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MASTER'S THESIS

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TITLE:

Industry 4.0 as a strategy related to the United Nations Sustainable Development Goals in Norwegian Industries

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Abstract

The new industrial revolution, known as Industry 4.0, is becoming increasingly important within Norwegian companies. Industry 4.0 is a future-oriented strategy and could be significant for maintaining and improving companies' competitiveness. Further, the importance of sustainability has increased in the last few years, which resulted in the United Nations (UN) Sustainable Development Goals (SDGs) and associated subgoals. Additionally, the triple bottom line (TBL) has been developed based on the term sustainability. This thesis aims to research how Industry 4.0 as a strategy is related to the UN SDGs within Norwegian industries.

As there exist limited studies related to *Industry 4.0 combining Sustainability* within Norwegian industries, a qualitative method is conducted. A literature study is executed based on a comprehensive literature search to acquire relevant data. This thesis consists of Industry 4.0 technologies provided by Bai, Dallasega, Orzes, and Sarkis (2020), and Oztemel and Gursev (2020), which evaluate Industry 4.0 technologies from a sustainable perspective. Further, the thesis analyzes the UN subgoals based on their relevance within Norwegian companies utilizing Industry 4.0 technologies. The relevant subgoals and Industry 4.0 technologies are linked with the TBL to generate the finding of this thesis.

Industry 4.0 allows for automated processes and decreased human interaction. Conclusively, it decreases the cost of human labor, increases production efficiency, and reduces waste. Additionally, rural companies in Norway could experience the demand for workforce exceeding the supply due to rural flight. Thus, Industry 4.0 is related to economic sustainability and SDG8.2. Further, automated processes reduce employee's exposure to dangerous work tasks and are therefore related to social sustainability and SDG3.d. Industry 4.0 increases the demand for a qualified workforce, indicating reskilling of employees. Social sustainability and SDG4.4 are thus correlated. The technologies' facilitation for local production results in shorter transportation routes, thus, reducing gas emissions. This is related to environmental sustainability and SDG9.4. Industry 4.0 also correlates with SDG12.5 and environmental sustainability, as it allows Norwegian companies to forecast demand and reduce overproduction.

Preface

This master's thesis marks the end of the MSc program in Business Administration at the University of Stavanger and is a result of the specialization: Strategic Marketing and Analytics.

Industry 4.0 is relevant for Norwegian companies to maintain and improve their competitiveness. The authors find the topic interesting as Industry 4.0 is a future-oriented strategy that challenges traditional operations within a company. Further, the increased focus on sustainability can make the findings of this thesis applicable to Norwegian companies. Working with the thesis has been comprehensive, as Industry 4.0 is a complex concept. However, the authors found the process to be interesting and rewarding.

We would like to thank our supervisor Jan Frick for providing good advice and feedback during the process. The frequent meetings throughout the process and the quick response have helped us stay focused and motivated. We would also like to thank our family and friends who have supported and answered all our questions.

Stavanger, June 10, 2021

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List of Concepts

Agricultural Industry	Referring to independent business owners that operate a farm in Norway.
High-Skilled	Referring to people with sufficient knowledge to handle Industry 4.0 technologies.
Norwegian Companies	Referring to companies located in Norway, regardless of whether they are of Norwegian origin.
Rural Companies	Referring to companies located in rural areas in Norway.

List of Abbreviations

AI	Artificial Intelligence
AM	Additive Manufacturing
AR	Augmented Reality
Cloud Technology	Cloud Systems and Cloud Computing
CPS	Cyber Physical Systems
ERP	Enterprise Resource Planning
GPS	Global Positioning System
IoT	Internet of Things
IIoT	Industrial Internet of Things
IT	Information Technology
M2M	Machine to Machine Communication
RFID	Radio Frequency Identification
Robotics	Autonomous Robotics
SDGs	Sustainable Development Goals
TBL	Triple Bottom Line
UAV	Unmanned Aerial Vehicle
UN	United Nations
VM	Virtual Manufacturing

1. Introduction

This chapter provides the motivation and the justification for choice of research. Further, it presents the research questions that will be answered, the limitations related to the research, and the structure of the thesis.

1.1 Motivation

According to the industry report provided by the Norwegian Ministry of Trade, Industry and Fisheries, the Government has developed a vision for the Norwegian industry, which is as follows: "Norway will be a world leader in industry and technology" (Regjeringen, 2017, p. 1). Further, due to customer expectations and society's increased focus on sustainability, Norwegian companies have to continuously and strategically work towards reaching the United Nations (UN) Sustainable Development Goals (SDGs) (Knutstad & Torvatn, 2020). This emphasizes the relevance of the topic *Industry 4.0 and Sustainability* and the authors' motivation to conduct this study within the Norwegian industry.

1.1.1 Industry 4.0

The fourth industrial revolution is characterized by technology (de Sousa Jabbour, Jabbour, Foropon, & Filho, 2018). Implementing Industry 4.0 could decrease lead times and increase organization performance by utilizing different technologies (Kamble, Gunasekaran, & Gawankar, 2018). Industry 4.0 will also continuously revolutionize the working environment, transforming how one works due to the consequences of changes in manufacturing and production systems (Romero et al., 2016). Further, the changing working environment affected by the fourth industrial revolution will create different ways for humans and machines to interact between "digital and physical worlds" (Romero et al., 2016, p. 2). The connection of devices could increase organizations' performance due to the combination of data and human insight (Chan, 2019). The way organizations operate will change substantially due to emerging technologies (Albert, 2017).

1.1.2 Sustainability

Sustainability is found by scholars to be contemplated as one of the leading developments of Industry 4.0 within production systems (Gobbo Junior, Busso, Gobbo, & Carreão, 2018). Further, it has become increasingly more focused on by organizations, due to pollution and change in climate, among other things. The triple bottom line (TBL), consisting of people, planet, and profit, measures organizations' sustainability. If organizations continuously support all of the factors of TBL, the organizations has a sustainable operation (Braccini & Margherita, 2019). Sustainability has gained increased attention as one has noticed the problems related to "climate change, pollution, waste, and depletion of natural resources" ("Increasing the focus on sustainability: Some potential barriers to overcome," 2018, p. 34). The UN SDGs include eliminating poverty, inequity and stopping climate change by 2030 (United Nations, n.d.-s). This has resulted in organizations being somehow enforced to become more sustainable, as the unsustainable operations are not seen as satisfactory. Most organizations have recognized that gaining a competitive advantage means operating sustainably ("Increasing the focus on sustainability: Some potential barriers to overcome," 2018).

1.2 Justification for Choice of Research

According to research, Industry 4.0 will increase organizations' sustainable manufacturing (Carvalho, Chaim, Cazarini, & Gerolamo, 2018; de Sousa Jabbour et al., 2018; Stock & Seliger, 2016). Both sustainability and Industry 4.0 are considered to be radical trends in traditional production systems. Theory finds that the two components combined will change production systems continually due to the synergy effect, as Industry 4.0 allows for increased sustainability. Industry 4.0 has affected the strategic process of decision-making within organizations due to the increased focus on sustainability (de Sousa Jabbour et al., 2018).

Despite the increased interest regarding Industry 4.0, limited scholars focus on the dynamic aspect of the topic, including sustainability (Kamble et al., 2018). Achieving economic, environmental, and social sustainability through the utilization of Industry 4.0 is increasingly in focus. The significance and result of Industry 4.0 on the TBL are predicted to be substantial but need further study (Ghobakhloo, 2020). Scholars have found an existing gap in research regarding how Industry 4.0 and sustainability can be realized and integrated in a complex and suitable way (de Sousa Jabbour et al., 2018). According to Bai, Dallasega, Orzes, & Sarkis (2020), the interface between sustainability and Industry 4.0 technologies should be explored further. Ghobakhloo (2020) finds that the research on this aspect is at its emergence. Additionally, the impact Industry 4.0 has on the TBL needs to be further studied (Ghobakhloo, 2020). This thesis aims to contribute to close this gap by exploring how utilizing Industry 4.0 in Norwegian companies will affect the TBL. Moreover, this research correlates with the global focus on sustainability and the UN SDGs that are initiated to decrease the causes of poverty, inequality, and climate change (United Nations, n.d.-s). This makes the research relevant to investigate further.

Based on several international trends and developments, NHO has predicted that by 2050 most industries in Norway will be characterized by digitalization. NHO has further forecasted that computer-driven innovation will become one of the most essential drivers of economic growth. Today, the Norwegian industries consist of an unexploited digital infrastructure with great potential combined with a well-educated population willing to adopt new technologies (NHO, 2018). This emphasizes the need to further investigate the effects of utilizing Industry 4.0.

1.3 Goal and Research Questions

This thesis aims to investigate how utilization of Industry 4.0 technologies is related to sustainability within Norwegian companies. Sustainability will be measured based on the UN SDGs, as they are established due to the increased focus on sustainability.

The goal of the thesis is as follows:
How does Industry 4.0 as a strategy relate to the United Nations Sustainable Development Goals within Norwegian industries?

The following research questions are defined to gain insight into the main goal:

RQ1 *How do the United Nations Sustainable Development Goals relate to Industry 4.0 within Norway?*

RQ2 *Which advantages and challenges relate to the triple bottom line for Norwegian companies with Industry 4.0 technologies?*

1.4 Limitations

To limit the scope of the thesis, the Industry 4.0 technologies have been analyzed individually. As Industry 4.0 is complex, analyzing several technologies combined is too broad for the scope of this thesis. Further, analyzing the technologies individually can result in more applicable findings. This is because companies' utilization of Industry 4.0 technologies varies.

The focus of this thesis is limited to Norwegian companies. However, utilizing Industry 4.0 technologies could have the same impacts in other countries with similar characteristics as

Norway. In addition, the thesis excludes non-service companies. Nevertheless, as one of the focal points of the UN SDGs concerns education, universities are included.

1.5 Structure of Thesis

This thesis consists of six chapters (see *Figure 1*). In the following, a brief explanation of the different chapter is provided:

Chapter 1: *Introduction* presents the motivation of the research and introduces the terms Industry 4.0 and sustainability. Further, the goal and research questions for the thesis are presented with the linked justification and limitations.

Chapter 2: *Theory* provides relevant obtained literature, which is characterized as the data collection. The chapter describes Industry 4.0 technologies, sustainability and TBL, the UN SDGs, and characteristics of Norway.

Chapter 3: *Methodology* describes the selected methodological approach for this thesis. Further, the approach for data collection is justified.

Chapter 4: *Analysis* investigates the relevant UN subgoals in Norway. Further, a matrix combining the subgoals relevant in Norway and Industry 4.0 technologies is presented. The content in the matrix is analyzed towards the TBL. Lastly, the findings are presented and summarized in a synthesis.

Chapter 5: *Validation* evaluates the quality of the thesis by assessing its trustworthiness. The validation is also measured by the validity and reliability of the selected methodology approach.

Chapter 6: *Conclusion* presents the results and the findings of the thesis.

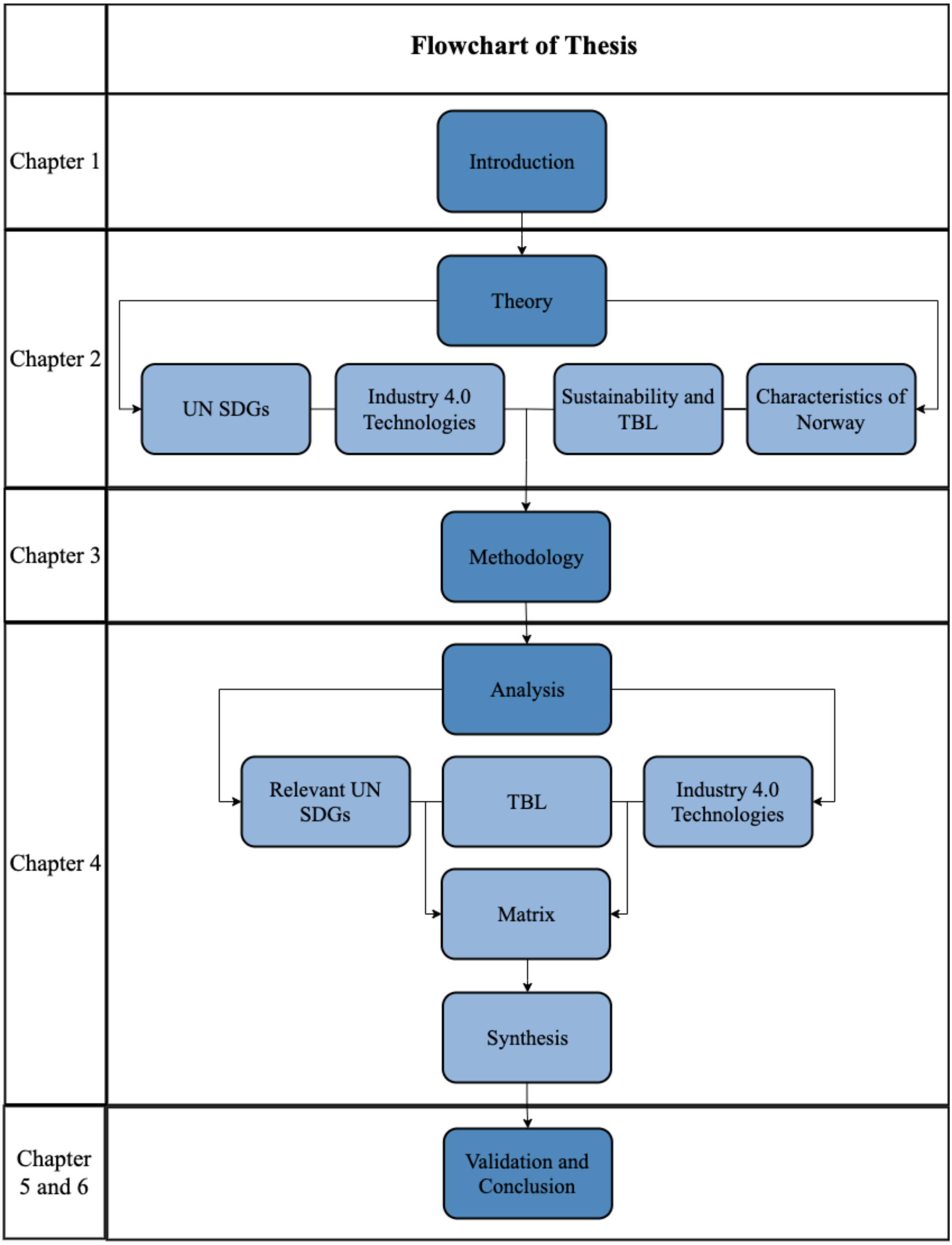

Figure 1: Structure of the thesis.

2 Theory

This chapter provides literature regarding Industry 4.0 and the technologies presented by Oztemel and Gursev (2020) and Bai et al. (2020). Further, theory relating sustainability and TBL is provided. The UN SDGs with an associated explanation are presented. Lastly, the characteristics of Norway related to industry, demographics, and culture are described.

2.1 Industry 4.0

The fourth industrial revolution, known as Industry 4.0, matured in Germany (Rao & Prasad, 2018). Industry 4.0 allows for smart manufacturing and intelligent technologies (Bai et al., 2020). It is known for interaction between employees, machines, and devices connected through the internet (Bai et al., 2020; Fatorachian & Kazemi, 2021; Rao & Prasad, 2018). Further, this enables a connection of the manufacturing systems with communication, information, and intelligence technologies (Bai et al., 2020). Utilizing Industry 4.0 technologies as a strategy for connection is found to impact the performance of the supply chain significantly. This could improve customer satisfaction and product delivery (Fatorachian & Kazemi, 2021).

Industry 4.0 technologies have the advantage of collecting data due to the connection of devices. The collected data could enable real-time decision-making and improve transparency (Fatorachian & Kazemi, 2021; Rao & Prasad, 2018). This is beneficial as it could reduce the bullwhip effect within the supply chain. The reduced bullwhip effect is found to decrease transactions and transportations. In addition, Industry 4.0 technologies can improve distribution by finding the most efficient transportation routes. Further, the data collected by utilizing Industry 4.0 could provide enhanced analysis of changes in demand patterns, thus improving production planning. The technologies also have the ability to identify bottlenecks in the production systems. This is beneficial due to ensuring sufficient product quality (Fatorachian & Kazemi, 2021).

The technologies of Industry 4.0 could perform tasks traditionally executed by humans, thus limit the humans' dangerous work tasks (Rao & Prasad, 2018). Further, the technologies increase efficiency (Bai et al., 2020; Rao & Prasad, 2018), reduce costs (Fatorachian & Kazemi, 2021), and therefore stimulates economic growth and social- and environmental sustainability (Bai et al., 2020; Mabkhot et al., 2021).

Scholars have studied various components of Industry 4.0 technologies (see Kamble et al., 2018; Rüßmann et al., 2015; Vaidya, Ambad, & Bhosle, 2018). This thesis is based on a literature review of Industry 4.0 technologies provided by Oztemel and Gursev (2020) and the research by Bai et al. (2020), which evaluates Industry 4.0 technologies from a sustainable perspective. The technologies have a great potential to stimulate sustainable manufacturing, thus increased sustainable companies (de Sousa Jabbour et al., 2018). The description of the Industry 4.0 technologies is presented in *Table 1*.

Industry 4.0 Technology	**Description**	**Source**
Additive Manufacturing (AM)	A physical production technology that creates three-dimensional objects through structured layers.	Bai et al. (2020)
Artificial Intelligence (AI)	A technology that creates intelligent machines and thus reacts and works like humans and allows for innovative solutions. AI consists of different technologies, such as virtual agents that can interact with humans.	Bai et al. (2020); Press (2017); Sima, Gheorghe, Subić, and Nancu (2020)
Augmented Reality (AR)	Enhance the experience of the real world through a display that is utilizing sound and is computer-driven.	Bai et al. (2020)
Autonomous Robots (Robotics)	Utilized to conduct past human actions within manufacturing operations.	Bai et al. (2020)
Big Data and Analytics	Utilized when the volume of the data is too large for traditional techniques to discover the essence of the data and fit with manufacturing goals.	Bai et al. (2020); Oztemel and Gursev (2020)
Blockchain	A database being administered as one system utilizing encrypted technology, where transactions are irreversible.	Bai et al. (2020); Conway and Mansa (2021); Lie and Øverby (2020)
Cloud Systems and Cloud Computing (Cloud Technology)	An online storage service correlated to web-based applications, where several actors have access to the same data simultaneously.	Oztemel and Gursev (2020)
Cobotic Systems	A robot that can interact with humans physically in a shared working area.	Bai et al. (2020)
Cyber Physical Systems (CPS)	Integrating communication between physical- and computer processes.	Oztemel and Gursev (2020)

Cybersecurity	Methods that are utilized to protect information from theft, attacks, or information being compromised.	Bai et al. (2020)
Data Mining	A process that identifies patterns from big data sets and thereby makes the information more useful.	Oztemel and Gursev (2020); Twin (2020)
Enterprise Resource Planning (ERP) and Business Intelligence	ERP utilizes all company resources efficiently. Business Intelligence is related to identifying changes and adapting to the changes.	Oztemel and Gursev (2020)
Global Positioning System (GPS)	A technology utilizing the satellites located in the Earth's orbit to calculate and exhibit accurate time, location and speed.	Bai et al. (2020)
Industrial Internet of Things (IIoT)	The connection of numerous hardware through the internet (Internet of Things) to increase the performance within manufacturing and industrial operations.	Bai et al. (2020)
Machine to Machine Communication (M2M)	Utilizing channels to communicate between different devices.	Oztemel and Gursev (2020)
Mobile Technology	The integration of wireless devices based on wireless communication technology.	Bai et al. (2020)
Nanotechnology	A technology that is utilized for controlling atoms and molecules individually in the fabrication of products of macroscale.	Bai et al. (2020)
Radio Frequency-Identification (RFID)	Automatically tracking and identifying objects through wireless communication technologies.	Bai et al. (2020)
Sensors and Actuators	A device that reacts to physical stimulation, such as heat, sound, light, or pressure, and transfers an impulse based on the given reaction.	Bai et al. (2020)
Simulation	A technology that utilizes a computer to imitate a process or system.	Bai et al. (2020)
Smart Factories	Includes decreased human interactions in a factory, where the humans' tasks are related to solving problems.	Oztemel and Gursev (2020)
Unmanned Aerial Vehicle (UAV)	An aircraft that navigates without a human pilot.	Bai et al. (2020)
Virtual Manufacturing (VM)	Utilization of computer technology to simulate critical operations within an operation.	Oztemel and Gursev (2020)

Table 1: Description of Industry 4.0 technologies retrieved from studies by Bai et al. (2020), and Oztemel and Gursev (2020).

2.2 Sustainability and Triple Bottom Line

According to theory, the most commonly utilized definition of *sustainable development* is "[...] meeting the needs of the present without compromising the ability of future generations to meet theirs." (Murray, 2019, p. 30). The concept of TBL has been developed based on this and was composed to describe that other factors than economy are essential for adding value to companies (Hammer & Pivo, 2017). The pillars of TBL are social, environmental, and economical, but are also referred to as people, planet, and profit (Murray, 2019). Further, TBL finds that a company's performance needs to be measured on other aspects than those that are directly affected by the company's behavior (Wanat & Stefańska, 2015). Therefore, sustainability has been utilized to measure the firm's performance (Jeble et al., 2018). TBL contributes to make companies aware that their operations could cause harmful effects on the social, environmental, and economic aspects (Wanat & Stefańska, 2015).

The pillars refer to how socially, environmentally, and profitably responsible the operations of a company are. The economic pillar is concerning economic growth, profit, and reducing costs. However, considering sustainable development, the profit aspect needs to include the benefits that profit provides to the environment. This means that the economic pillar is not limited to the internal profit of a company, as the profit needs to be in accordance with both the social and environmental aspects. Further, it presents to the community that a company operates for other reasons than just profit (Wanat & Stefańska, 2015). Social sustainability refers to the effect a company and the supply chain have on the community (e.g., living standards, level of education, and equality). It further relates to both the internal and external social aspects of a company. This means that both employees and the community should be considered when conducting activities. Lastly, the environmental aspect is related to companies' utilization of resources in their operation (e.g., energy and water) and the consequences of the operation (e.g., waste and emissions). Companies should preserve the natural environment, or at least focus on limiting the damage to the environment (Wanat & Stefańska, 2015).

The increased focus on sustainable development culminated in the UN SDGs (Bergman, Bergman, Fernandes, Grossrieder, & Schneider, 2018). They were established in 2015 and are created to end poverty, fight inequality and fight climate change by 2030. The SDGs consist of 17 goals and 169 subgoals (United Nations, n.d.-s). According to the Norwegian Government, one is dependent on joint effort from all companies to achieve the SDGs (Regjeringen, 2020a). An explanation of the UN SDGs is presented in *Table 2*.

SDGs	Explanation	Source
SDG1: No Poverty	Eradicating all poverty worldwide. Decreasing poverty worldwide requires more sustainable economic growth and a more equitable allocation of resources among people. Statistics for 2019 show that the number of people living in extreme poverty decreased to 6.6 percent of the world's workers.	United Nations (n.d.-e)
SDG2: Zero Hunger	Ending hunger, accomplishing food security, and for everybody to have access to nutrition and sustainable food. The numbers of starving people have declined for decades; however, the numbers are now increasing. According to the UN, the resources must be allocated, and more sustainable and local food should be produced.	United Nations (n.d.-d)
SDG3: Good Health and Well-Being	To ensure good health for everybody of all ages is crucial for people to reach their full potential to contribute to development in the community. According to the UN, the environment, economy, and social conditions impact people's health.	United Nations (n.d.-h)
SDG4: Quality Education	Ensure fair and good education and facilitate lifelong learning for all. Education of good quality is fundamental for people's health and equality in all societies. Further, education is seen as essential for development and contributes to obtaining a sustainable world.	United Nations (n.d.-i)
SDG5: Gender Equality	Achieving equality and strengthening the position of girls and women in society. Today, gender equality is higher than it previously was; however, social norms and discriminatory laws contribute to women having fewer opportunities and insufficient finance to decide over their own lives.	United Nations (n.d.-a)
SDG6: Clear Water and Sanitation	To ensure clear access to water and sanitation to all. Climate change will make it more challenging for everybody to have access in the future. This goal is further about protecting and restoring ecosystems related to water, such as rivers and lakes.	United Nations (n.d.-g)
SDG7: Affordable and Clean Energy	Make sure that all have access to energy that is modern, reliable, and sustainable. In 2018, 789 million people did not have access to electricity. It is increasingly required effort in renewable energy to fulfill this goal. Statistics find that in 2017, only 17 percent of the energy consumption was renewable energy. This goal is crucial as it is related to SDG3 because affordable energy is essential regarding healthcare. Because of this, the energy also needs to be at an affordable price.	United Nations (n.d.-f)

SDG8: Decent Work and Economic Growth	Full employment and decent work for all. Focus on innovation and improving technology to increase economic productivity, focusing on sectors characterized by high workload. The world is dependent on creating economic growth and new jobs to eradicate poverty and fight inequality. Therefore, it is suggested that young inhabitants and women are included in the workforce more significantly.	United Nations (n.d.-n)
SDG9: Industry, Innovation and Infrastructure	Investing in building a solid infrastructure that contributes to economic development and human well-being. Further, promote sustainable industrialization and encourage innovation.	United Nations (n.d.-b)
SDG10: Reduce Inequality	Reducing inequalities between and within countries. Further, to include everybody related to the economic, political, and social aspects, independent of sex, age, religion, disability, and ethnicity.	United Nations (n.d.-p)
SDG11: Sustainable Cities and Communities	To make the cities and communities safer and more sustainable. Rapid urbanization has caused increased slum residents and air pollution. In 2018, the number of people who lived in slum areas increased to 28 percent of the urban population. 4.2 million people had premature deaths in 2016 due to air pollution.	United Nations (n.d.-l)
SDG12: Responsible Consumption and Production	Ensuring that the consumption and production are sustainable. In 2016, food waste was 13.8 percent throughout the supply chain. The goal further includes increasing resource efficiency to reduce consumption. Europe and Northern America have 40 percent higher resource consumption per inhabitant than the global average.	United Nations (n.d.-j)
SDG13: Climate Action	To fight the climate changes and the impacts that occur as a consequence of it. The amount of greenhouse gasses is continuously increasing. Countries worldwide are establishing greenhouse emission reduction plans; however, the national plans are not comprehensive enough. The UN suggests that Governments and businesses should utilize their knowledge to become more sustainable.	United Nations (n.d.-r)
SDG14: Life Below Water	To preserve and utilize the sea and ocean resources in a way that promotes sustainable development. 23 percent of the carbon dioxide is absorbed into the sea. This positively affects life on land but negatively affects the sea as the pH decreases in the ocean. The reduction of sustainable fishery resources has a declining trend, where 65.8 percent of fish stocks were seen as sustainable in 2017, compared to 90 percent in 1974. Life on earth is dependent on the sea. Despite this, people continuously have a lifestyle that destroys it. Sustainable utilization of the sea's resources requires stopping littering and overfishing, and protecting animals and coral reefs.	United Nations (n.d.-c)

SDG15: Life on Land	To preserve, restore and encourage sustainable utilization of ecosystems, woods, fight desertification, and stop the extinction of biological diversity. On a global level, the extinction of biological diversity has increased by approximately 10 percent in the last 3 years. This is mainly due to deforestation, unsustainable agriculture, and invasion of alien species.	United Nations (n.d.-o)
SDG16: Peace, Justice and Strong Institutions	Inclusive societies and decreasing violence to ensure increased sustainability. In 2019, 79.5 million refugees were registered, which is the highest number recorded. The number of countries that have successfully implemented principles for human rights was 40 percent of the countries in 2019.	United Nations (n.d.-m)
SDG17: Partnerships for the Goals	Reestablishing global partnerships to increase sustainability. The goal further includes the tools needed for sustainable development. However, the lack of financial resources, trade tensions, and theological complications makes it more challenging.	United Nations (n.d.-q)

Table 2: Explanation of SDGs developed by the UN (see the corresponding sources in table).

2.3 Characteristics of Norway

This chapter describes the characteristics of Norway related to the industry, demographics, and culture.

2.3.1 Norwegian Industry

The Norwegian labor market is characterized by high employment among both men and women, and in January 2020, approximately 70.2 percent of the Norwegian population was a part of the workforce. The unemployment rate in Norway is low compared to the majority of the European countries, and most of the employed population is also characterized as highly educated (Bergsli, 2018). According to statistics, 78 percent of the Norwegian workforce were employed within commerce and public services in 2019. Further, 20 percent were employed within manufacturing and industry, and 2 percent within the agriculture and fishing industry (Statistics Norway, n.d.).

The industry with the highest economic value creation in Norway is considered the oil and gas sector. The calculation is based on the value of a company's production minus the operation cost associated with the production within the private sector. Further, the second, third, and fourth industries with high value creation in Norway are respectively commerce, industry, and construction (Statistics Norway, n.d.). *Figure 2* illustrates the four industries in Norway with the highest economic value creation with their respective employees.

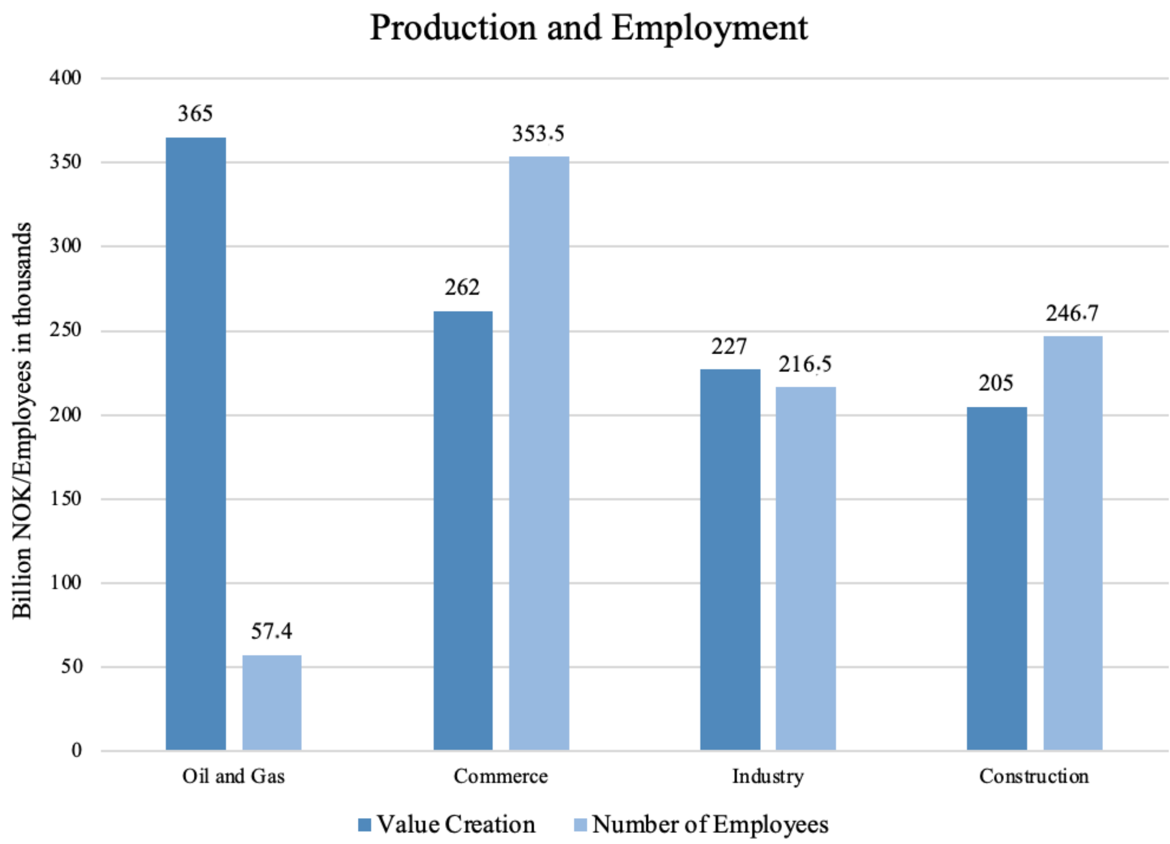

Figure 2: Illustration of Norwegian industries' production and employment (Modification of Statistics Norway (n.d.).

2.3.2 Demographics of Norway

Statistics show that the population density in Norway is 18 per square kilometer[1] (Statistics Norway, 2020a). Despite that the population density on a national basis is low, there are significant differences when comparing the different municipalities in Norway. In 2020, the population density varied between 1 per square kilometer to 1628 per square kilometer[2] (Statistics Norway, 2020a).

In 2020, 82.29 percent of the Norwegian population lived in urban areas (Statistics Norway, 2020d). It is expected that the biggest cities will experience enormous population growth when

[1] Variables: innbyggere pr km2 landareal; 2020; hele landet

[2] Variables: innbyggere pr km2 landareal; 2020; kommune 2020- ; velg alle 356

the Norwegian population is estimated to increase by 11 percent by 2050. The forecast also indicates that the districts will experience rural flight and decreased population, especially among young inhabitants (Leknes & Løkken, 2020). *Figure 3* illustrates the expected growth within the Norwegian municipalities from 2020 to 2050. The rural flight will increase the elderly population by 8 percentage points, compared to today's population (Leknes & Løkken, 2020). In addition, statistics suggest that the Norwegian population will, within ten years, experience a demographic shift, as there will be more elderly inhabitants than young. By 2060 it is forecasted that one in five of the Norwegian population is aged 70 or over (Statistics Norway, 2020b). Based on the clear aging of the population, the number of retirements will increase, which will reduce the Norwegian workforce (NHO, n.d.).

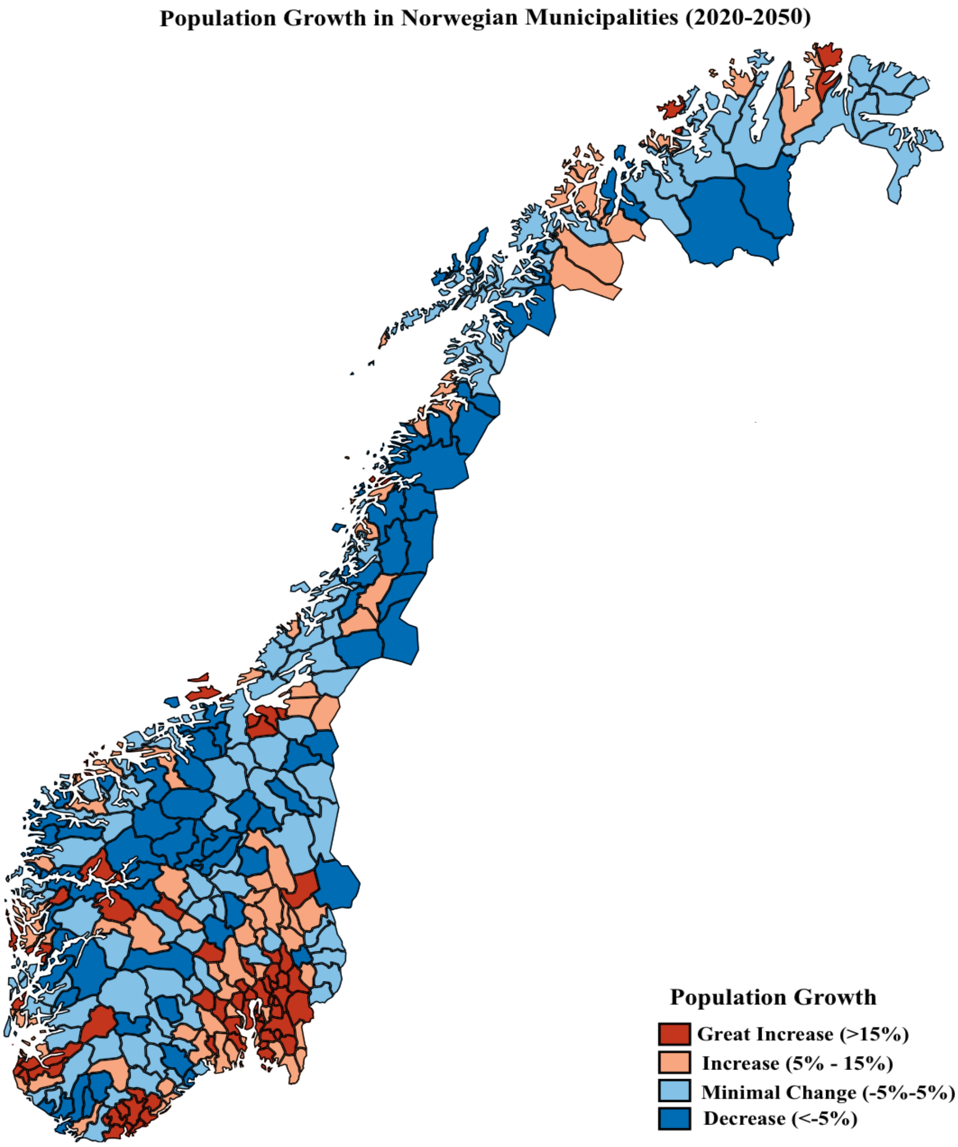

Figure 3: Population growth in Norwegian Municipalities from 2020-2050. (Modification of Leknes & Løkken, 2020).

2.3.3 Norwegian Culture

According to Hofstede, the values within a company are influenced by the country's culture (Hofstede Insights, n.d.-b). Hofstede's model of national culture provides an overview of preferences and drivers related to a country's culture (Hofstede Insights, n.d.-a). The model consists of six dimensions: power distance, individualism, masculinity, uncertainty avoidance, long-term termination, and indulgence (Hofstede Insights, n.d.-b). By studying the preferences and habits of the Norwegian population in combination with the six steps, one can acquire knowledge related to the characteristics of the drivers of Norwegian culture. According to Hofstede, the power distance within Norwegian culture is low, as equal rights, independence, and decentralization are in focus (Hofstede Insights, n.d.-a). Further, the culture is characterized as an individualistic society as personal opinions are appreciated and often expressed. There is also a clear distinction between private life and work. Nevertheless, the Norwegian culture is characterized by high job mobility, and the inhabitants are busy with their individual careers. Moreover, Hofstede's model of national culture finds Norwegian culture as very feminine, as the quality of life, flexibility, and free time are seen as essential. In addition, the society in Norway is characterized as normative, and the population, therefore, prefers time-consuming traditions before radical changes. It is also essential to achieve goals and results quickly (Hofstede Insights, n.d.-a).

3. Methodology

The collected data and theory obtained is essential for the analysis. This chapter describes the selected methodological approach for this thesis. The research method and the approach for data collection will be presented.

3.1 Research Method

A qualitative method is conducted to acquire knowledge of how Industry 4.0 as a strategy is related to the UN SDGs within Norwegian industries. As there are limited studies related to the topic *Industry 4.0 and Sustainability*, qualitative research will be beneficial as it allows for acquiring extensive knowledge (Andersen, 2019). The research will also use an exploratory design to reach a conclusion based on relevant literature. As there do not exist studies related to the chosen topic and Norwegian industries, this research design will be beneficial to obtain knowledge of the theme. The authors had an observational role when deriving information from relevant scholars. This method allows the authors to be objective when obtaining information.

In other words, the authors have found relevant literature and then observed the scholars' findings. Further, the information is compared to other literature with correlating findings and then analyzed. Finally, the analysis resulted in a conclusion.

3.2 Data Collection

A literature study has been conducted, as the authors have acquired knowledge related to the topic of this thesis based on a comprehensive literature search. The literature obtained is further reviewed and analyzed. Additionally, the literature is assembled and evaluated for the authors to provide an analysis and conclusion. To gain insights about Industry 4.0 and sustainability, both primary and secondary sources have been utilized. There exists research related to Industry 4.0 and sustainability separately; thus, there is substantial availability of primary sources. As there is limited research on the two terms combined, secondary sources have been essential for the data collection of this thesis. Therefore, the primary and secondary sources have been combined to form a holistic impression of how Industry 4.0 as a strategy is related to the UN SDGs within Norwegian industries.

The data obtained for this thesis is related to the UN SDGs and Industry 4.0 technologies. A good measure of sustainability is through the SDGs that consist of 169 subgoals applicable to the entire world. Based on the scope of this thesis, the SDGs are limited to 22 subgoals, based on the Norwegian Government's statements (Regjeringen, n.d.-a), and the Industry 4.0 technologies. Further, there exist numerous Industry 4.0 technologies referred to by scholars. This thesis is based on Industry 4.0 technologies collected from Oztemel and Gursev (2020) and Bai et al. (2020). However, studies by other scholars have been utilized to advance the information on relevant technologies. To connect the information to the Norwegian industry, web pages, reports, and statistics have been utilized. Moreover, to illustrate the evaluated correlation between the relevant UN SDGs in Norway and Industry 4.0 technologies, a matrix (see *Table 4)* is developed. The matrix is utilized as a framework for the analysis.

4. Analysis

This chapter provides an analysis of the UN SDGs relevant within Norway and Industry 4.0 technologies. To analyze the SDGs in context with Norway, chapter 4.1 analyzes the 17 main goals provided by the UN. Further, the chapter presents the UN subgoals that are relevant within Norway. The subgoals are established to target the main goals, as the subgoals are more explicitly described. Further, chapter 4.3 provides a matrix combining relevant UN subgoals within Norway with Industry 4.0 technologies. Lastly, chapter 4.4 provides a synthesis that summarizes the findings of the analysis.

4.1 Linking the UN SDGs, Industry 4.0 and Norway

In the following, an analysis relating the UN SDGs within Norway and Industry 4.0 is provided.

4.1.1 SDG1: No Poverty

The majority of the Norwegian population has good living conditions and a high standard of living. This is due to high employment, high economic growth, high tax rates, and good welfare systems on a national basis (Regjeringen, 2018a). The poverty rate in Norway is low and thus a small challenge in contrast to countries worldwide. Nevertheless, statistics provided by NAV show that 11.2 percent of the Norwegian population lived in low-income households in 2018 (Sandvik, 2020). According to the Norwegian Government, the main reason for low-income households in Norway is low employment (Regjeringen, 2018a). Studies show that utilizing Industry 4.0 would create jobs that have not existed before (Grenčíková, Kordoš, & Berkovič, 2020). As increased employment is fundamental for Norway to maintain the welfare state and social security (Sandvik, 2020), one can argue that automated processes within Norwegian companies would contribute to maintaining the social benefits. According to Lund and Steen (2020), utilization of Industry 4.0 created 12 840 jobs in Europe between 2015 and 2018 due to 253 businesses reshoring operations. Further, Meland (2019) found that 15 Norwegian companies were reshoring their operations between 2014 and 2019. This indicates that utilization of Industry 4.0 within Norwegian companies would improve the labor market opportunities. However, a Norwegian case study found that automated production reshoring to Norway decreased the number of employees from 15 to 3 (Lund & Steen, 2020).

4.1.2 SDG2: End Hunger

There is high food security in Norway due to the high food production and the great access to imported goods (Regjeringen, 2018j). According to a report provided by the Ministry of Agriculture and Food, the Ministry of Trade and Industry, and the Ministry of Health and Care Services, the main focus in Norway is to improve the population’s diet by 2030 (Bollestad, Ingebrigtsen, & Høye, 2021). Moreover, statistics show that 8.9 percent of the world’s population was registered as hungry in 2019 (FN-sambandet, 2021; United Nations, n.d.-k). As the focal point in Norway is associated with nutrition and diets, the challenge related to ending hunger is narrow compared to countries worldwide. However, this goal also relates to food production and implementing new sustainable methods for increased production and productivity. Norwegian farmers have rapidly adapted to Industry 4.0 technologies and are significantly automated compared to other countries. Nevertheless, there is a need for increased entrepreneurship and modernization of operations within Norwegian agriculture to ensure more efficient production. Technology could contribute to exploiting all resources available at the farm (Regjeringen, n.d.-b). Moreover, Norwegian agriculture was in 2019 responsible for 8.7 percent of the total Norwegian greenhouse gas emissions (Regjeringen, 2020c). Utilizing Industry 4.0 has the potential to decrease this percentage by using the farmers' own data for more efficient and sustainable utilization of resources (Ruan et al., 2019).

4.1.3 SDG3: Good Health and Well-Being

The Norwegian population's health is generally good compared to countries worldwide. According to the Norwegian Government, mental and physical health are factors that strongly correlate with a person's well-being (Regjeringen, 2018k). Research finds that Industry 4.0 technologies will eliminate traditional physical activities performed by humans and replace them with automated systems (Bonekamp & Sure, 2015). However, significant organizational changes, such as utilizing Industry 4.0, could lead to employees experiencing work-related stress. Stress over a more extended period could cause physical and mental health issues and could therefore affect employees' well-being (Arbeidstilsynet, n.d.-a). Moreover, Bonekamp and Sure (2015) find that utilizing Industry 4.0 will increase the work tasks related to planning, control, and information technology (IT), indicating decreased physical work. Statistics show that 23 percent of Norwegians over the age of 18 are overweight or obese (Aamo, Lind, Myklebust, Stormo, & Skogli, 2019), and could therefore become an increasing challenge among the Norwegian population. In addition, the number of employees experiencing back pain could increase due to long office hours (Bontrup et al., 2019). However, as the work routines are changed, the employees could experience decreased health risks related to heavy physical work, often associated with pain in the back, hips, and knees (Arbeidstilsynet, n.d.-b).

4.1.4 SDG4: Quality Education

In Norway, the education level is high compared to the majority of other countries. The education system is well established, and there is a substantial focus on quality (OECD, 2019). Dubey et al. (2019) state that knowledge gets outdated due to new technologies emerging. Utilizing Industry 4.0 technologies requires increased collaboration between humans and intelligent machines (Ansari, Erol, & Sihn, 2018). Bonekamp and Sure (2015) state that constant training, learning, and education are fundamental for employees to be qualified to control Industry 4.0 technologies. Further, it is expected that the technologies of Industry 4.0 will affect the education system, as former industrial revolutions have had an impact on the output of education (Benešová & Tupa, 2017). Therefore, the educational programs need to adapt to the specialized knowledge required to handle the technologies. As the Norwegian education system focuses on high quality, it is arguable that the education will adapt to the companies' new knowledge requirements. This will contribute to people having relevant knowledge, thus be better suited to handle the technologies. Relevant education will also increase the possibility of getting employed (With, 2017).

4.1.5 SDG5: Gender Equality

Norway is one of the most equated countries globally; however, men still dominate leadership (Grande, 2019). In 2018, 36.3 percent of the leaders in Norway were women (Statistics Norway, 2019). Research finds that education and career in Norway are characterized by traditional gender choices, which further leads to a gender-segregated labor market, and differences in development and career opportunities (Grande, 2019). Moreover, 23 percent of the Norwegian students taking a bachelor's or master's degree in IT were women, which increased 4 percentage points from 2013 to 2018 (Statistics Norway, 2020c). In collaboration with NITO and the Norwegian Universities, NHO has established an annual conference called "Jenter og Teknologi" which is a project aiming to stimulate girls to choose education related to technology (NHO, 2018). In 2019, the Norwegian Government increased the financial support to the project (Grande, 2019), indicating an existing challenge related to technical skills and the gender-segregated labor market in Norway.

Scholars have found that Industry 4.0 will increase the need for technical skills. Pinzone et al. (2017) established that jobs, such as supply chain management, will increasingly focus on data analysis, and jobs related to data science and IT will increase. Further, Machado, Despeisse, Winroth and Silva (2019) substantiate the need for IT competencies and that Industry 4.0 will lead to job opportunities in that work area. This indicates that Industry 4.0 could impact the labor market in terms of gender equality, as increasingly more jobs related to technology will emerge.

4.1.6 SDG6: Clear Water and Sanitation

The supply of water is superlative in Norway, and the Norwegian population is either connected to small or bigger water supply systems that distribute clear and drinkable water. Despite this, the water system infrastructure in Norway is antiquated and requires improvements to continuously deliver clear water (Regjeringen, 2018l). According to the UN, approximately 29 percent of the population worldwide did not have access to safe drinkable water in 2017 (United Nations, n.d.-g). This emphasizes that the threat related to the Norwegian water infrastructure is relatively small compared to other countries, as maintenance is the main challenge. Retrieved data shows that 30 percent of the water in the Norwegian water systems leaked out, which resulted in an extra cost of NOK350 million in 2018 (Mattilsynet, 2019). However, Industry 4.0 could be essential for this challenge as it provides new opportunities related to preventative maintenance, damage limitation, and improvement of systems (Pipelife, n.d.).

4.1.7 SDG7: Affordable and Clean Energy

According to the Norwegian Government, SDG7 is either accomplished or is expected to be reached within 2030. 69 percent of the energy consumption in Norway is renewable, which is high compared to the worldwide rate (Regjeringen, 2018m). However, research finds that Norwegian industries waste energy valuable at NOK1.5 billion (Omland, 2019). According to McKinsey & Company (2015), Industry 4.0 in production industries could result in 10 to 20 percent energy savings, thus motivate to accomplish the goal before 2030.

4.1.8 SDG8: Decent Work and Economic Growth

In recent decades Norway has been characterized by high economic growth and low unemployment compared to other developed countries. One of the main reasons for this is the great success of the petroleum industry (Regjeringen, 2018n). Due to a switch in market expectations, the petroleum industry is rapidly changing. Increasingly more companies within the oil and gas sector are focusing on renewable energy (Fiskaaen, n.d.). However, according to the Government, Norway is now dependent on other sectors to maintain and develop economic growth (Regjeringen, 2018n).

A study provided by OECD (2015), states that utilization of Industry 4.0 could result in 5 to 10 percent increased productivity. Further, technological innovations have earlier resulted in economic growth. This is due to increased resource efficiency, which further leads to decreased production costs (NHO, 2018). General access to education and a well-functioning labor market are factors that will provide access to new technologies and knowledge (Regjeringen, 2018n).

4.1.9 SDG9: Industry, Innovation and Infrastructure

Infrastructure for transport, access to energy and water, and efficient conveyance of information are fundamental for a well-functioning community. The infrastructure in Norway is well-developed; however, continuous development would promote innovation and development of new technologies (Regjeringen, 2018o). Research states that the utilization of Industry 4.0 technologies will improve the flow of information (Beier, Niehoff, & Xue, 2018), indicating that the infrastructure will be improved.

4.1.10 SDG10: Reduce Inequalities

The income inequality in Norway is small compared to the majority of the countries worldwide. Both the high employment rate and the welfare system contribute to decreasing the differences among the Norwegian population. Nevertheless, to reduce the existing inequality in Norway, it is essential to maintain the high employment rate and the high education level (Regjeringen, 2018b). Research states that the wealthy population will have a lower risk for poverty, the higher level of digitization a country conduct (Kwilinski, Vyshnevskyi, & Dzwigol, 2020). According to NHO (2018), utilization of Industry 4.0 technologies will reduce jobs with low competence requirements. This could result in the wealthy population getting wealthier. In addition, it emphasizes the importance of increasing and specializing the knowledge within the Norwegian communities.

4.1.11 SDG11: Sustainable Cities and Communities

Most citizens live well in Norwegian cities, with access to clear drinking water and a reliable energy supply. However, it is expected that the largest cities will grow and require robust infrastructure development (Regjeringen, 2018c). There is a low risk of death in Norway due to air pollution compared to other countries in Europe. Additionally, in recent decades the air quality within Norwegian cities has improved gradually (Regjeringen, 2018c, 2020b). However, research shows that Industry 4.0 contributes to decreased climate gas emissions (Kopp & Lange, 2019), which could improve living conditions.

4.1.12 SDG12: Responsible Consumption and Production

There are several challenges related to consumption and production in Norway. These challenges include but are not limited to gas emissions and managing the resources efficiently

(Regjeringen, 2018d). In Norway, there are established laws and measures to ensure good management of the natural resources on land and at sea. The measures would promote more efficient resource utilization (Regjeringen, 2018d). Simeone, Caggiano, Boun and Deng (2019) find that Industry 4.0 technologies can contribute to resources being more efficiently utilized. Further, Kamble et al. (2018) state that Industry 4.0 could lead to decreased overproduction, indicating reduced waste.

4.1.13 SDG13: Climate Action

The Paris Agreement is the basis of accomplishing SDG13. Norway has committed to reducing climate gas emissions by at least 40 percent within 2030. Emission fees are one of the most important means in Norway for reducing climate gas emissions. Further, the Norwegian Government wants to increase the fee by 5 percent annually until 2025 (Regjeringen, 2018e). Research found that Industry 4.0 technologies could display smarter transportation routes (Levina, Dubgorn, & Iliashenko, 2017), thus indicating decreased CO_2 emissions. Further, Liboni, Cezarino, Jabbour, Oliveira and Stefanelli (2019) state that utilizing Industry 4.0 will make some companies reshoring their operations. This indicates a shorter transportation route, which could cause less CO_2 emissions.

4.1.14 SDG14: Life Below Water

Norway is one of the leading ocean nations worldwide (Mæland, Sandberg, & Søviknes, 2017), and numerous Norwegian companies are dependent on the sea (Regjeringen, 2018f). For the companies to be profitable in the future, it is essential to manage and utilize marine resources in a sustainable way and increase productivity (Mæland et al., 2017). According to the Norwegian Government, there are established regulations and systems to ensure good management of the sea areas located on the Norwegian coast. In addition, Norway has invested in research and monitoring of the sea (Regjeringen, 2018f), as there is a need for increased knowledge and development of new technologies within this area (Mæland et al., 2017).

4.1.15 SDG15: Life on Land

The Norwegian ecosystems are in a relatively good condition due to the Government's actions to take care of nature. However, there exist challenges related to maintaining nature's state. Meld. St. 14 (2015–2016), white paper on the Norwegian action plan for biodiversity, is one of the most essential tools to accomplish this goal (Regjeringen, 2018g). The white paper states that climate changes, foreign organisms, overharvesting, and pollution are significant factors impacting nature. Further, increased knowledge within companies is the main element of improving the Norwegian ecosystems. The white paper found that surveillance of areas needs to be compared to similar areas (Regjeringen, 2015). Industry 4.0 technologies could connect these systems (Machado, Winroth, et al., 2019) and thus be easier to monitor.

4.1.16 SDG16: Peace, Justice and Strong Institutions

The Norwegian constitution is fundamental for ensuring freedom of expression, democracy, human rights, and a well-functioning judiciary (Regjeringen, 2018h). Money laundering is one of the threats in Norway. Statistics show that the most significant risk of money laundering in Norway is within businesses, using new payment services, or utilizing cryptocurrency (Økokrim, 2020). Industry 4.0 technologies could increase transparency (Beier et al., 2018), indicating decreased fraud.

4.1.17 SDG17: Partnerships for the Goals

Norway supports the international work towards liberalization of the trade of goods and services. Free international trade is fundamental for countries to utilize their resources and competitive advantages, which further contributes to providing new technologies (Regjeringen, 2018i). Utilizing Industry 4.0 technologies could cause increased collaboration and sharing of knowledge (Shahbaz et al., 2010). Based on this, Industry 4.0 could improve international collaborations, thus working towards reaching the SDGs. One could further argue that Industry 4.0 could improve the collaborations between Norwegian companies, thus aiming to achieve the SDGs.

4.1.18 UN Subgoals

To further investigate how the utilization of Industry 4.0 technologies impacts Norwegian companies' sustainability, the UN subgoals will be analyzed. The reason for this is that the subgoals are more explicitly described, thus increased relevance with the utilization of Industry 4.0 technologies. The number of subgoals that will be analyzed is limited based on their relevance in Norwegian companies utilizing Industry 4.0 technologies. *Table 3* presents the relevant UN subgoals.

UN SDG	Subgoal	Explanation	Source
SDG1: No Poverty	SDG1.2	By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.	United Nations (n.d.-e)
SDG2: End Hunger	SDG2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding, and other disasters and that progressively improve land and soil quality.	United Nations (n.d.-d)
SDG3: Good Health and Well-Being	SDG3.d	Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.	United Nations (n.d.-h)
SDG4: Quality Education	SDG4.4	By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.	United Nations (n.d.-i)
SDG5: Gender Equality	SDG5.5	Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.	United Nations (n.d.-a)
SDG6: Clear Water and Sanitation	SDG6.b	Support and strengthen the participation of local communities in improving water and sanitation management.	United Nations (n.d.-g)
SDG7: Affordable and Clean Energy	SDG7.2	By 2030, increase substantially the share of renewable energy in the global energy mix.	United Nations (n.d.-f)
	SDG7.3	By 2030, double the global rate of improvement in energy efficiency.	

SDG8: Decent Work and Economic Growth	SDG8.1	Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries.	United Nations (n.d.-n)
	SDG8.2	Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor-intensive sectors.	
SDG9: Industry, Innovation and Infrastructure	SDG9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.	United Nations (n.d.-b)
SDG10: Reduced Inequalities	SDG10.1	By 2030, progressively achieve and sustain income growth of the bottom 40 percent of the population at a rate higher than the national average.	United Nations (n.d.-p)
SDG11: Sustainable Cities and Communities	SDG11.6	By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.	United Nations (n.d.-l)
SDG12: Responsible Consumption and Production	SDG12.2	By 2030, achieve the sustainable management and efficient use of natural resources.	United Nations (n.d.-j)
	SDG12.5	By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.	
SDG13: Climate Action	SDG13.3	Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.	United Nations (n.d.-r)

SDG14: Life Below Water	SDG14.1	By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.	United Nations (n.d.-c)
	SDG14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.	
SDG15: Life on Land	SDG15.6	Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.	United Nations (n.d.-o)
SDG16: Peace, Justice and Strong Institutions	SDG16.5	Substantially reduce corruption and bribery in all their forms.	United Nations (n.d.-m)
	SDG16.6	Develop effective, accountable and transparent institutions at all levels.	
SDG17: Partnerships for the Goals	SDG17.16	Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology, and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries.	United Nations (n.d.-q)

Table 3: Presentation of relevant UN subgoals. The explanation of the subgoals are direct quotes of the subgoals established by the United Nations (see the corresponding sources in table).

4.3 Matrix

The correlation between UN subgoals and Industry 4.0 technologies is presented in a matrix (see *Table 4*). The codes in the matrix illustrate the relationship between a specific subgoal and Industry 4.0 technology.

	SDG1.2	SDG2.4	SDG3.d	SDG4.4	SDG5.5	SDG6.b	SDG7.2	SDG7.3	SDG8.1	SDG8.2	SDG9.4	SDG10.1	SDG11.6	SDG12.2	SDG12.5	SDG13.3	SDG14.1	SDG14.2	SDG15.6	SDG16.5	SDG16.6	SDG17.16
Additive Manufacturing (AM)	A1		A3	A4						A10	A11	A12			A15						A21	
Artificial Intelligence (AI)			B3	B4						B10					B15					B20		
Augmented Reality (AR)				C4																		
Autonomous Robots (Robotics)	D1	D2							D9			D12										
Big Data and Analytics		E2		E4						E10					E15							
Blockchain								F8												F20	F21	F22
Cloud Systems and Cloud Computing (Cloud Technology)				G4				G8		G10	G11				G15					G20	G21	
Cobotic Systems	H1											H12			H15							
Cyber Physical Systems (CPS)			I3	I3																		
Cybersecurity																				J20	J21	
Data Mining																						K22
Enterprise Resource Planning (ERP) and Business Intelligence															L15							

Table 4: Correlation between the UN subgoals and Industry 4.0 technologies.

	SDG1.2	SDG2.4	SDG3.d	SDG4.4	SDG5.5	SDG6.b	SDG7.2	SDG7.3	SDG8.1	SDG8.2	SDG9.4	SDG10.1	SDG11.6	SDG12.2	SDG12.5	SDG13.3	SDG14.1	SDG14.2	SDG15.6	SDG16.5	SDG16.6	SDG17.16
Global Positioning System (GPS)		M2																				
Industrial Internet of Things (IIoT)	N1	N2	N3	N4		N6	N7		N9			N12		N14		N16					N21	N22
Machine to Machine Communication (M2M)																						
Mobile Technology										P10												
Nanotechnology		Q2						Q8			Q11											
Radio Frequency Identification (RFID)															R15						R21	
Sensors and Actuators																						
Simulation								T8							T15							
Smart Factories	U1		U3	U4				U8		U10												
Unmanned Aerial Vehicle (UAV)		V2								V10	V11					V16						
Virtual Manufacturing (VM)															W15							

Table 4 (continuation): Correlation between the UN subgoals and Industry 4.0 technologies.

The technologies presented in the matrix are retrieved from research provided by Oztemel and Gursev (2020) and Bai et al. (2020) (see *Table 1*). Sensors and actuators and Machine to Machine Communication (M2M) are not analyzed, as the technologies facilitate innovative applications (Barreto, Amaral, & Pereira, 2017) and are utilized in existing Industry 4.0 technologies. Further, some technologies, such as Global Positioning System (GPS), Enterprise Resource Planning (ERP) and business intelligence, and data mining, are less analyzed, as there exists limited relevant literature. Nonetheless, as the technologies derived from Oztemel and Gursev (2020) and Bai et al. (2020) are the framework of this thesis, all technologies are included in the matrix, even though some could be found as less relevant.

The relevant UN subgoals are presented in *Table 3*. Some subgoals are not found to be directly correlated to either of the Industry 4.0 technologies and have, as a consequence, not been coded. According to chapter 4.1, the majority of IT students are men (Statistics Norway, 2020c). As Industry 4.0 increases the need for technical skills (Machado, Despeisse, et al., 2019; Pinzone et al., 2017), gender equality within Norway could be affected. As there is limited literature on this aspect, SDG5.5 is not analyzed. In addition, SDG11.6 is not analyzed as air quality is not directly correlated with Industry 4.0 technology. Further, SDG14.1 and SDG14.2 related to preventing marine pollution and the protection of marine ecosystems are not analyzed. This also applies to SDG15.6, considering life on land. The reason for this is that the SDGs could be indirectly affected by other SDGs.

4.3.1 Analysis of Matrix

An analysis based on the matrix (*Table 4*) is provided. The following subheadings represent the codes from the matrix, with associated impact on the TBL.

A1, A12, D1, D12, H1 & H12 – People and Profit (AM; Robotics; Cobotic Systems; SDG1.2; and SDG10.1)

Additive Manufacturing (AM), Autonomous Robots (robotics), and cobotic systems are technologies that consist of a high degree of automation. Therefore, investing in these technologies will affect the demand for labor (Bai et al., 2020; Mabkhot et al., 2021; Naghshineh, Ribeiro, Jacinto, & Carvalho, 2021). The machines require high-skilled employees who have the relevant knowledge to handle manufacturing operations and execute maintenance (Bonekamp & Sure, 2015). This will result in jobs being created, and the demand for high-skilled labor will increase. Moreover, cobotic systems will perform standardized tasks

(Moulières-Seban, Bitonneau, Salotti, Thibault, & Claverie, 2017). Therefore, one can assume that employees who traditionally perform the standardized tasks are low-skilled and could lose their jobs due to their job being automated. Low-skilled laborers are highly represented within low-income households in Norway (With, 2019). Based on this, the number of people living in low-income households in Norway can be affected. This is associated with SDG1.2 and SDG10.1, considering income and inequalities.

A3, B3 & U3 – People (AM; AI; Smart Factories; and SDG3.d)

Artificial Intelligence (AI) can perform tasks traditionally executed by humans (Dwivedi et al., 2021), and smart factories could operate with limited human interaction (Benotsmane, Kovács, & Dudás, 2019). Due to the technologies' ability to replace human tasks at work, it is arguable that the employees could start feeling anxious when they realize that AI could take over their work tasks. This could negatively impact the health and well-being of employees related to SDG3.d. Moreover, as the AM machines are portable and available anywhere (Naghshineh et al., 2021), it permits the employees to have a more flexible work schedule. The study provided by Hofstede also emphasizes this, as the Norwegian culture finds free time and flexibility as essential (Hofstede Insights, n.d.-a). However, as AM allows for increased flexibility, it could isolate the employees from their traditional workplace and result in psychological risks (Naghshineh et al., 2021). Based on this, AM could impact the employees' health and well-being as the social interaction with colleagues can be decreased.

It is expected that 375 million worldwide lose their jobs by 2030 due to companies utilizing AI (Dwivedi et al., 2021). This could negatively impact the well-being of former employees replaced by AI, as work is found to be crucial for people's well-being (Arbeidsgiverforeningen Spekter, 2018). A reduction in the workforce could also harm the remaining employees in terms of anxiety of losing their job. For the remaining workforce, changes in work tasks could be expected due to technologies such as AI and AM (Dwivedi et al., 2021; Naghshineh et al., 2021). Organizational changes could lead to employees experiencing increased levels of stress due to the adjusted expectations of the workforce. As Hofstede found that the Norwegian population prefers traditions over changes (Hofstede Insights, n.d.-a), it is emphasized that the employees will experience increased levels of stress due to the utilization of technologies and organizational changes. However, AM could have a positive effect on the remaining workforce. AM processes decrease the hazards related to traditional manufacturing, as it allows the employees to avoid the working environment over longer periods (Naghshineh et al., 2021).

Therefore, one can argue that companies utilizing AM can reduce the physical deterioration of the employees related to weak knees and hips, which contributes to achieving SDG3.d. Contradictory, as it reduces the employees' physical activity, it could increase the back-pain of the employees. In addition, decreased physical activity could increase the employees' waist circumference, therefore negatively affecting the health on a national basis.

A4, B4 & U4 – People (AM; AI; Smart Factories; and SDG4.4)

Smart factories and interacting with AI and AM will increase the need for a qualified workforce (Benotsmane et al., 2019; Dwivedi et al., 2021; Naghshineh et al., 2021); thus, reskilling could be necessary. As the education output is required to fit with the knowledge of handling the technologies, one could argue that the output of education will change due to Norwegian companies utilizing AI, AM, and smart factories. The argument is also justified by the Norwegian education system's focus on quality (OECD, 2019). This indicates that the education system will change the output to adapt to the knowledge required by companies. Based on this, utilization of the technologies is correlated with SDG4.4. However, Norwegian companies have not explored the full advantage of AI, and only 25 percent of Norwegian companies are planning to implement AI within 2021 (Hagbartsen, n.d.). Therefore, one could raise the question of how many companies must utilize the technology for the outcome of the Norwegian education systems to be changed.

AM, AI and smart factories will increase the demand for high-skilled labor and decrease the need for low-skilled labor (Bonekamp & Sure, 2015). As statistics show that there will be more elderly than young Norwegian inhabitants within ten years (Statistics Norway, 2020b), one can argue that this can influence the number of employees reskilling. There could be numerous reasons why people do not want to study and acquire high-skilled knowledge. However, the oldest in the workforce could be less motivated to reskill according to how many working years they have left. Further, it is predicted that the Norwegian districts will experience rural flight among young inhabitants (Leknes & Løkken, 2020). Consequently, the rural companies could experience a lack of knowledge to handle the technologies and stay competitive. Based on this, SDG4.4 could negatively be impacted by Norwegian companies utilizing the technologies. Further, the impact could be reinforced due to rural flight among young inhabitants.

A10 & A15 – Planet and Profit (AM; SDG8.2; and SDG12.5)

AM requires a significant investment (Breen, 2019), which could be challenging for companies with insufficient financial capital. However, companies that manage to invest in the technology could experience increased economic productivity, correlated with SDG8.2.

Utilizing AM could lead to a shift from mass production to more customized production. The customized production will increase the perceived value as the products will meet the customer's requirement to a greater extent (Matos & Jacinto, 2018). As the products produced by AM satisfy the customers increasingly, one can argue that the product lifetime increases. As the customized products will increasingly cover the customers' needs, one can assume that it will lead to fewer purchases; thus, decreased production. A result of this is increased responsible consumption, which will contribute to achieving SDG12.5. Products manufactured by AM machines would therefore have a positive environmental impact. However, increased responsible consumption will reduce production; thus, it could decrease the company's profit.

AM allows for just-in-time production and on-demand manufacturing (Machado, Despeisse, et al., 2019). As on-demand manufacturing could reduce the possibility of supply exceeding demand, it is considered a more sustainable operation. Further, the costs related to inventory and stock will decrease or, in some cases be eliminated, when on-demand manufacturing is applicable. This indicates that AM would positively affect the companies' profit, thus is correlated with SDG8.2. In addition, AM allows for local manufacturing (Naghshineh et al., 2021), which will result in shorter transportation routes. The local manufacturing will therefore have a positive impact on the environment in terms of decreased gas emission. However, the low population density in rural areas and the large geographic distances in Norway could significantly affect the transportation routes, as rural companies are dependent on longer transportation.

A11 – Planet & Profit (AM; and SDG9.4)

AM is characterized as a fusion method as the machines allow the product to be manufactured as a whole in one operation (Machado, Despeisse, et al., 2019). This would lead to reconfiguring the existing logistic network, which eliminates several stages of the supply chain (Naghshineh et al., 2021). However, AM machines require higher energy intensity, and the calculated manufacturing time is longer than traditional methods (Machado, Despeisse, et al., 2019). Despite this, as utilization of AM technology shortens the supply chain, one can argue that it will be beneficial for both the environment and the company's profitability. As there are fewer operations within the AM supply chain, the material and products have a shorter transportation route, indicating decreased gas emission. A shorter transportation route will also result in lower transportation costs and maintenance on the means of transportation. The same applies to the maintenance of roads, railway, quays, and other essential parts of the infrastructure in Norway, which is associated with SDG9.4. Nevertheless, as the AM machines allow for the product to be manufactured as a whole, utilization of the technology could consequently exclude subcontractors.

A21 – Planet & Profit (AM; and SDG16.6)

AM is a facilitator for transparency as it contributes to open innovation and customer co-creation (Naghshineh et al., 2021), which correlates with SDG16.6. Transparency within a company can result in decreased asymmetric information between the customers and the company. Customers having increased knowledge related to the company's operations, will to a greater extent, force the companies to become more sustainable for the customers to get satisfied. Further, this could cause ripple effects as it could increase the customer loyalty and customer base, and as a consequence, companies could experience increased profit.

Customers' perception of a company's environmental sustainability is affected by the number of suppliers (Gong, Gao, Koh, Sutcliffe, & Cullen, 2019). As AM allows for more local production, thus shrinking the supply chain (Naghshineh et al., 2021), fewer parts influence the company's sustainability. One can assume that if one operation in the supply chain is not perceived as sustainable, it could affect the perception of overall sustainability. Therefore, one can argue that it is beneficial to utilize AM as fewer steps in the supply chain make it easier to monitor the sustainability of each operation.

B10 – Profit (AI; and SDG8.2)

AI's ability to predict potential outcomes of a trade could be beneficial for companies, as it increases the possibility of the trade having desired profitable outcomes (Nadimpalli, 2017). This is therefore associated with SDG8.2 as utilization of AI could lead to economic productivity. However, AI could fail to involve factors such as trust when calculating the outcome of a trade. The interaction between humans could also be a factor to include when calculating the outcome.

B15 – Planet and Profit (AI; and SDG12.5)

As AI can interact with customers to detect their needs (Sima et al., 2020), the technology could impact SDG12.5. Utilizing AI could reduce waste as the customer's satisfaction with a product could increase, thus increasing the product lifetime. The technology could be a preventive tool to reduce overproduction and therefore have a positive environmental impact. Customers' increased product satisfaction could increase customer loyalty. This indicates increased purchases and consequently increased profit for the company. However, this could harm the planet, as customers purchase products they initially do not demand. Further, AI could misinterpret customer demand (Sima et al., 2020) and create a bullwhip effect in the form of overproduction.

B20 – Profit (AI; and SDG16.5)

A benefit of AI is the possibility to detect fraud due to predicting potential outcomes (Dwivedi et al., 2021; Nadimpalli, 2017) and is therefore correlated with SDG16.5.

C4 – People (AR; and SDG4.4)

The extensive utilization of mobile devices in combination with Augmented Reality (AR) could contribute to increased education output. Further, theory finds a correlation between AR and SDG4.4 due to the technology's ability to improve education to become increasingly practically related. The technologies could, for instance, provide students with 3D visualizations of topics (Velázquez & Méndez, 2018). This could result in students experiencing increased interest in the topic and become more involved with their learning outcome. Further, it could improve the quality of the education, as the students could acquire increasingly more practical understanding before being employed.

AR could be utilized both within and outside the education institutions (Velázquez & Méndez, 2018), indicating that the geographical limitations of universities are diminished. This corresponds with SDG4.4, as students choose their desired educational program based on interest and not limited to geography. On the other hand, the social aspect of education is essential for increasing the academic outcome (Taylor & Dymnicki, 2007). This means that the quality of education could be affected by students not participating physically at the education institution. Nevertheless, as the young Norwegian inhabitants are not required to move to a city to study, utilizing AR can limit rural flight. Further, this could positively impact the challenge for rural companies to acquire employees with relevant knowledge.

D2 – Planet and Profit (Robotics; and SDG2.4)

Utilizing robotics within agriculture will improve yield and productivity (Sparrow & Howard, 2020), correlated with SDG2.4. One can further indicate that there exist unexploited economic opportunities. However, replacing humans with robotics demands higher financial capital (Sparrow & Howard, 2020), and one can assume that it will make it more challenging to enter farming and food production. Despite this, it would be beneficial for the companies that successfully implemented robotics within agriculture as they become more competitive. Norway is characterized as a wealthy country, which increases the possibility for Norwegian companies to invest in robotics (Sparrow & Howard, 2020). The invention of small autonomous machines makes it possible for all companies within the agriculture industry to invest in the technology (Sparrow & Howard, 2020).

D9 – Profit (Robotics; and SDG8.1)

Companies utilizing robotics within their operations will experience increased accuracy and efficiency (Lima, 2020). Despite that robotics requires a sizeable one-time investment (RobotWorx, n.d.), one can assume that the companies will experience a severe decrease in the fixed costs. In Norway, the utilization of robotics does not require expenses related to human labor, such as labor costs and statutory sick pay (Kaarbø, 2017). In addition, companies do not have to pay employer's national insurance contributions calculated to be 14.1 percent for ordinary industries (Skatteetaten, n.d.). It would therefore be beneficial for Norwegian companies to utilize robotics within their operations. However, there has been discussed to add taxes when companies utilize robotics in Norway (Hestman, 2017; Lunde, 2017). One can assume that adding tax for autonomous machines utilized within the production would be less profitable for the companies, as their fixed costs would increase. However, the welfare state could be threatened by loss of income related to employer's national insurance contributions and could therefore constrain the economic growth in Norway. Based on this, robotics could be related to SDG8.1. Further, adding taxes could be perceived as a discouragement to utilize robotics to execute operations, resulting in decreased technological development in Norway. Nevertheless, taxing robotics could result in a more competitive corporate market. Companies with insufficient capital could compete against the companies with sufficient capital to invest in robotics. This is because companies have to pay taxes related to both human labor and the utilization of robotics.

E2 – Planet and Profit (Big Data and Analytics; and SDG2.4)

Big data and analytics could provide data that can be utilized to monitor the soil quality (Mabkhot et al., 2021; Ruan et al., 2019) and is therefore correlated with SDG2.4. The soil quality could affect the crops and plants and is crucial for life in the soil. Past data has the advantage of detecting the reason for something to happen (Mabkhot et al., 2021) and could be beneficial to determine what factors made the soil of insufficient quality. Further, the data could be utilized to improve the management of the resources, as one could predict future trends. If decision-makers can predict future trends, it can prevent the quality of resources from being insufficient. This have not only environmental benefits but also economic benefits due to the improvement of resource utilization. Further, increased soil quality monitoring could decrease the waste of soil and plants with insufficient quality. Therefore, one can assume that big data and analytics could improve food production in Norway, as the soil quality is better maintained.

Utilizing big data and analytics has its disadvantage regarding lacking real-time information and the time it takes to process the data (Mabkhot et al., 2021). This could be a challenge when monitoring crops, which is dependent on sufficient soil quality. It might be critical to have access to the information as soon as possible to diminish the problems occurring. Even though big data and analytics could predict future trends (Mabkhot et al., 2021), unexpected events could occur, and the long process-time could cause the crops to be wasted. This could lead to a financial liability within Norwegian agriculture due to the waste of resources utilized on plants and soil.

E4 – People (Big Data and Analytics; and SDG4.4)

To handle big data and analytics efficiently, one is dependent on employees with skills related to machine learning, statistical analysis, and problem-solving (Jeble et al., 2018). This indicates that big data and analytics are associated with SDG4.4 as the technology requires high-skilled employees.

E10 & E15 – Profit (Big Data and Analytics; SDG8.2; and SDG12.5)

Big data and analytics could be utilized for personalized marketing by exploiting data from shopping preferences and habits (Lee, 2017). This could increase the profit for companies as the marketing targets consumers' wants. Big data and analytics are therefore correlated with SDG8.2 as it facilitates economic productivity. Personalized marketing will arguably increase sales, as the customer are exposed to products they are demanding. In addition, big data and analytics could provide more accurate demand forecasts, which would prevent supply from exceeding demand (Lee, 2017). Thus, the technology is associated with SDG12.5. The prevention of supply exceeding demand will positively impact, as it will reduce the waste of products that are not sold.

F8 – Planet (Blockchain; and SDG7.3)

The utilization of blockchain and management of the distributed ledger systems requires a significant amount of energy (Koh, Dolgui, & Sarkis, 2020). Thus, taking advantage of blockchain will negatively correlate to SDG7.3 and improvement of energy efficiency.

F20 & F21 – People and Profit (Blockchain; SDG16.5 and SDG16.6)

Blockchain is found to make institutions more transparent, thus preventing fraud and corruption (Hughes et al., 2019). Transactions within a blockchain are irreversible and available for all members (Schinckus, 2020). This could cause a challenge related to privacy, as the transactions can be traced; thus, the party could be identified (Seyedsayamdost & Vanderwal, 2020). However, as the characteristic of blockchain is transparency, it is natural that one could identify all parties. Blockchain is therefore correlated with SDG16.6 of transparent institutions and SDG16.5 of reducing bribery.

F22 – People, Planet, and Profit (Blockchain; and SDG17.16)

Blockchain could establish trust between companies (Mohamed, Al-Jaroodi, & Lazarova-Molnar, 2019) as processes are being tracked. This aspect could be beneficial within partnerships and is therefore related to SDG17.16. As the SDGs relate to the three pillars: people, planet, and profit, blockchain is arguably correlated with all of them. As blockchain is recording the transactions within a partnership, trust becomes a less significant factor. This could exclude a third party's responsibility for the formal agreements, as it is incorporated within the blockchain (Mohamed et al., 2019). As trust is an essential factor in partnerships, utilizing blockchain could contribute to establishing partnerships.

G4 & I4 – People (Cloud Technology; CPS and SDG4.4)

Utilizing Cyber Physical Systems (CPS) and Cloud Systems and Cloud Computing (cloud technology) will increase the demand for high-skilled labor (Benešová & Tupa, 2017; L. Wang, Törngren, & Onori, 2015). The employees must handle both implementations of the systems and support the users in the system (Benešová & Tupa, 2017). Based on this, utilization of CPS and cloud technology are related to SDG4.4, as one can assume that the current employees need to acquire new knowledge to handle the technologies. Hofstede found that traditions characterize the Norwegian culture and that the population does not appreciate radical changes (Hofstede Insights, n.d.-a). This indicates that the population has a reluctance to reskill. However, according to Hofstede, the Norwegian population considers individual careers and achieving goals as important (Hofstede Insights, n.d.-a). As reskilling could positively impact the employees' careers, one could assume that the employees will be motivated to acquire high-skilled knowledge.

G8 – Planet (Cloud Technology; and SDG7.3)

Companies investing in cloud technology will experience that the operations require less energy, as the companies do not need independent cooling systems when utilizing cloud storage (Puica, 2020). Thus, cloud technology is correlated with SDG7.3 as the technology could contribute to improving energy efficiency. The technology's impact on energy efficiency is huge, even when it is implemented by smaller companies (Puica, 2020). This indicates that if the biggest companies utilize cloud technology, it will have an enormous positive impact on energy efficiency.

G10 & G11 – Profit (Cloud Technology; SDG8.2; and SDG9.4)

Cloud technology allows for storage of resources, which leads to companies saving costs related to energy consumption, server and storage, and software maintenance. The technology will therefore function as a replacement to companies' own infrastructure (Puica, 2020). Based on this, cloud technology is associated with SDG8.2 as it increases economic productivity. The technology is also correlated with SDG9.4 as it could facilitate improved infrastructure within the companies. Further, the utilization of cloud technology can decrease the differences between economically large and small companies, as the companies do not have to invest in their own IT infrastructure (Puica, 2020). This indicates that economically smaller companies will experience increased competitiveness, and could to a greater extent, compete with economically larger companies. As cloud technology allows companies to take advantage of already existing IT infrastructure, one can argue that it would be less challenging to develop a viable business. The operating costs will decrease when utilizing the technology, which will result in improved economic sustainability.

G15, G20 & G21 – Planet and Profit (Cloud Technology; SDG12.5; SDG16.5; and SDG16.6)

When utilizing cloud technology, the retailers, suppliers, and distributors within the supply chain share the same platform. The technology collects data through the internet and thereby performs forecasts and analyzes of the demand for all the involved parts in the supply chain (Puica, 2020). Therefore, cloud technology is correlated with SDG12.5, as it decreases the possibility of the supply exceeding the demand. The technology also offers real-time visibility of the resource flow, which improves the transparency in the supply chain. Thus, cloud technology is associated with SDG16.6. One can argue that this will lead to more efficient production, which will increase economic sustainability within companies. Further, making the supply chain more transparent could result in fraud prevention among the parties involved (Puica, 2020) and could therefore be related to SDG16.5.

H15 – Profit (Cobotic Systems; and SDG12.5)

Cobotic systems correlate with SDG12.5, as inappropriate handling of the technology can lead to errors, which can cause decreased performance quality (Askarpour, Mandrioli, Rossi, & Vicentini, 2019). It is argued that the employees' state of mind is an essential factor when handling cobotic systems, as errors can occur based on the employees' decisions. This could lead to products of insufficient quality. A consequence of this is loss of profit due to customers' unwillingness to purchase products that do not meet their expectations. This would therefore be characterized as waste.

I3 – People (CPS; and SDG3.d)

CPS could operate without human interaction, and the automation could therefore reduce humans' dangerous work tasks (L. Wang et al., 2015). Based on this, CPS is correlated with SDG3.d related to reducing health risks.

J20 & J21 – Profit (Cybersecurity; SDG16.5; and SDG16.6)

As cybersecurity contributes to protecting information from being attacked or stolen (Bai et al., 2020), it is argued that the technology is correlated with SDG16.5 and SDG16.6. This is based on that cybersecurity is relevant for all Industry 4.0 technologies due to the security challenge of increased information and data. Therefore, utilization of cybersecurity could lead to economic sustainability, as the information could cause a financial burden if stolen.

K22 – People, Planet, and Profit (Data Mining; and SDG17.16)

Data mining could share knowledge between companies (Shahbaz et al., 2010) and is therefore correlated to SDG17.16. The shared knowledge could contribute to increasing the knowledge related to sustainability among the companies. This could result in companies being more aware of sustainability challenges, consequently leading to companies working towards achieving the SDGs.

L15 – Planet and Profit (ERP and Business Intelligence; SDG12.5)

ERP could increase resource efficiency, and business intelligence could identify and adapt to changes (Oztemel & Gursev, 2020). Based on this, ERP and business intelligence are correlated to SDG12.5. The increased resource efficiency and adapting to changes could prevent waste, as the company could adapt to changes in the market. This could lead to a decrease in overproduction and production of undemanded products. It will further have a positive impact on the company's profit, as resources utilized on non-value-added activities and products will decrease.

M2 – People, Planet & Profit (GPS; and SDG2.4)

GPS utilized on agricultural machinery makes maintaining the land and soil more efficient (Kovács & Husti, 2018; Ruan et al., 2019). Based on this, GPS is correlated with SDG2.4. GPS in agriculture could guide the driver of the vehicle with coverage maps in near real-time (M. Wang, Wang, Sepasgozar, & Zlatanova, 2020). Further, the driver gets information regarding the vehicle's position (Kovács & Husti, 2018), which is beneficial for the overall performance of the land and soil. This could further have a positive social impact as the tracking of the field could decrease the driver's stress levels and increase efficiency (Kovács & Husti, 2018). The driver could have the main focus on the actual task of the operation and let the GPS handle the tracking of the covered and remaining field. Reduction in multitasking could be argued to improve the efficiency of the work, as it could decrease the human error of double processing parts of the field or skip parts of the land. This could further increase the soil quality as it increases the possibility of the whole land and crops getting treated equally. Further, this has an economic benefit as GPS technology could turn off the machines when driving on already processed land (Kovács & Husti, 2018). This decreases the waste of resources as one does not utilize resources, such as seeds, on already sewed land.

N1, N4, N9 & N12 – People and Profit (IIoT; SDG1.2; SDG4.4; SDG8.1; and SDG10.1)
Industrial Internet of Things (IIoT) matured from Internet of Things (IoT) based on the emergence of Industry 4.0 (Mabkhot et al., 2021). IoT will affect companies' size of workforce (McKinsey & Company, 2015), which could result in employees experiencing loss of income. IIoT is therefore associated with SDG1.2. Further, the technology will cause employees to reskill (McKinsey & Company, 2015), and IIoT is consequently related to SDG4.4. The utilization of IIoT will increase the need for certain knowledge related to decision-making and human judgment and decrease the need for employees with automated work tasks. The need for manual work will further decline due to intelligent machines. However, the technology will cause a need for employees with knowledge of designing, developing, installing, and managing intelligent machines (McKinsey & Company, 2015).

Employees in rural areas will be more affected than employees in urban areas. This is because one can assume that there exist more jobs in urban areas than in rural areas. Thus, it could be more challenging for job seekers in rural areas to get employed, even after studying. Based on this, demography could differently affect the poverty rate within Norway and cause economic inequalities. IIoT is therefore correlated with SDG10.1 and SDG8.1.

N2 & N14 – Planet and Profit (IIoT; SDG2.4; and SDG12.2)
IoT could increase information of the natural resources (Phupattanasilp & Tong, 2019) thus, IIoT is correlated with SDG2.4 and SDG12.2. As plants in nature could be challenged by weather and diseases, IIoT could positively affect the output when invisible challenges occur. The technology could influence decisions within agriculture (Phupattanasilp & Tong, 2019) as the farmers obtain increased data on crops. One can argue that increased data on the quality of the crops and soil will benefit farmers' decision-making, which could further increase the profit. From an environmental perspective, IIoT could cause the natural resources to be managed more efficiently.

N3 & N16 – People & Planet (IIoT; SDG3.d; and SDG13.3)
IoT could be utilized to planning optimal routes (Levina et al., 2017), and therefore contribute to decreasing gas emissions related to transportation and providing more efficient routes. Thus, IIoT is correlated with SDG13.3. Further, the technology could provide traffic information and find more efficient transportation routes (Levina et al., 2017). This could contribute to the goods being more efficiently distributed and therefore increase customer loyalty. When

transportation is more efficient, it could positively impact emissions as it decreases unnecessary long transportation routes. More efficient transportation routes could further increase social sustainability as it improves the working conditions for transportation drivers. The working conditions could be improved due to decreased working hours and stress related to deadlines of deliveries. IIoT is therefore correlated with SDG3.d.

N6 – Planet and Profit (IIoT; and SDG6.b)

McKinsey & Company (2015) found that utilizing IoT could contribute to discovering water leaks and IIoT is therefore related to SDG6.b. As Norway's water infrastructure leaked water worth NOK350 million in 2018 (Mattilsynet, 2019), it can be argued that the Norwegian water infrastructure could be improved by utilizing IIoT. This could have a positive impact on profit.

N7 & N22 – Planet (IIoT; SDG7.2; and SDG17.16)

IIoT could increase the share of renewable energy (Beier et al., 2018) and could therefore be correlated with SDG7.2. The share of renewable energy is found to increase as IIoT decreases the volatility of renewable energy. The technology could do this by releasing or storing energy based on the available renewable energy in the market (Beier et al., 2018). Therefore, it could be argued that companies utilizing IIoT are dependent on collaborations to increase the share of renewable energy. Based on this, IIoT is also correlated with SDG17.16.

N21 – Planet (IIoT; and SDG16.6)

Supply chains with total transparency are found to improving environmental management. IIoT could provide information throughout the supply chain (Beier et al., 2018) and could therefore be associated with SDG16.6. Achieving transparency within the supply chain requires that all suppliers have access to the same information. This will contribute to improving the environmental sustainability of the operations within the supply chain. Nevertheless, if the information is asymmetric, one can assume that sustainability does not improve. If one operation is reducing its emission while another operation increases its emissions, the environmental impact on the supply chain will be limited. This will negatively affect the sustainability of the entire supply chain. However, if one operation within the supply chain becomes more environmentally sustainable, the transparency could cause other companies within the supply chain to become more sustainable. Nevertheless, for the supply chain to improve sustainability, one is dependent on all the suppliers involved to contribute. Further, one can argue that the suppliers that are not willing to make their operations more sustainable are less competitive. Based on this, the company can find other distributors and subcontractors for collaboration that significantly focus on sustainability. This will, in some way, pressure the subcontractors to improve their environmental sustainability.

P10 – Profit (Mobile Technology; and SDG8.2)

The fifth-generation (5G) of mobile technology is in the development phase, which is expected to be an essential factor for the growth of Industry 4.0 technologies (Rao & Prasad, 2018). One can assume that the utilization of 5G can increase the benefits gained from the technologies. Operations within a company could become more productive, and one could experience faster communication between the utilized machinery due to 5G performance. Based on this, the implementation of 5G is associated with SDG8.2 as it could result in increased economic productivity.

Q2 & Q11 – Planet (Nanotechnology; SDG2.4; and SDG9.4)

The utilization of nanotechnology within transportation could be advantageous as it could improve the vehicle's performance. By utilizing nanocomposites, the vehicle's weight will be reduced (European Commission, 2017), indicating that the means of transport will be more environmentally friendly as gas emissions will decrease. One can also assume that a lighter vehicle will lead to reduced wear on the road, which reduces the need for maintenance of the road. Based on this, nanotechnology correlates with SDG9.4. As the utilization of nanocomposites minimizes the weight of vehicles, one can exploit this advantage within the agricultural industry. Lighter machinery can decrease problems related to the topsoil compaction, resulting in increased sustainable food production and improved soil quality. Based on this, nanotechnology is associated with SDG2.4.

Q8 – Planet (Nanotechnology; and SDG7.3)

Nanotechnology can be utilized to provide cleaner energy with increased efficiency (Babatunde et al., 2020). The utilization of the technology would not necessarily directly affect energy transmission; nevertheless, it increases the possibility of reducing the need for electricity and other energy sources (Babatunde et al., 2020). Based on this, nanotechnology is correlated with SDG7.3.

R15 – Planet (RFID; and SDG12.5)

There are many advantages of companies utilizing Radio Frequency Identification (RFID) (Zelbst, Green, Sower, & Bond, 2020) (see R21). However, the RFID tags' material makes it challenging to recycle (Gladysz, Ejsmont, Kluczek, Corti, & Marciniak, 2020). Based on this, utilization of the technology would negatively correlate with SDG12.5.

R21 – Planet & Profit (RFID; SDG16.6)

The utilization of RFID can contribute to providing transparency through the entire supply chain, as the technology allows for tracking shipments in real-time (Zelbst et al., 2020). Based on this, companies will experience increased knowledge related to where shipments from suppliers are located and at what time. This would lower the risk to members of the supply chain, as the operations among the parts are visual for everybody involved (Zelbst et al., 2020). One can also assume that transparency will improve supply chain performance due to increased productivity and efficiency. As the technology allows for real-time tracking, companies can make better decisions based on the shipment's location. Companies can save costs related to stock, as material management can be improved. One can argue that economic benefits could cause environmental benefits, as increased accuracy in stock could decrease transportation and its accordingly emissions. Further, companies utilizing RFID technology will also track the shipments sent to customers (Zelbst et al., 2020), indicating that this will increase customer service due to their ability to track the order. Based on this, RFID is correlated with SDG16.6.

T8 – Planet (Simulation; and SDG7.3)

Simulation has the advantage of testing processes before manufacturing (see T15 & W15). Energy efficiency could be an outcome of simulation processes (Beier et al., 2018), thus correlated with SDG7.3.

T15 & W15 – Planet and Profit (Simulation; VM; SDG12.5)

Simulation utilizes real-time data and could be used to test the operations before the actual manufacturing (Bahrin, Othman, Azli, & Talib, 2016). Comparable, Virtual Manufacturing (VM) tests manufacturing processes virtually and gives valuable information about the process. This allows for testing the production in a virtual environment before the actual manufacturing (Oztemel & Gursev, 2020). VM could provide valuable information on critical operations that could affect the products to be of insufficient quality. Based on this, simulation and VM are correlated with SDG12.5. This could influence the company to adjust the manufacturing process, so the output of the manufacturing is of increased quality. Further, VM could cause the company to detect bottlenecks and make changes to increase efficiency. This could have a positive economic impact in reducing production time and labor costs. Costs related to the supply chain, including maintenance and outsourcing costs, are found to decrease when utilizing VM (Oztemel & Gursev, 2020). In addition, VM could detect the need for maintenance. This could be beneficial as it allows for the detection of required maintenance on machines before the actual production. Consequently, this could reduce waste generation.

U1, U8 & U10 – People, Planet, and Profit (Smart Factories; SDG1.2; SDG7.3; and SDG8.2)

Smart factories are more productive and resource-efficient compared to traditional factories (Benotsmane et al., 2019). This indicates that smart factories are correlated with SDG8.2. The technology requires limited human interaction, and it allows production around the clock as machines can produce continuously without resting (Hozdić, 2015). This could cause economic productivity due to more efficient production. However, the increased production hours could cause harm to the environment. Inhabitants surrounding the environment could get negatively affected by the noises around the clock, as the production does not follow ordinary working hours. Further, machines are to a certain point not affected by the temperature to function. Thus, the smart factories could operate at lower temperatures. This is beneficial as the limited human interaction allows for temperature management, which could positively affect energy consumption and efficiency (Mohamed et al., 2019). SDG7.3 is therefore correlated with smart factories.

As smart factories operate with limited human interaction, parts of the workforce will be excessive. The workforce in smart factories is required to be high-skilled (Benotsmane et al., 2019) to handle the operations. This could cause the workforce to acquire new knowledge. Moreover, one could question if the supply of labor could exceed demand, as automation of processes will affect the required number of employees. Consequently, it could result in shorter working hours if the entire labor force in Norway is dependent on employment. This could further affect the proportion of Norwegian citizens living in low-income households. It is predicted that the population will increase in urban areas, while rural areas experience a decrease in population (Statistics Norway, 2020b). The rural companies could experience limited access to qualified employees. This is because of the predicted rural flight (Leknes & Løkken, 2020), which could cause the rural companies to experience the demand of workforce exceeding the supply. Further, as the parts of the urban population are estimated to increase (Leknes & Løkken, 2020), the labor market in urban areas could become saturated. Therefore, one can argue that smart factories are correlated with SDG1.2.

V2 & V16 – Planet (UAV; SDG2.4; and SDG13.3)

Unmanned Aerial Vehicle (UAV), also known as a drone, is correlated with SDG2.4 as it could promote sustainable agriculture (Kitonsa & Kruglikov, 2018). Compared to other machinery, utilization of UAVs within the industry could be advantageous as the technology is operating in the air and would therefore not harm the soil. One can assume that this would increase the soil quality, which could further improve food production. In addition, UAVs substituting agricultural machinery could lead to decreased gas emissions and would therefore be beneficial for the planet (Kitonsa & Kruglikov, 2018). Based on this, UAVs are associated with SDG13.3.

V10 & V11 – People, Planet, and Profit (UAV; SDG8.2; and SDG9.4)

UAV's are operating in the air, it can reach rural areas and is not hindered by challenging landscape (Kitonsa & Kruglikov, 2018). This is an essential factor for the transportation within the industry in Norway, as the Norwegian roads leading to rural areas often are characterized as winding and narrow. One can assume that country roads will make transportation between urban and rural areas more challenging. The insufficient infrastructure surrounding rural areas could constrain the development of industries in these areas. One can argue that this is because rural areas are dependent on urban areas for the supply of materials and export of products. However, utilizing UAVs could improve the interaction between different areas within Norway. UAV is therefore correlated with SDG9.4, as the technology allows for improved infrastructure. As the technology facilitates improved infrastructure, it could result in new business development in rural areas, improving the economic growth in Norway. UAVs can therefore be related to SDG8.2.

UAVs could also decrease the workload for transportation workers, as the routes will be shortened. This could positively affect the employees working conditions, as one can assume that the work hours will be shortened. In addition, UAVs will be more time-efficient and will therefore increase productivity. This could result in decreased cost of production, which will be advantageous for Norwegian companies. Furthermore, UAVs are characterized as environmental technology (Kitonsa & Kruglikov, 2018) and can substitute traditional delivery methods to decrease the gas emissions related to delivery.

4.4 Synthesis

According to the findings in the analysis, there are both advantages and challenges related to Norwegian companies' utilization of Industry 4.0 technologies. In the following, a synthesis to combine and link the findings from the analysis is provided. The synthesis will connect the Industry 4.0 technologies and UN subgoals with social, environmental, and economic sustainability.

4.4.1 People

The utilization of Industry 4.0 technologies within Norwegian companies is found to impact social sustainability in numerous ways. A common denominator for companies utilizing the technologies is changes in work tasks (Bonekamp & Sure, 2015; Dwivedi et al., 2021; McKinsey & Company, 2015; Naghshineh et al., 2021). A consequence of this is increased demand for a qualified workforce. Industry 4.0 technologies could impact social sustainability, as employees need to reskill to handle the technologies. This indicates that some employees will have irrelevant skills if they do not acquire new knowledge. Reskilling of employees due to Norwegian companies utilizing Industry 4.0 technologies is therefore positively correlated with SDG4.4. However, if the employees do not acquire new knowledge, the technologies are negatively correlated. This is because the employees do not have the relevant skills to handle the technologies sufficiently.

The challenges related to changes in the workforce could trigger stress among the employees (Arbeidstilsynet, n.d.-a). One of the reasons is related to the possibility of employees losing their jobs due to the automation of work tasks. Further, the increased demand for a qualified workforce could cause stress for the employees, as they have to adjust to handle the Industry 4.0 technologies. On the other hand, some can find it motivating to be challenged and rewarding to acquire new knowledge. SDG3.d related to health is correlated with Industry 4.0 technologies' automatization of work tasks. The stress associated with reskilling and the possibility of employees losing their jobs could be seen as a health risk, as stress affects a person's well-being. Further, as the Norwegian population prefers traditions over changes (Hofstede Insights, n.d.-a), the adjusted work tasks could increase the employees' stress level. However, Norwegian citizens are engaged in their individual careers (Hofstede Insights, n.d.-a), and one could therefore assume that the employees are motivated to reskill if required to retain their job.

The utilization of Industry 4.0 technologies within Norwegian companies could also positively impact employees' stress levels. Reduction of manual work could cause the working hours to become more flexible, which could have a positive impact on social sustainability. The employees could plan their days to become more optimized considering their professional and personal life, which can be stress relieving. This could positively impact the employees, as flexibility is essential for the Norwegian population (Hofstede Insights, n.d.-a). However, social interaction is an important aspect of working (Naghshineh et al., 2021) and can become challenging due to employees having flexible working hours. This can reduce social interaction between colleagues. Thus, Norwegian companies utilizing Industry 4.0 technologies could negatively impact social sustainability. This correlates with SDG3.d.

The automatization of processes due to Industry 4.0 technologies could positively correlate with SDG3.d, as the technologies could reduce the physical work within Norwegian companies. The technologies can perform numerous dangerous operations that often are associated with manual labor. The reduction of physical activity could therefore be advantageous for the employees' health in terms of decreased exposure to dangerous work tasks. Further, automated processes could reduce the possibility of employees experiencing health risks related to weak hips and knees, often associated with heavy physical work (Arbeidstilsynet, n.d.-b). On the other hand, automated operations can decrease physical work and cause other health risks, such as increased waist circumferences and back pain. Obesity could result from decreased physical activity, which will exacerbate the already existing challenge in Norway (Aamo et al., 2019).

Lack of motivation to acquire new knowledge and insufficient employers for the desired work-field can be reasons for unemployment. Increased unemployment due to Norwegian companies utilizing Industry 4.0 technologies can be associated with SDG1.2, as it can increase the poverty rate according to the Norwegian definition. Nevertheless, the unemployed can obtain a job in other companies to persistently be a part of the Norwegian workforce, to maintain income. However, it is limited to how many job seekers the labor market can handle before it is saturated. Based on this, one could question whether the labor supply within the Norwegian market could exceed the demand. Automated processes due to Industry 4.0 technologies could result in employees having shorter working hours to ensure that the entire labor force in Norway is employed. Further, the labor market could be divided between urban and rural areas. As the Norwegian population is expected to increase in urban areas and decrease in rural areas by 2050, the demand and supply of labor will be unbalanced. One can assume that the rural areas will demand more labor, while the urban areas will experience the supply of labor exceeding the demand.

To summarize, utilizing Industry 4.0 technologies will have a significant impact on the workforce. The technologies will cause changes in work tasks and increased demand for a qualified workforce. This could cause employees to reskill to be able to handle the technologies. A challenge related to changes in work tasks is associated with employees experiencing stress as their traditional work tasks get automated. As Industry 4.0 technologies decrease manual work and facilitate flexible working hours, employees could experience stress relief. Another advantage of process automatization is the reduction of employees' exposure to dangerous work tasks. However, decreased physical work can be a challenge, as it can impact the obesity rate in Norway. The automatization of operations can also cause challenges related to the supply and demand of the Norwegian labor force. This could vary between urban and rural areas, as the most significant part of the labor force will be located in urban areas. This could make the difference between urban and rural areas more prominent in the future.

4.4.2 Planet

The environmental advantages of utilizing Industry 4.0 technologies are related to the production due to on-demand manufacturing (Machado, Despeisse, et al., 2019). Norwegian companies with on-demand manufacturing can reduce overproduction. This will positively impact environmental sustainability, as the approach for manufacturing will prevent waste. Therefore, SDG12.5 correlates with the utilization of Industry 4.0 technologies, as it can result in responsible production. Norwegian companies utilizing the technologies could also have the benefit of shortening the supply chain as the technologies permit local production (Naghshineh et al., 2021). This will have a positive impact on the environment in terms of shorter transportation routes. A result of this is decreased gas emission, and the technologies can therefore be associated with SDG9.4. However, one can question the difference in environmental impact in urban and rural areas. Although Industry 4.0 technologies allow for local production, the rural companies could be dependent on longer transportations routes. Therefore, the gas emission related to transportation from rural areas could have a limited impact on sustainability. In addition, as there are limited choices of transportation routes in the rural areas in Norway, it is more challenging to optimize the routes.

Companies utilizing Industry 4.0 technologies have the opportunity to make the products personalized for the customer (Matos & Jacinto, 2018). This could benefit the environment in terms of fulfilling the customers' needs, thus reducing waste. Further, the customer could become increasingly satisfied with the product, resulting in an increased product lifetime. Based on this, there is a correlation with SDG12.5, as utilization of Industry 4.0 technologies can contribute to responsible consumption. In addition, the increased customer satisfaction could cause customers to become more loyal, thus purchasing more products. This could negatively impact environmental sustainability as customers purchase products originally not demanded. This could lead to irresponsible consumption and production and could therefore harm the environment unnecessarily.

Another advantage for Norwegian companies utilizing Industry 4.0 technologies is detecting customer demand and changes in demand (Oztemel & Gursev, 2020; Puica, 2020). This could have a positive environmental impact as it could reduce overproduction. Further, the possibility to adapt to changes in demand could influence environmental sustainability in terms of not producing products not demanded. The utilization of Industry 4.0 technologies are therefore associated with SDG12.5, as it stimulates responsible production.

SDG12.5 could also be correlated with Norwegian companies utilizing Industry 4.0 technologies due to its advantage of simulating the manufacturing process before the actual production. This could positively affect environmental sustainability in terms of detecting bottlenecks and the need for maintenance. It could further decrease the possibility of producing defective products, thus reducing waste.

Generally, Industry 4.0 technologies have the advantage of improving energy efficiency (Babatunde et al., 2020; Beier et al., 2018; Mohamed et al., 2019; Puica, 2020) and are therefore correlated with SDG7.3. However, two technologies are found to increase energy utilization. Thus, the energy efficiency will probably be improved by utilizing Industry 4.0 technologies, with the exception of blockchain and AM.

Utilizing Industry 4.0 technologies can provide transparency within a company and its supply chain (Beier et al., 2018; Mohamed et al., 2019; Naghshineh et al., 2021; Puica, 2020; Zelbst et al., 2020), which can improve environmental sustainability. Based on this, the technologies are associated with SDG16.6. A challenge related to environmental sustainability within a supply chain is related to situations where one operation reduces its emissions while another increases its emission. This will negatively affect the sustainability of the supply chain. However, if one operation becomes more environmentally sustainable, the transparency could cause other companies within the supply chain to become more sustainable. This is because companies could become more competitive if they increase their environmental sustainability. It will further result in improved sustainability within the entire supply chain. Based on this, it would be advantageous for Norwegian companies to utilize Industry 4.0 technologies, as the supply chain transparency could allow the companies to find co-distributors and subcontractors focusing on environmental sustainability.

To summarize, on-demand manufacturing, and the ability to adapt to changes in demand, are advantages of utilizing Industry 4.0 technologies. This has a positive impact on the environment due to a decrease in overproduction and waste. The personalization of products can reduce waste and increase customer lifetime due to increased customer satisfaction. An environmental challenge associated with this is when customers buy products not demanded initially, resulting in irresponsible consumption and production. Local production due to the utilization of Industry 4.0 technologies will be advantageous to the environment. The reason is that shorter transportation routes cause decreased gas emissions. However, the population density and the geographic distances within Norway could affect the optimization of transportation. This will be a challenge for rural companies, as they depend on longer transportation routes.

4.4.3 Profit

Economic sustainability will be impacted by the utilization of Industry 4.0 technologies within Norwegian companies. One of the main challenges related to the technologies are that they require a tremendous financial investment (RobotWorx, n.d.). As the investment is of great size, it would be more challenging for companies with insufficient financial capital. However, Norwegian companies that manage to invest in Industry 4.0 technologies could experience numerous advantages. Financially smaller companies utilizing Industry 4.0 technologies could compete on equal terms as financially larger companies. This could result in increased competitiveness and increased profit which is correlated with SDG8.2.

Industry 4.0 technologies allow for shared platforms and storage of resources in a cloud (Puica, 2020; Shahbaz et al., 2010). This is perceived as an economic advantage, as Norwegian companies do not have to invest in their own IT infrastructure, as the cloud will function as a replacement. Based on this, Industry 4.0 technologies are associated with SDG9.4 as Norwegian companies could become more economically sustainable.

Industry 4.0 technologies can cause shortened supply chain, as the technologies allow for fusion method operations (Machado, Despeisse, et al., 2019) and improved opportunities for local production (Naghshineh et al., 2021). As fewer parts are involved in the distribution channel, the resources and products have a shorter transportation route. This will lead to several economic advantages, such as decreased cost related to the transportation itself and reduced need for maintenance on the means of transport. Industry 4.0 technologies could also improve the interaction between different areas within Norway. UAVs operate in the air and can therefore reach rural areas without getting hindered by challenging landscape. In addition, cloud technology facilitates communication and sharing of resources among companies despite a geographic distance. Industry 4.0 technologies are therefore correlated with SDG9.4 as they could facilitate improved infrastructure. Further, rural companies are dependent on urban areas for the supply of materials and exportation of products. The utilization of technologies could increase business development in rural areas, which could improve the economic sustainability of Norwegian companies.

Industry 4.0 technologies have the advantage of operating with decreased human interaction (Benotsmane et al., 2019; Mohamed et al., 2019; L. Wang et al., 2015). This could make the Norwegian companies' operations more efficient, as machines do not need rest to be productive. The limited human interaction could also improve companies' economic sustainability, as it decreases human errors and increases the accuracy within the production. A result of this is reducing waste, which could prevent companies from utilizing resources on products that are not sold. Based on this, Industry 4.0 technologies are correlated with SDG8.2, as it could increase economic productivity.

The transparency among the retailers, suppliers, and distributors will increase when companies utilize Industry 4.0 technologies (Beier et al., 2018; Mohamed et al., 2019; Naghshineh et al., 2021; Puica, 2020; Zelbst et al., 2020) and are therefore associated with SDG16.6. The technologies offer real-time visibility of the resource flow within the supply chain. This could improve decisions making and make production more efficient. The reason for this is that the companies gain location insight of the shipment's, improving the economic sustainability. A result of this is avoidance of supply exceeding the demand, which is associated with SDG12.5.

Industry 4.0 technologies allow for customized production (Matos & Jacinto, 2018), which can increase the perceived value as the products meet the customer needs to a greater extent. Products covering the customer needs can improve customer loyalty. Based on this, companies could increase their sales, thus their profitability. Industry 4.0 technologies could also provide data related to forecasts of demand and shopping preferences among customers (Lee, 2017; Puica, 2020). This could improve companies' economic sustainability, as the marketing is targeting consumers' demand. Further, Industry 4.0 technologies could prevent the supply from exceeding the demand and are beneficial as overproduction could negatively affect companies' profit. The technologies are therefore associated with SDG8.2 as it allow for economic growth. SDG12.5 is also correlated, as companies can forecast the demand and therefore avoid overproduction. This could prevent companies from utilizing financial resources on products that are not sold. In addition, it is advantageous as the companies avoid costs related to inventory and stock.

Although implementing Industry 4.0 could be expensive, Norwegian companies can experience economic advantages by making the investment. Companies utilizing autonomous technologies do not have to pay costs related to human labor, such as labor cost, statutory sick pay, and employer's national insurance contributions (Kaarbø, 2017). Based on this, Norwegian companies could improve economic sustainability by utilizing Industry 4.0 technologies. SDG8.2 is therefore correlated with the technologies. However, adding tax for utilization of autonomous technology could be applicable in the future and could limit the economic benefits of utilizing Industry 4.0 technologies.

To summarize, the financial investment required for utilizing Industry 4.0 technologies could be a challenge for companies. However, managing to invest in the technologies could lead to advantages related to profit. Utilizing Industry 4.0 technologies makes companies able to compete on equal terms. Companies do not have to invest in their own IT infrastructure, thus saving costs related to establishment and service maintenance. Utilizing Industry 4.0 technologies could shorten the supply chain and permit local production. The advantages of a shortened supply chain are related to decreased costs of transportation. Further, Industry 4.0 technologies facilitate communication between different areas in Norway. In addition, the infrastructure could be improved, as the technologies allow for urban and rural areas in Norway to share resources more efficiently. As the population density in the Norwegian municipalities varies greatly, utilization of Industry 4.0 technologies will be advantageous, especially for rural companies. As the technologies permit local production, the cost related to transportation of resources will decrease due to shorter transportation routes. Moreover, the automatization will make operations more efficient, reduce human errors and waste, and increase accuracy within production. The automatization will also decrease costs related to human labor. Further, as Industry 4.0 technologies facilitate transparency within the supply chain, it could result in advantages related to real-time visibility of resources. The economic advantage is associated with improved decisions based on data from the flow of resources, thus increasing productivity.

5. Validation

This chapter will evaluate the quality of this thesis and its trustworthiness. The validation is measured by the validity and the reliability of the thesis' methodology approach.

5.1 Validity

A challenge related to this thesis is that the data collection is based on articles, reports, and statistics composed for another analytical purpose and could affect the validity of this research. However, the primary sources, a scholar's own findings, are beneficial as the findings are not misinterpreted (Kildekompasset, n.d.). Due to the limited research on Industry 4.0 combining sustainability, secondary sources are also utilized in this thesis. The authors have, however, supplemented the secondary sources with other references to ensure validity. Further, the objectivity of this thesis could be a challenge, as the authors of this thesis have a close involvement when finding relevant literature. Nevertheless, as the research team consists of two individuals, continual discussion of pertinent literature has contributed to the authors' objectivity. In addition, cross-checking the references has been done to ensure that the information obtained is verified by other scholars. This allow the authors to reach a valid and objective conclusion based on the data collected.

As there is limited research on Industry 4.0 combining sustainability, this thesis aims to investigate the topic within Norwegian industries. As the thesis is relevant for numerous Norwegian industries, the outcome will be more applicable. Further, the thesis has utilized sources retrieved from the Norwegian Government and Statistics Norway to make the general findings of Industry 4.0 and sustainability, related to the Norwegian industries.

5.2 Reliability

The collected data and literature are retrieved from the search engines Google Scholar and Oria. Articles retrieved from the latter search engine are peer-reviewed due to their academic assessment of the research articles. Further, it ensures that the articles are independent and impartial (Svartdal, 2021; Utdanningsforskning, 2016). The articles from Google Scholar are chosen based on the number of citations and their relevance for this thesis. However, the selection of sources could be critical for the outcome, as crucial information could be omitted.

Reports provided by the Norwegian Government are characterized as reliable sources, as they are composed by a Government agency. However, as the Norwegian Government reports are conducted with a political focus, it could be discussed if the sources can provide transferable information related to Norwegian industries.

Evaluating the reliability of the collected data related to Industry 4.0 technologies, one could discuss if the technologies are representative of the characteristics of Industry 4.0. However, the Industry 4.0 technologies analyzed throughout this thesis are also supported by other literature. Based on this, the technologies analyzed are seen as a reliable assessment of Industry 4.0.

6. Conclusion

The thesis addresses how Industry 4.0 as a strategy relates to the UN SDGs within Norwegian industries. This chapter provides a conclusion based on the findings of this research. To conclude, two research questions are answered.

RQ1: How do the United Nations Sustainable Development Goals relate to Industry 4.0 in Norway?

The thesis found that some of the SDGs are, to a smaller extent, related to Norwegian companies utilizing Industry 4.0 technologies. Thus, the most prominent UN subgoals related to Industry 4.0 in Norway are concluded in the following. SDG3.d is related to Norwegian companies utilizing Industry 4.0, as automated processes could make working hours more flexible and reduce employees' stress levels. It also reduces the health risks related to interacting with dangerous work tasks. However, employees' physical activity could be reduced due to automatization. Thus, increase the health risks associated with obesity, which is an already existing challenge in Norway. Reskilling due to changes in work tasks is related to SDG4.4, as it could increase the rate of the Norwegian population with relevant skills. Utilizing Industry 4.0 in Norway is also related to SDG8.2, as technological innovation could improve the economic growth in Norway. The automated processes make the operations more efficient and could therefore increase the economic productivity within Norwegian companies. However, economic growth could be divided between rural and urban areas, as rural companies could experience a lack of required knowledge to handle the technologies. The local production and shortened supply chain will decrease the transportation routes, thus decrease gas emissions. Utilizing Industry 4.0 technologies within Norwegian companies is therefore related to SDG9.4. As companies can forecast demand and reduce overproduction, the technologies is also associated with SDG12.5.

RQ2: Which advantages and challenges relate to the triple bottom line for Norwegian companies with Industry 4.0 technologies?

Norwegian companies utilizing Industry 4.0 technologies generate advantages and challenges related to the TBL. Industry 4.0 technologies facilitate automatization of processes due to decreased human interaction and could therefore lower the costs of human labor. In addition, reduced human interaction will decrease errors and waste and increase accuracy within production. Further, as machines work continuously without resting, operations become more efficient. Therefore, one can conclude that utilizing Industry 4.0 technologies allows for economic productivity within Norwegian companies, thus improving economic sustainability.

Norwegian companies will increasingly demand a qualified workforce to handle the Industry 4.0 technologies. Therefore, reskilling employees is essential. Automated operations will result in changes in work tasks, and the organizational change can increase the stress level of the employees. However, the working hours could become more flexible, which can be stress relieving, thus advantageous for social sustainability. Additionally, increased automated processes will reduce employee’s interaction with dangerous work tasks, which is advantageous for social sustainability. Nevertheless, it decreases physical work and can cause increased obesity, which is already an existing challenge in Norway.

As the population density in urban areas is higher than in rural areas, utilizing Industry 4.0 within Norwegian companies can result in the demand for workforce exceeding the supply. However, rural companies could experience the opposite effect due to predicted rural flight. It could therefore be challenging for rural companies to improve their economic sustainability. As Industry 4.0 technologies facilitate local production, the transportation routes and the supply chain could be shortened. This will decrease the gas emissions related to transportation and would be advantageous for environmental sustainability. However, rural companies in Norway can experience limited sustainability improvement due to low population density and great geographical distances.

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