedia Computer Science*, *180*, 308–317. https://doi.org/10.1016/j.procs.2021.01.168

Sienkiewicz, M., Janik, H., Borzędowska-Labuda, K., & Kucińska-Lipka, J. (2017). Environmentally friendly polymer-rubber composites obtained from waste tyres: A review. *Journal of Cleaner Production*, *147*, 560–571. https://doi.org/10.1016/j.jclepro.2017.01.121

Singhal, K., & Singhal, J. (2012). Opportunities for developing the science of operations and supply-chain management. *Journal of Operations Management*, *30*(3), 245–252. https://doi.org/10.1016/j.jom.2011.11.002

Stake, R. E. (2003). Case Studies . In Y. Lincoln & N. Denzin (Eds.), *Strategies of qualitative inquiry.* (pp. 134–164). Thousand Oaks, Sage.

Stanfield, S. (2019). *Is Rubber Sustainable? Why It's Not so Simple (Explained)*. CitizenSustainable. https://citizensustainable.com/rubber-sustainable/?utm_content=cmp-true

Starks, L., Venkat, P., & Zhu, Q. (2017). *Corporate ESG Profiles and Investor Horizons **. 30–50. https://www.blackrock.com/corporate/investor-relations/2016-larry-fink-ceo-letter.

Stock, T., & Seliger, G. (2016). Opportunities of Sustainable Manufacturing in Industry 4.0. *Procedia CIRP*, *40*, 536–541. https://doi.org/10.1016/j.procir.2016.01.129

Storero, J. K., & Barychev, Y. (2022). Creating a Sustainable Corporation for the Long Term: A Guide to Effectively Implementing ESG Initiatives for Boards. *Board Leadership*, *2022*(183), 2–7. https://doi.org/10.1002/bl.30224

SustainoMetric. (n.d.). *ESG to SDGs: Connected Paths to a Sustainable Future – SustainoMetric*. SustainoMetric. Retrieved March 31, 2023, from https://sustainometric.com/esg-to-sdgs-connected-paths-to-a-sustainable-future/

Tanielian, A. (2018). Sustainability and Competitiveness in Thai Rubber Industries. *The Copenhagen Journal of Asian Studies*, *36*(1), 50–78. https://doi.org/10.22439/cjas.v36i1.5512

Thames, L., & Schaefer, D. (2016). Software-defined Cloud Manufacturing for Industry 4.0. *Procedia CIRP*, *52*, 12–17. https://doi.org/10.1016/j.procir.2016.07.041

The Global Goals. (n.d.). *The 17 Goals - The Global Goals*. The Global Goals. Retrieved November 1, 2022, from https://www.globalgoals.org/goals/

Thomas, D. R. (2006). A General Inductive Approach for Analyzing Qualitative Evaluation Data. *American Journal of Evaluation*, *27*(2), 237–246. https://doi.org/10.1177/1098214005283748

Tian, G., Li, B., & Cheng, Y. (2022). Does digital transformation matter for corporate risk-taking? *Finance Research Letters*, *49*, 103107. https://doi.org/10.1016/j.frl.2022.103107

Tiwari, S. (2015). Framework for adopting sustainability in the supply chain. *International Journal of Automation and Logistics*, *1*(3), 256. https://doi.org/10.1504/IJAL.2015.071724

*Towards a green, digital and resilient economy*. (2022, March 2). https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1467

Transparency Market Research. (2022, May). *Industrial Rubber Products Market | Industry Report, 2031*. https://www.transparencymarketresearch.com/industrial-rubber-products.html

UN Global Compact. (2015). *A Global Compact for Sustainable Development* . https://www.unglobalcompact.org/library/2291

UNDP. (2014). *Business and the SDGs | United Nations Development Programme*. United Nations Development Programme. https://www.undp.org/sdg-accelerator/business-and-sdgs

United Nations. (2004). *Who Cares Wins*.

United Nations. (2018). *Sustainable Development | UN Global Compact*. United Nations Global Compact. https://www.unglobalcompact.org/what-is-gc/our-work/sustainable-development

United Nations Department of Economic and Social affairs. (2022). *THE 17 GOALS | Sustainable Development*. United Nations, Department of Economic and Social Affairs. https://sdgs.un.org/goals#implementation

United Nations Global Compact. (n.d.). *Advancing Sustainable Development*. Retrieved November 29, 2022, from https://www.unglobalcompact.org/what-is-gc/our-work/sustainable-development

United Nations Global Compact. (2016). *Global goals for people and planet | UN Global Compact*. United Nations Global Compact. https://www.unglobalcompact.org/sdgs/about

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, *28*(2), 118–144. https://doi.org/10.1016/j.jsis.2019.01.003

Wang, S., Wan, J., Li, D., & Zhang, C. (2016). Implementing Smart Factory of Industrie 4.0: An Outlook. *International Journal of Distributed Sensor Networks*, *12*(1), 3159805. https://doi.org/10.1155/2016/3159805

Wayne Rubber. (2021, November 11). *Sustainability in the Rubber Industry*. Wayne Rubber. https://waynerubber.com/sustainability-in-the-rubber-industry/

World Economic Forum. (2015). *Industrial Internet of Things: Unleashing the Potential of Connected Products and Services*.

World Economic Forum. (2018). *Internet of things, Guidelines for sustainability*.

World Economic Forum. (2020). Measuring Stakeholder Capitalism Towards Common Metrics and Consistent Reporting of Sustainable Value Creation . *World Economic Forum* .

Yang, F., & Gu, S. (2021). Industry 4.0, a revolution that requires technology and national strategies. *Complex & Intelligent Systems*, *7*(3), 1311–1325. https://doi.org/10.1007/s40747-020-00267-9

Yin, R. K. (2003). *Case Study Research: Design and Methods* (K. Wiley, S. Robinson, & G. Dickens, Eds.; 3rd ed., Vol. 5). Sage Publication Inc. https://books.google.fi/books?id=BWea_9ZGQMwC&printsec=frontcover&hl=fi&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Yin, R. K. (2009a). *Case Study Research: design and methods* (4th ed.). Sage Publications Inc.

Yin, R. K. (2009b). *Case Study Research: Design and Methods - Robert K. Yin* (V. Knight, S. Connelly, C. M. Chilton, & G. Dickens, Eds.; 4th ed., Vol. 5). Sage Publications Inc. https://books.google.fi/books?id=FzawIAdilHkC&printsec=frontcover&hl=fi&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Zanten, J. A., & Tulder, R. (2021). Improving companies' impacts on sustainable development: A nexus approach to the SDGS. *Business Strategy and the Environment*, *30*(8), 3703–3720. https://doi.org/10.1002/bse.2835

Zhu, C., Leung, V. C. M., Shu, L., & Ngai, E. C.-H. (2015). Green Internet of Things for Smart World. *IEEE Access*, *3*, 2151–2162. https://doi.org/10.1109/ACCESS.2015.2497312

# Annex A

| Research Question | Operationalized interview questions |
|---|---|
| **RQ 1: How can IIoT tackle ESG goals in the industrial rubber sector?** | 1. The abbreviation ESG has gained popularity in recent years. It is becoming increasingly widely known, but few people know what it really is, often confused with CSR. So, what exactly is this notorious ESG?<br>2. How do you incorporate ESG considerations into your investment process?<br>3. Does adapting to ESG also mean costs for businesses? And if so - how high?<br>4. What ESG regulation and compliance obligations does the organization have now, and what requirements may be coming in future?<br>5. Is there a comprehensive audit undertaken to understand the entire organisation's current ESG outputs and performance?<br>6. What are some of the challenges you see in ESG integration?<br>7. What do you think about the role of ESG in driving innovation and competitive advantage?<br>8. What technologies have you adopted lately in the company?<br>9. What kind of technologies are you using to meet your ESG goals?<br>10. If not, what technologies are you planning to implement to follow these ESG goals? |
| **RQ 2: What are the advantages and hurdles in adopting IIoT to support rubber companies in ESG processes?** | 11. What issues have you encountered in adopting technologies/IIOT into the ESG processes? From the technology implementation to producing valid and useful data.<br>12. If not, where do you think the implementation will or can fail?<br>13. What kind of support would you need to overcome these issues to adopt IIOT successfully when measuring ESG efforts?<br>14. What kind of advantages and opportunities have you recognized that the IIOT brings?<br>15. How has IIoT helped the organization to identify and address environmental risks that may have other gone unnoticed?<br>16. What impact has the adoption of IIoT had on the efficiency in your operations? |
| **RQ 3: Does IIoT and ESG implementation processes contribute to SDGs in Finnish industry rubber sector?** | 17. So, what exactly is the SDGs?<br>18. How can Reka Rubber contribute to SDGs? And do you see opportunities regarding this?<br>19. How do you measure Reka Rubbers contributions towards SDGs? If not do you know if other rubber companies in the industry report their contributions? |

| | |
|---|---|
| | 20. How do you prioritize which ESG factors to focus on, what factors have been most important for your company?<br>21. Can you give an example of how an ESG consideration has influenced a recent business decision? |
| **RQ4: How to translate the ESG goals into practical, measurable, and trackable efforts in the industrial rubber sector. How does ESG change due diligence?** | 22. How have you translated your ESG goals to practical and measurable efforts?<br>23. What metrics do you use to measure ESG progress in a specific? Regarding all three factors Environmental, Social and Governance?<br>24. What challenges have you faced in translating ESG goals into practical efforts?<br>25. How has the diligence process influenced Reka, positively or negatively?<br>26. How have ESG goals influenced the due diligence process within your company? What changes have you made to ensure that environmental, social and governance factors are considered in the decision making? How do you see them affecting in the future? |

# Annex B

Each interview's transcripts are summarized below:

Interviewee 1:

In the interview, the discussion revolved around ESG (Environmental, Social, and Governance) considerations within the company, particularly its impacts, challenges, and integration of technology. The interviewee mentioned that ESG has gained prominence. The company focuses on social healthcare systems, environmental improvements like solar panels, and maintaining a comprehensive healthcare system. The company is conscious of environmental concerns, such as rubber waste, but faces challenges in incorporating more sustainable practices due to cost considerations. While some technologies like solar panels have been adopted, the interviewee felt that the company's operations are still quite manual. The interviewee highlighted the need for a mindset shift towards prioritizing sustainability over cost concerns. The concept of UN Sustainable Development Goals was discussed, with the company potentially contributing to goals related to equality and a positive work environment. The interviewee shared insights into how due diligence affects the company, citing efforts in the sales team to improve customer relationship management and address customer demands related to sustainability.

Interviewee 2:

The company focuses on various factors related to environmental impact, employee well-being, and effective management. ESG encompasses a broad range of topics, and its significance varies across companies and countries. Some perceive it as environmental responsibility, like reducing electricity consumption and fossil fuel usage. Others emphasize good governance and ethical practices. ESG's complexity arises from differing interpretations. While ESG has gained popularity, it's still evolving, with multiple concepts and levels of implementation. Notable examples of ESG efforts in the company include using green electricity and reducing accidents and waste. Metrics for progress involve measuring safety incidents, illness days, training participation, waste reduction, and energy consumption. Prioritization in ESG focus varies. Ensuring employee safety and well-being is paramount, reflecting the belief that every employee should return home safely. Sustainable practices, such as reducing waste and saving energy through green initiatives, hold significance too. These efforts not only align with customer expectations but also result in cost savings, reduced environmental impact, and streamlined processes. In summary, ESG involves addressing environmental, social, and governance aspects. The company's approach to ESG includes employee safety, green initiatives, waste reduction, and energy conservation, with metrics used to measure progress. While customer demands are evolving, ESG's impact on purchasing decisions is still developing.

Interviewee 3:

The interview covered the history of sustainability efforts, the Responsible Care program, audits and certifications, challenges in transitioning to more sustainable practices, and the importance of adapting to customer demands. They highlight challenges in transitioning to more sustainable practices, particularly when it comes to replacing fossil fuels and balancing costs with customer demands. The interviewee also talks about the implementation of technologies like the Internet of Things (IoT) and digitization, which have been used for improving processes and data management. They mention instances where technological changes have led to unexpected challenges, such as rapid order changes disrupting production processes. The interviewee emphasizes the need for training and sharing real-life cases to learn and adapt to new technologies and solutions. The conversation also touched on the complexities of transitioning to greener alternatives, especially when it comes to raw materials and global competition. Overall, the company aims to balance sustainability efforts with practical business considerations and customer demands.

Interviewee 4:

The interviewee discussed the company's recent commitment to the UN Global Compact's sustainability goals and the upcoming training program they will undergo. They highlighted the challenges of turning non-ESG goals into practical measures, especially in complex areas like human rights. The interviewee noted challenges in transitioning to greener alternatives within the rubber industry, where technical solutions already exist for energy sources but not yet for specific rubber-related products. The company has begun monitoring water and steam consumption and is considering LED lighting. They mentioned that their focus is still at the early stages and that they are exploring possibilities, potentially including IoT solutions. The implementation of sensors faced challenges due to resource constraints, with deployment taking longer than expected. The interviewee also mentioned the potential benefits of IoT for predictive maintenance once the company upgrades its machinery. The conversation revealed the company's dedication to adopting sustainable practices while navigating technical and operational hurdles.

Interviewee 5:

The interviewee discusses the company's approach to ESG goals and their challenges. They mention that the organization has not conducted a comprehensive audit yet but is working on improving safety culture and occupational health. The company's primary focus is on safety and security, while the carbon footprint is also considered, but less prioritized. Challenges include limited organizational resources and potential conflicts between responsible practices and cost-effectiveness. The interviewee mentions a measurement initiative to monitor steam consumption and improve energy efficiency. Future plans involve technology implementation to enhance production processes, reduce manual work, and increase efficiency. There's a mention of projects involving automation solutions to rethink production lines and improve efficiency.

Interviewee 6:

The interviewee discusses the lack of a comprehensive ESG audit and expresses uncertainty about the reasons behind it. They mention some metrics for measuring ESG progress, such as waste tracking and energy consumption. Challenges in turning ESG goals into practical ones are highlighted, including the need to break down abstract concepts into smaller parts. The interviewee prioritizes waste reduction and energy consumption as key ESG factors. The role of ESG in promoting innovation and competition is acknowledged, with a focus on implementing IoT technology into rubber products for added value. However, the interviewee notes that the company hasn't made significant advancements in implementing

technology for ESG purposes. They also mention a lack of awareness regarding the UN Sustainable Development Goals and how the company could contribute to them.

Interviewee 7:

The interviewee discusses the challenges of implementing sensors in the manufacturing process due to the aggressive nature of the method. They mention the importance of meeting customer needs and optimizing processes with IoT technology, particularly for inventory management. The interviewee acknowledges not being aware of specific instances where technology has addressed environmental issues. They admit not being well-versed in the UN Sustainable Development Goals but mention waste reduction and minimizing transportation as potential areas of contribution. The discussion briefly touches on the role of measurements in contributing to sustainable development goals. Lastly, the interviewee addresses external pressures and customer demands for environmental certifications but notes no recent significant limiting factors. The conversation ends with a question about how ESG goals have influenced due diligence in the company's operations.