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# The Potential of Artificial Intelligence in Utilizing Circular Business Models

A Systematic Literature Review

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**ABSTRACT:**
Artificial intelligence is one of the fourth industrial revolution technologies that have been utilized in organizations. This research studies the potential benefits that artificial intelligence can provide to the organization in combination to circular economy. A concept of “sustainable industry 4.0” is introduced as the one concept that describes the sustainable dimension of industry 4.0 and combines circular economy and the technologies of industry 4.0. Focusing on the artificial intelligence benefits, especially in circular business models, provides the viewpoint of sustainability to artificial intelligence. Challenges and barriers to sustainable industry 4.0 and specially to utilizing artificial intelligence through circular economy and circular business models are presented.

The research focuses on business-driven transition to circular business models from the linear model with the support of artificial intelligence. The aim of this research is to identify the potential of artificial intelligence and whether it provides the organization a competitive advantage. At the same time, providing knowledge of sustainable industry 4.0 and circular business models to ease the transition towards circularity for organizations. The research question of potential benefits provided by artificial intelligence technologies to the organization when transitioned to circular business models is answered by conducting a systematic literature review.

From a total of 1634 articles, 11 papers were selected as primary study. The systematic literature review resulted in finding multiple benefits provided by artificial intelligence to organization while enhancing the transition to circular business models. Generally, the results provided a confirmation on how artificial intelligence can accelerate the transition to circularity through sustainable development goals and reciprocally sustainability provides a multifaceted platform for the artificial intelligence to work. Results presented how for example, artificial intelligence and machine learning algorithms supported decision making is the most prominent artificial technology for the organization to be beneficial. Besides the enhanced decision making, the results presented as benefits the flexibility of AI, which helps the organization to adapt to changes in the digital age as also the AI supported foundation for strategic development that leads to more sustainable business models. The results also presented drivers for organization to utilize artificial intelligence through circular business models. Such as savings and cost reductions, increased transparency and trust from consumers, and sustainable competitive advantage is seen as drivers for the organization to utilize artificial intelligence to achieve sustainable development goals.

**KEYWORDS:** artificial intelligence, business models, circular economy, decision making, sustainable development

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**TIIVISTELMÄ:**

Tekoäly on yksi neljännen teollisen vallankumouksen teknologioista, joita on hyödynnetty organisaatioissa. Tämä tutkimus tutkii mahdollisia hyötyjä, joita tekoäly yhdistettynä kiertotalouteen voi tarjota organisaatiolle. Tutkimus esittele käsitteen "kestävä teollisuus 4.0", joka kuvaa teollisuus 4.0:n kestävää ulottuvuutta sekä yhdistää kiertotalouden ja teollisuus 4.0:n teknologiat. Keskittymällä erityisesti tekoälyn tuomiin etuihin kiertotalouden liiketoimintamalleissa, tutkimus tarjoaa kestävän näkökulman tekoälylle. Kestävän teollisuus 4.0:n ja erityisesti tekoälyn hyödyntämisen haasteita ja esteitä esitellään kiertotalouden ja kiertotalouden liiketoimintamallien kautta.

Tutkimus keskittyy liiketoimintalähtöiseen siirtymiseen kiertotalouden liiketoimintamalleihin nykyisestä lineaarisesta talousmallista tekoälyn tuella. Tämän tutkimuksen tavoitteena on tunnistaa tekoälyn potentiaali ja todentaa tarjoaako se organisaatiolle kilpailuetua. Samalla tarjotaan tietoa kestävästä teollisuus 4.0:sta ja kiertotalouden liiketoimintamalleista helpottamaan organisaatioiden siirtymistä kiertotalouteen. Tutkimuskysymyksenä on: millaisia mahdollisia hyötyjä tekoäly voi antaa yritykselle siirryttäessä kiertotalouden liiketoimintamalleihin. Tutkimuskysymykseen vastataan systemaattisen kirjallisuuskatsauksen avulla.

Yhteensä 1634 artikkelista valittiin 11 artikkelia ensisijaiseksi materiaaliksi (primary study). Systemaattisen kirjallisuuskatsauksen tuloksena löydettiin useita tekoälyn tarjoamia etuja organisaatiolle siirryttäessä kiertotalouden liiketoimintamalleihin. Yleisesti ottaen tulokset vahvistivat, kuinka tekoäly voi nopeuttaa siirtymistä kiertotalouteen kestävän kehityksen tavoitteiden kautta ja miten vastavuoroisesti kestävyys tarjoaa monipuolisen alustan tekoälylle toimia. Tulokset esittivät, kuinka esimerkiksi tekoälyn ja koneoppimisalgoritmien tukema päätöksenteko on merkittävin keinotekoinen teknologia organisaation hyödyksi. Tehostetun päätöksenteon lisäksi tulokset esittivät hyötyjä olevan muun muassa tekoälyn joustavuus, joka auttaa yritystä toimimaan digitaalisella aikakaudella muutoksiin sopeutuen sekä tekoälyn tukema perusta yrityksen strategiselle kehittämiselle kohti kestävämpiä liiketoimintamalleja. Tulokset esittelivät myös kannustimia organisaatiolle tekoälyn hyödyntämiseen kiertotalouden liiketoimintamallien kautta. Esimerkiksi säästöt ja kustannusten väheneminen, lisääntynyt läpinäkyvyys ja kuluttajien luottamus sekä kestävä kilpailuetu nähdään kannustimina organisaatiolle tekoälyn hyödyntämiseen kestävän kehityksen tavoitteiden saavuttamiseksi.

**KEYWORDS:** artificial intelligence, business models, circular economy, decision making, sustainable development

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## Abbreviations

| | |
|---|---|
| AI | Artificial Intelligence |
| ANN | Artificial neural networks |
| APIs | application programming interfaces |
| CE | Circular Economy |
| CBM | Circular Business Model |
| CSR | Corporate Social Responsibility |
| ESG | Environmental, social, and governance |
| IoT | Internet of Things |
| IT | Information Technology |
| I4.0 | Industry 4.0 |
| KMS | Knowledge management systems |
| LCA | Life Cycle Assessment |
| ML | machine learning |
| PaaS | Product-as-a-Service |
| RPA | Robotic Process Automation |
| SBM | Sustainable Business Model |
| SDG | Sustainable Development Goal |
| SLR | Systematic Literature Review |
| SME | small and medium-sized enterprises |
| TBL | Triple bottom line |
| 3BL | Triple bottom line |
| 3R | reduce, reuse, and recycle |
| 4R | reduce, reuse, recycle, and renew |

# 1 Introduction

"…*all you can talk about is money and fairy tales of eternal economic growth*" (Herz, 2019).

The above citation summarizes environmental activist Greta Thunberg's speech held at the United Nations Climate Action Summit on September 23rd, 2019. It refers to the current state of climate and actions that have led the society in the situation. In the 1950s economists believed in infinite economic growth and environment as a source of resources and as a sink for waste. (Herz, 2019.) Today, we are in the midst of a climate crisis (Leahy, 2019). Organizations keep track on their sustainable and environmental actions by producing sustainability or corporate social responsibility (CSR) reports. However, the meaning of sustainability and how it should be implemented depends on how companies interpret it. (Landrum & Ohsowski, 2018, pp. 128-129.)

Circular economy offers the solution for organizations to adapt sustainability into their business models for example in terms of waste management, reusage of materials, and product design. Utilizing circular economy is estimated to create a net benefit of EUR 1.8 trillion by 2030 alone in Europe. Besides the financial benefits, circular economy addresses the resource-related challenges, creates jobs, advances and supports innovation, and generates substantial environmental benefits. (Ellen MacArthur Foundation, 2019, pp. 4-12.)

Society is inevitably being led towards new kinds of business models by circular economy from the current linear business model of "take, make, use, dispose" (Okorie, et al., 2018, p. 2). With new technology and agile methods, it is possible to expedite the transition to *circular business models*. Artificial Intelligence is in key role to enable fast and agile shift to a more diverse business model (Ellen MacArthur Foundation, 2019, pp. 4-6) that not only considers the financial benefits and impacts but also the environmental and social benefits and impacts (Lewandowski, 2016, p. 1). Research and studies of circular business models have been published at an accelerating pace in the recent years and actual models have been designed. The existing knowledge to utilize these designed circular and sustainable business models may not be enough at the moment and there are known research gaps in the field. (Ferasso, et al., 2020, pp. 3007, 3009.)

With technology and tools of Fourth Industrial Revolution, in other words *industry 4.0*, such as artificial intelligence, the systemic shift to circular business models is seen more possible and effortless (Ellen MacArthur Foundation, 2019, p. 4). AI does not have a commonly accepted definition. It can be referred to as “the ability of a machine to learn from experience, adjust to new inputs and perform human-like tasks.” (Duan, et al., 2019, p. 63.) Generally, AI is associated with human intelligence, and it can complement human skills by allowing people to deal with complexity in a more efficient manner and “make a better sense of abundant data” (Ellen MacArthur Foundation, 2019, p. 4). Three main benefits of AI technologies are the execution of time-consuming tasks to allowing people to focus on higher-value work, revealing insights from massive amounts of unstructured data, and harnessing great number of computers and other resources to solve complex problems (Nishant, et al., 2020, p. 1). With these benefits AI offers a possibility to a more sustainable future.

Utilizing AI in circular economy has not been studied as broadly as it could be. Nevertheless, new research of their integration is constantly being published. Similarly, the terminology and definition of the terms related to the combination of circular economy and industry 4.0 may become more precise with new research. This study examines the benefits of AI in combination to circular economy which refers to *sustainable industry 4.0*. The term sustainable industry 4.0 refers to the environmental impacts of industry 4.0 and how circular economy and sustainability are taken into account in industry 4.0 (Bonilla, et al., 2018, pp. 1-3; Ejsmont, et al., 2020, pp. 1-2).

## 1.1 Research Gap

Circular economy and industry 4.0 as separate topics have been researched and analysed for decades but as an integrated topic, there is only little research done in the last years (Jabbour, et al., 2018, p. 274). Due to the risen interest towards circular economy and business models in government, business, society, and academia (Ferasso, et al., 2020, p. 3006), it is important to similarly increase the number of studies and research done concerning CE and advancement of it. Artificial intelligence is one of the industry 4.0 technology tools to help advance CE. Different kinds of AI applications are expected to be developed increasingly over time. (Ellen MacArthur Foundation, 2019, pp. 4, 10.)

Di Vaio, Palladino, Hassan, and Escobar (2020) have identified in their research how AI is linked to the *Sustainable Development Goals (SDGs)* that are outlined in the 2030 Agenda by United Nations. The research recognizes how the increasing use of data management is a leading reason for enterprises to implement AI in their solutions. Besides data management for private organizations the use of AI is to improve their competitive advantage. As per the SDGs, they represent common goals that address for example sustainable economic growth and industrialization (United Nations, 2015).

Circular business models are extensively analysed within the broad framework of sustainable development principles and the achievement of SDGs (Ferasso, et al., 2020, p. 3015). Nishant, et al. (2020) stress how central money has been for capitalist societies to evolve from and still function from even today. The researchers propose following to measure economic value for AI: "AI for sustainability should examine the economic value of AI for sustainability to develop our understanding of how AI differs from conventional Information Systems."

The meaning of AI has changed throughout the decades as AI is constantly evolving and advancing. AI based systems for decision making have been described with the following terms for example: "expert systems, knowledge-based systems, intelligent decision support systems, intelligent software agent systems, intelligent executive systems, etc."

(Duan, et al., 2019, p. 67.) However, it is difficult to prognosticate what the future of AI looks like as it is still in its infancy (Di Vaio, Palladino, Hassan, & Escobar, 2020, p. 283). In consequence of Big Data powered technologies, there is a new generation of AI in the era of Big Data. Duan, et al. (2020) propose in their research that AI as a concept should be re-defined to express the changing nature of AI development and applications in the Big Data era.

Ferasso, et al. (2020) studied the relationship of CE and business models in the current business and management literature. The findings revealed networks of topics and research gaps related to artificial intelligence in CE. The role and influence of disruptive technologies such as artificial intelligence in circular business models need further research and studies as it is not clear. It is unknown in what extent and how the disruptive technologies influence circular business models and what is the impact in organizations that adopt these new technologies. The research gap can also be viewed from another viewpoint such as the extent to which the circular economy can influence the uptake of new technologies by organizations. (Ferasso, et al., 2020, p. 3015.) This research focuses on the relationship of artificial intelligence and circular economy in organizations as an integration in the business model.

## 1.2 Research Objectives and Research Question

The main objective of this research is to study the possible benefits of artificial intelligence in transition to circular business models. One of the objectives is to identify AI based solutions in business models in which the business can become more sustainable. The research focuses on benefits achieved by organizations through AI and aims to verify why there is a need to transit into circular business models from the current linear business model. The viewpoint of the study is on how AI promotes the transition.

The research combines circular economy and industry 4.0 and examines the conditions under which combining these ideologies the organizations are able to pursue sustainable industry 4.0. Research objectives of this research will be analysed by answering the following research question:

*How does artificial intelligence benefit organizations in utilizing Circular Business Model(s)?*

The research question supports the main aim of this research: to identify the potential behind artificial intelligence in utilizing circular business models and whether it offers organizations the possibility of a competitive advantage. This research also aims to increase and clarify the knowledge and context of a circular business model which could ease the transition into CBM for organizations. By analysing CBMs and sustainability in organizations, this research provides knowledge of circular economy and its potential from the economic and environmental viewpoints. The research question is answered by conducting a systematic literature review.

The research is conducted by first opening the meaning behind terms such as artificial intelligence, circular economy, circular business model, and sustainable industry 4.0 in chapter 2. With chapter 2 including the concepts and terminology, chapter 3 dives into the theory of combining AI, CE, and sustainability. After the theory of AI and CE, the method of systematic literature review will be introduced in chapter 4 as the chapter includes a detailed information of the review process and method. Next, chapter 5 introduces the data, and results from the conducted systematic literature review will be presented. Results will be discussed in chapter 6 as the chapter will conclude the research and acknowledge the results of conducted research reflected to the composed synthesis.

# 2 Sustainable Industry 4.0 and Sustainability

The term *Sustainable industry 4.0* does not yet have a commonly agreed definition in the literature as it has not been researched in great depths. The term itself is rather new to the field of combining sustainability and industry 4.0. (Ejsmont, et al., 2020, pp. 1-3.) Salvador da Motta Reis, et al. (2021, p. 3) study how to achieve sustainability through intelligent industry 4.0 technologies, hence the authors use term "sustainability 4.0" to describe the sustainable dimension of industry 4.0. Harikannan, et al. (2021, p. 358) have defined sustainable industry 4.0 in their research as "using the superior capabilities of industry 4.0 in conjunction with tools, techniques, practices, and procedure of sustainability to achieve the goals of triple bottom line benefits for an organization."

As industry 4.0 as a concept was introduced only a decade ago in 2011, it illustrates exclusively the technology-driven and agile nature of the concept. By adding sustainability into I4.0, businesses can expect great benefits by for example increased energy efficiency and decreased amount of manufacturing scrap waste. I4.0 with a sustainability viewpoint is considered trending and there is a growing number of reviews and studies published over the last years. (Ejsmont, et al., 2020, pp. 1-3.)

The following chapter will introduce the concepts and definitions related to this research as terms such as *sustainability* and *artificial intelligence* can be interpreted from multiple viewpoints. The chapter introduces the scope in which these terms are used and includes the concept map to illustrate the relationship between concepts.

## 2.1 Concepts and Definitions

The definition of *Sustainable industry 4.0* presented in this research is combined from many definitions in the literature. As a concept, sustainable industry 4.0 includes the technologies of industry 4.0 such as artificial intelligence and the circular approaches from circular economy (Ejsmont, et al., 2020, pp. 1-3). From sustainability viewpoint, sustainable industry 4.0 includes the sustainable development goals that can be advanced with industry 4.0 technologies to improve environmental and sustainable performance (Bonilla, et al., 2018, p. 18) that is often measured with corporate social responsibility (CSR) reports (Landrum & Ohsowski, 2018, p. 128).

Though environmental and sustainable performance with CSR reports is not in the scope for this research, it is important to understand how related the two areas of environmental and sustainable performance, and circular approaches in sustainability are. CSR is related to terms such as sustainable development, corporate sustainability, and the triple bottom line. (Landrum & Ohsowski, 2018, p. 129.) Sustainable development is defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987). Whereas corporate sustainability is seen as "*more humane, more ethical, and more transparent way of doing business*" which includes the viewpoint of sustainable development in business (Marrewijk, 2003, p. 101).

The term *triple bottom line* has been in use since the 90s and describes the measurability of social and environmental performance. The results of measuring social and environmental performance ought to be used to improve these "bottom lines". These improved two bottom lines are thought to have a positive correlation in a long run to a third bottom line: financial bottom line. (Norman and MacDonald, 2004, pp. 244, 246.) Cricelli and Strazzullo (2021, p. 1) describe organizations' essential qualities that are to be considered sustainable along the framework of TBL; organizations must be "economically viable, environmentally friendly and socially responsible".

Pava (2007, pp. 108-109) arguments Norman and MacDonald's way of describing triple bottom line by explaining financial realm in an organization to be more complex than by expecting correlation just by summarizing social and environmental performance. The author therefore suggests that instead of term "3BL" as in triple bottom line, the term should be *multiple bottom line* to describe the multi-dimensional character of corporate performance. Pava expresses:

> *"There is no bottom line nor was there ever a bottom line – only multiple and contingent bottom lines".*

The author's reason for correcting the thought of singular bottom lines to multi-dimensional and contingent bottom lines is that if the terms regarding sustainability are used with a narrow point of view, they are easily misused to gain organizational benefits by misleading the consumers to associate the company to seem "green" or sustainable when in fact, it is not sustainable comprehensively (Pava, 2007, p. 109).

All of these above introduced terms relating to sustainability have been in use for decades and are often used interchangeably regardless the on-going debate on differentiating the terms. (Landrum & Ohsowski, 2018, p. 129.) Schwarts and Carroll (2008, p. 169) stress that no matter under what term the value is generated by the business, it must be sustainable. By placing value creation in the core focus of a business model, it will allow concepts such as CSR and sustainability to be adapted naturally in the business (Wheeler, et al., 2003, p. 2).

Achtenhagen, et al. (2013, p. 2) describe how important it is for an organization to be able to change and develop the business model to achieve sustained value creation. If the organization is not able to change their business model as their environment changes, they have a high risk of failing. Not because they did wrong commitments and choices or mediocre actions, but because they pursued with the same path for too long and fell victim to the rigidity of their business model. (Doz & Kosonen, 2010, p. 370.)

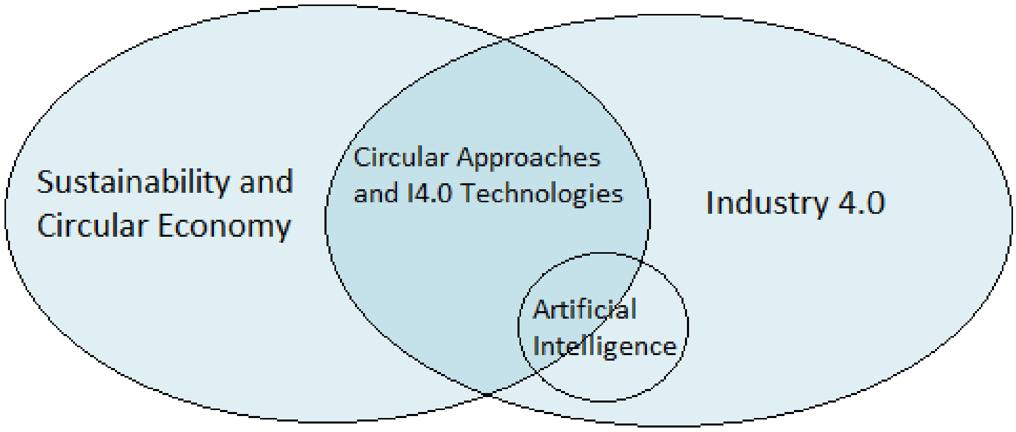
The confusion in concepts in the field of sustainable business is summarized well by Marrewijk (2013):

*An intensive debate has been taking place among academics, consultants and corporate executives resulting in many definitions of a more humane, more ethical and a more transparent way of doing business. They have created, supported or criticized related concepts such as sustainable development, corporate citizenship...Triple Bottom Line, business ethics, and corporate social responsibility... [The] wide array of concepts, definitions and...lots of critique...has put business executives in an awkward situation, especially those who are beginning to take up their responsibility towards society and its stakeholders, leaving them with more questions than answers.* (pp. 95-96.)

Ruggerio (2021) identifies several authors that note the flawed definitions of e.g., the concept of sustainable development. The WCED (1987) definition of sustainable development is seen insufficient decades later by multiple authors. Ruggerio's review on definitions is a contribution to the ongoing debate regarding definitions of terms and concepts related to sustainability. The author states regarding the definition of sustainable development, that because of the continuous development of ideology of the concept and its lack of precision, the debate stays unsolvable. (Ruggerio, 2021, pp. 2-4.) Marrewijk (2013, p. 96) stresses the same results regarding the concept of corporate social responsibility. The concepts and definitions that are currently used related to sustainability are often biased towards specific interests and viewpoints.

## 2.2 Terminology and Concept Map

The picture 1 below represents the combination between circular economy and industry 4.0. The amalgamation can be described as circular approaches with technologies of industry 4.0 such as artificial intelligence. Picture 1 describes the research focus, theme, and terminology of this research. The picture 1 is based on Okorie, et al. (2018, p. 7) illustrated picture of their article research focus where the authors describe the combination of circular economy and industry 4.0. In this research, AI has been placed in between the "Industry 4.0" and "Circular Approaches and I4.0 Technologies" as it is not only exploited in circular economy purposes but is rather one of the potential tools to be benefitted from in the purpose of advancing CE (Okorie, et al., 2018). As of the industry 4.0 technologies, this research focuses on artificial intelligence from the many technologies of industry 4.0.




**Picture 1.** Research focus of combining Circular Economy and Industry 4.0 based on Okorie, et al. (2018, p. 7)

The amalgamation between CE and I4.0 is not named as “Sustainable Industry 4.0” in picture 1 that describes the combination of the two subjects. In this thesis, *sustainable industry 4.0* is considered as a roof term to “Circular Approaches and I4.0 Technologies” as described in figure 1. Sustainable industry 4.0 is more diverse than including only “Circular Approaches and I4.0 Technologies” (Bonilla, et al., 2018, p. 18; Salvador da Motta Reis, et al., 2021, p. 3) but due to the aim of this research, other concepts have been excluded.

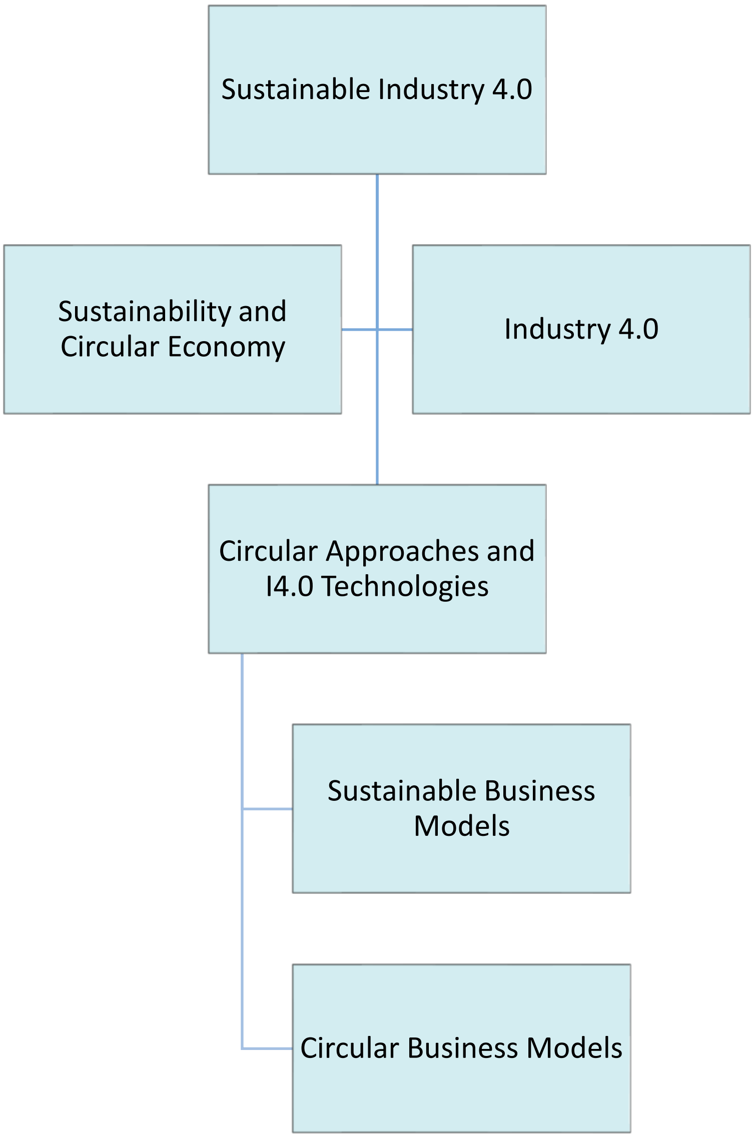



**Figure 1.** Concept map based on Bonilla, et al., 2018, p. 5; Ejsmont, et al., 2020, pp. 1-3; Hofmann, 2019, p. 363

The concept map in figure 1 above illustrates the relationships of the used main terminology in this thesis. Below the roof term *Sustainable Industry 4.0* is the two separate terms *Sustainability and Circular Economy* and *Industry 4.0.* These two are then combined as *Circular Approaches and I4.0 Technologies* that include terms such as *Circular Business Models* and *Sustainable Business Models.* The viewpoint of business models represents the organizational viewpoint in this research. The terminology presented has been gathered from multiple different studies. (Bonilla, et al., 2018, p. 5; Ejsmont, et al., 2020, pp. 1-3; Hofmann, 2019, p. 363.)

# 3 Circular Economy and Artificial Intelligence in Organizations

Circular economy and artificial intelligence can be combined in organizations through circular business models in which the artificial intelligence is used as a tool to emphasize the circularity. The following chapter introduces the dimensions of circular economy and circular business models, and the variety of ways how artificial intelligence can be utilized to increase the circularity of organizations.

## 3.1 Circular Economy

> *"An economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and material loops, and facilitate sustainable development through its implementation…"*

The above definition of circular economy (CE) is based on the academic literature reviewed by Prieto-Sandoval, et al. (2018, p. 610). In essence, the focus in CE is to maximize the circularity of resources and energy within production systems. The model acknowledges the fact that natural resources are scarce, and waste at the end of its lifecycle may retain some of its value. (Ghisellini, et al., 2016, pp. 1-2.) CE's principle is refined from the so-called linear economic model that is described as "take, make, use, and dispose" -economic model. The circularity in the system means that after disposal, the materials are alternatively recycled, recovered or reused. (Okorie, et al., 2018, p. 2; Prieto-Sandoval, et al., 2018, p. 608.) All in all, with more efficient use and reuse of resources the idea is to be able to reduce negative environmental impacts and to achieve balance between the economy, environment, and society (Ghisellini, et al., 2016, pp. 1-2).

Roots to the circular system comes from the ideology of "3R framework" that entails reducing, reusing, and recycling (Hartley, et al., 2020, p. 1). The principle of 3R is also recognized as 4R with including renewing as the fourth "R". The purpose of 3R/4R is to enable factors that enhance the lifecycle of a product by reusing it after the first cycle of usage. These factors are e.g., Product-as-a-Service (PaaS), consumption patterns, collection of used goods, repair, and an efficient distribution and material handling system. (Patwa, et al., 2021, p. 726.)

Hartley, et al. (2020, p. 2) concludes the fact that after nearly 30 years of developing the concept of CE, there is still no scholarly consensus of the concept. The research of Okorie, et al. (2018) identified the key difference in the many definitions of CE to be derived from the fact that it is handled by different stakeholders with different viewpoints. Prieto-Sandoval, et al. (2018, pp. 608, 610) conducted a systematic literature review to gather a dozen explicit definitions of circular economy. The authors were able to summarize four essential components from these gathered definitions that are necessary to establish the concept of CE:

1. The recirculation of resources and energy, the minimization of resources demand, and the recovery of value from waste
2. A multi-level approach
3. Its importance as a path to achieve sustainable development
4. Its close relationship with the way society innovates

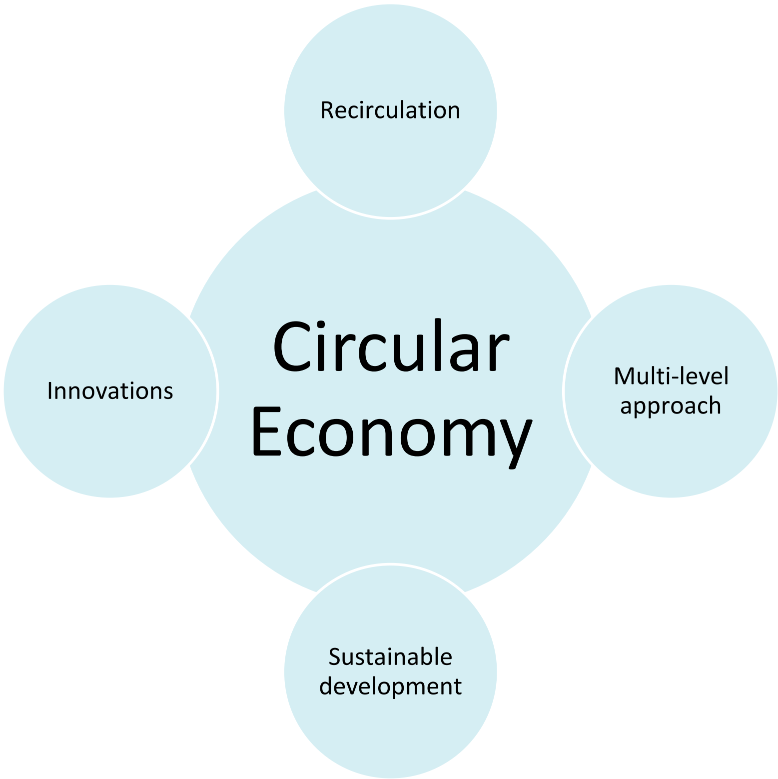



**Figure 2.** The four essential components of Circular Economy (Prieto-Sandoval, et al., 2018, pp. 608, 610.)

The fourth component of "close relationship with the way society innovates" is related to governments and policy makers. Regulation and policy determinants are in central position to influence and motivate consumers' and suppliers' environmental practices. To ease the transition to CE implementation, policy makers may propose instruments to decrease resource demand and make a change in consumer behaviour. These instruments are such as incentives for example repairing or renovating products (including electronics) instead of purchasing new ones and encouraging a sharing economy. (Kalmykova, et al., 2016, p. 80.) Therefore, it is important for organizations to change as their environment changes and adjust their business model to become slowing, closing, and narrowing resource loops (Ferasso, et al., 2020, p. 3007).

## 3.2 Circular Business Models

Circular business models, CBMs, are a sustainable system with intelligent and connected activities that define how organizations create value whilst in accordance with CE principles (Ávila-Gutiérrez, et al., 2020, p. 6; Lüdeke-Freund, et al., 2018, p. 36). Business models in general can be described as following: *"(1) the business model is a unit of analysis that is distinct from the product, company or network. It is centred on a focal company, but its boundaries are wider than those of the company; (2) business models emphasize a system-level approach to explain how companies run their businesses; (3) business models explain both value creation and value capture."* (Antikainen, et al., 2018, p. 46; Zott, et al., 2011.) CBMs can be considered to be included in the broader group of SBMs, sustainable business models (Lüdeke-Freund, et al., 2018, p. 41).

CBMs can be separated into three groups: slowing resource loops, closing resource loops, and narrowing resource flows (Bocken, et al., 2016, p. 309). Slowing the loop is a model of extending the product life cycle by design and maintenance. The second group, closing the loop, focuses on efficient recycling of materials and can be accomplished through e.g., by industrial symbiosis. The third group, narrowing the loop or resource flow targets at using less resources per product and can be significantly boosted by intelligent technologies. As these above presented models are closely supporting to each other, often circular business models include multiple groups or even all of them. (Antikainen, et al., 2018, p. 46.)

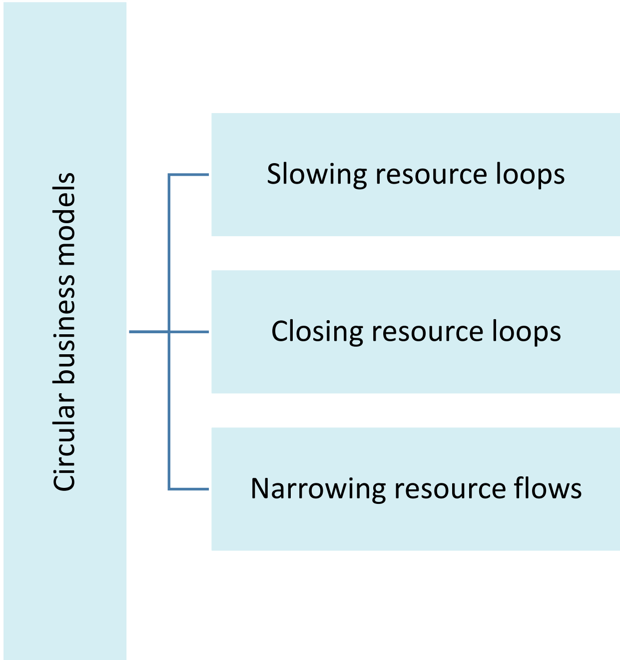



**Figure 3.** Categories of circular business models (Bocken, et al., 2016, p. 309.)

Antikainen and Valkokari (2016, p. 7) identify consumers having a large role in CE as the relationship between consumers and products will change drastically from owning to e.g., buying access to a service. Other archetypes of sustainable or circular business models are e.g., creating value from waste, substituting with renewables and natural processes, adopting stewardship role, encouraging sufficiency, re-purposing the business for society, and developing scale-up solutions (Bocken, et al., 2014, p. 48). The sustainable and circular business models integrate elements from macro (global trends and drivers), meso (ecosystem and value co-creation), and micro (company, customers, and consumers) levels (Antikainen & Valkokari, 2016, p. 8). At the micro level organizations are focused on their own development processes, meso level includes companies of an industrial symbiosis where benefits go not only to the regional economy but also to the natural environment, and macro level aims to develop eco-cities, eco-municipalities or eco-provinces through the development of environmental policies (Geng, et al., 2012; Ormazabal, et al., 2016; Yuan, et al., 2006).

Truly the CBMs offer a change into the ideology of business strategy. Hofmann (2019, p. 371) argues how CBM conceptions must go beyond efficiency and consistency strategies. A rebound effect has been identified in linkage to circular economy. As there is a strong parallel regarding energy efficiency rebound, Zink and Geyer (2017, p. 593, 600) have termed the rebound effect regarding CE as "*circular economy rebound*". The authors describe circular economy rebound occurring in CE activities that have a lower per-unit-production impacts which also cause increased levels of production by reducing their original positive benefit. By evaluating the net consequences of environmental impacts of organizational activities, it is possible only then to answer when bolstering the CE is environmentally worthwhile. Zink and Geyer point out: "*What is truly required to reduce environmental impact is less production and less consumption.*"

## 3.3 Industry 4.0

Efficiency, accuracy, and precision are the qualities that describe the fourth industrial revolution, industry 4.0. It has emerged as the promising technology due to advancement in disruptive technologies such as artificial intelligence and big data. (Rajput & Singh, 2021, p. 1717.) Big data is a key in industry 4.0 to reveal new forms of value creation in organizations (Bonilla, et al., 2018, p. 4). Big data technologies have a revitalizing impact to AI as the use of the new generation of AI in decision making is looking promising (Duan, et al., 2019, pp. 63, 67). "Intelligent" factories are connected to the progression of industry 4.0. AI is one of the technologies that bring organizations closer to digital transformation. (Cricelli & Strazzullo, 2021, p. 3.) Machine learning approaches and AI algorithms are seen as opportunities for industry 4.0 that have major benefits in sustainable manufacturing as they aim to improve sustainability, especially in the manufacturing units. (Jamwal, et al. 2021, p. 9).

### 3.3.1 Artificial Intelligence

As introduced earlier, AI can be described as “the ability of a machine to learn from experience, adjust to new inputs and perform human-like tasks” (Duan, et al., 2019, p. 63). Another definition of AI describes it as “computational agents that act intelligently” (Poole & Mackworth, 2010, p. 3). Paschen, et al. (2020, p. 2) identify the main difference in these two definitions that is the latter definition does not emphasize AI as humanlike intelligence but rather involving an agent in the process. An agent is something that perceives and acts in an environment by doing actions in practice and not just by in theory. An agent is considered to act intelligently when it makes actions appropriately for its circumstances and changing goals, it is flexible to changing environments and goals, it learns from experience, and it acts accordingly and makes appropriate choices taking in note its perceptual and computational limitations. (Poole & Mackworth, 2010, p. 4.)

The following description by Vinuesa, et al. (2020, p. 1) represents all AI technology that are accounted for in this thesis:

> *“… we consider as AI any software technology with at least one of the following capabilities: perception – including audio, visual, textual, and tactile (e.g., face recognition), decision-making (e.g., medical diagnosis systems), prediction (e.g., weather forecast), automatic knowledge extraction and pattern recognition from data (e.g., discovery of fake news circles in social media), interactive communication (e.g., social robots or chat bots), and logical reasoning (e.g., theory development from premises). This view encompasses a large variety of subfields, including machine learning.”*

Weichhart, et al. (2015) identify sensing, smart, and sustainable organizations being the path for enterprises that want to stay competitive in the changing environment. The authors list accelerating technologies such as big data analytics that are a part of the entire system behind smart and sustainable organizations. Weicchart, et al. suggest companies to become smart and sustainable, they need to adapt improved business models. An AI based tool, such as big data analytics, can be used as a decision-making model to collect and process large quantities of product and customer data and utilize the results in developing successful and profitable circular business models for the organization (Ellen MacArthur Foundation, 2019, p. 14). Shortly described, organizations that utilize AI and ML are using computational and mathematical models to e.g., their decision-making (Mishra & Tripathi, 2021, p. 1).

### 3.3.2 Different Technologies of Artificial Intelligence

Duan, et al. (2019, pp. 64-65) implemented research of identifying the varying AI algorithm techniques and/or forms of knowledge representation. The authors identified five main categories of AI technologies and some minor others. The identified main technologies are rule-based inference, semantic linguistic analysis, Bayesian networks, similarity measures, and neural networks. Some other techniques are e.g., frame-based representation, and genetic algorithms.

Out of all, the rule-based inference is the most common technique which nowadays uses rules that are most likely developed by automated method such as classification and regression trees or association rule mining. Semantic linguistic analysis maps natural language in documents for retrieving information. Bayesian networks are rather new and utilizes learning in intelligent systems. It is based on probability-based reasoning where conditional probabilities associated with the path between nodes in a network adapt new data which entails learning. Similarity measures identify examples of similar or close to a new observation into clusters which is considered as case-based reasoning. (Duan, et al., 2019, p. 65.)

Neural networks are also called as artificial neural networks (ANN) which are supposed to copy the way the human brain works.  ANN has not been utilized broadly based on the research done by the authors. Other techniques such as the frame-based representation allows broader and richer representation of knowledge than rules but is more complex, and thus is not as much utilized. Genetic algorithms copy the process of Darwinian natural selection until the greatest solution is found. (Duan, et al., 2019, p. 65.)

### 3.3.3 Sustainability in Artificial Intelligence

Industry 4.0 is seen as serving the purpose of 3R (reduce, reuse, and recycle) well by prolonging the usage value of a product, materials, and components (Rajput & Singh, 2021, p. 1733). Patwa, et al. (2021, p. 728) agree on artificial intelligence increasing the 3R applicability in organizations. AI can have a pivotal role in expediting and acquiring CE principles. For example, organizations can use product concept designs created by AI to change the way materials are developed for consumer electronics. This improves the product lifecycle and reduces the design cycle and waste material. By performing a large-scale pattern-recognition, AI can solve environmental problems with the extensive amounts of data and gives the opportunity to e.g., expedite policies (Nishant, et al., 2020, p. 2).

Nishant, et al. (2020, p. 5) identified in their literature review that machine learning (ML) has been exploited in many AI solutions for sustainability. Authors note that with ML observing models and relationships, AI is able to learn and make predictions from the historical data. With developed algorithms, advanced or 'deep' ML can extract new information from a vast amount of data (Paschen, et al., 2020, p. 4).

The potential sustainability related benefits and harms that are linked to AI, can be evaluated and categorized through sustainable development goals. The SDGs cover environmental goals, goals related to social justice, and economic growth, health and employment. Therefore, SDGs are convenient for analysing the sustainability of AI that include both viewpoints of benefits and harms of AI in sustainability. SDGs are useful in analysing how AI is utilized for sustainable activities and whether the usage of AI might have negative environmental impacts. (Sætra, 2021, p. 2.) Companies are increasingly required to take measures to increase sustainable development, in which case the challenges of improving the scale of innovations must take place in ways that the company is able to preserve ecosystem integrity and improve the use of natural resources (Joyce & Paquin, 2016).

## 3.4 Utilization of Artificial Intelligence in Organizations

In organizations AI is used to intensify decision making, reinventing business models and ecosystems as also to improve customer experience into new extent (Duan, et al., 2019, p. 63). Decision making and customer experience are included in business models as decision making is linked to the strategy that leads the business model, and customer experience is one of the most important dimensions of what the company wants to achieve with the business model. As if the customer experience is not ideal and the services or products does not appeal to the customer, it brings only minimum value for the company to execute business that is based on the chosen business model. Panetta (2017) refers to a Gartner survey conducted in 2017, how in year 2017 only 59% of the organizations are in the midst of developing and gathering information to build their AI strategies. This points out the young age of AI technology what we consider intelligent in the current era.

Cricelli and Strazzullo (2021, p. 4) address the full integration of digital technologies such as AI into corporate business models enabling economic and environmental benefits through e.g., better corporate image, energy savings, reduction of material costs, and resource efficiency. More in detail, the authors identified 21 economic sustainability metrics through systematic literature review that were associated with industry 4.0 technologies. With AI the found economic sustainability metrics were competitiveness, customization, economic development, extension of product/equipment life cycle, fostering innovation and entrepreneurship, market share, reduction of water consumption, reduction of production mistakes and accidental damages, reduction of waste costs, and resources recovery. The metrics were divided into having either direct or indirect impact.

Direct metrics impact the company's economy whilst the indirect metrics have an impact in the global economy of the environment where the company operates. The metrics are presented in table 1.

**Table 1.** Classification of economic sustainability metrics associated with artificial intelligence (Cricelli & Strazzullo, 2021, p.8.)

| **Economic Sustainability Metrics** | **Direct** | **Indirect** |
|---|---|---|
| Competitiveness | x | |
| Customization | | x |
| Economic development | | x |
| Extension of the product/equipment lifecycle | | x |
| Fostering innovation and entrepreneurship | | x |
| Market share | x | |
| Reduction of water consumption | | x |
| Reduction of production mistakes and accidental damages | x | |
| Reduction of waste costs | | x |
| Resources recovery | | x |

The above presented metrics measure the potential benefits of AI from a viewpoint of economic sustainability. Combining sustainability and AI, the organization gains economic opportunity to increase competitiveness and market share, which favours development of new business models. The further the transitioning goes with implementing AI (and other industry 4.0 technologies) with sustainability focus, the closer the entire industrial sector is of complete revolutionizing with new business models. AI has positive impact to the sector with ability to mass customization, extending product or equipment life cycles, and enhancing innovation. In longer time period, AI has potential impact in reducing company's water consumption, waste costs, and it enables the company to use resources efficiently. (Cricelli & Strazzullo, 2021, p. 10.)

## 3.5 Challenges in Sustainable Industry 4.0

Rajput & Singh identified 20 barriers in their study of industry 4.0 and in which ways it is challenging to achieve circular economy. These barriers are e.g., data analysis, smart devices development, automation system virtualization, investment cost, global standards, security, and other barriers regarding the technology and its implementation sustainably. Data analysis is seen as a challenge as analytics is a mandatory tool in industry 4.0 as voluminous data is captured in different formats and the data to be useful for the organization, it needs to be retrieved as user-ready. (Rajput & Singh, 2021, pp. 1725-1726.)

Compatibility and the development of smart devices is also important and represents itself as a challenge to the organization. The industry 4.0 environment needs smart and advanced devices for the system components to be able to communicate with each other without human intervention. (Rajput & Singh, 2021, pp. 1725-1726.) Paschen, et al. (2020, p. 7) stress the current lack of standards that may lead to incompatible application programming interfaces (APIs) which can result in interoperability and usability gaps in AI applications.

The idea of industry 4.0 is to be efficient which also means reducing the human intervention and maximizing the real-time visibility of the operation processes by virtualizing the automation system. However, the investment cost presents itself as a challenge as it is required to standardize the infrastructure and to develop smart devices and sensor technology. The security is also seen as a challenge as vulnerability is high in attacking the system and to be conducting industry 4.0 safely, prerequisites standards and protocols are essential for data sharing when processing the data. (Paschen, et al., 2020, p. 7; Rajput & Singh, 2021, pp. 1725-1726.) Nevertheless, Rajput and Singh (2021) state that after identifying these barriers and challenges the organizations face with industry 4.0 integration to circular economy, overcoming them could be the next major step towards achieving circularity.

Vinuesa, et al. (2020, p. 6) have studied the possible negative effects of implementing AI. The organizations must consider the negative effects in order to have a holistic view of the technology to be implemented. One of the negative viewpoints is how AI-based developments are based on the needs and values of nations in which AI is being developed. If the organization has businesses in multiple nations, it is important to check the basis of ethical usage and transparency of AI before conducting further analysis or decision-making based on AI.

Jamwal, et al. (2021, p. 16) stress the importance of worker's skillsets regarding industry 4.0 technologies, including AI. SMEs often do not have a dedicated team for industry 4.0 activities which indicates the lack of required skillsets in SMEs. AI can accelerate personal development schemes or learning programs based on the experience and personality of each employee (Cricelli & Strazzullo, 2021, p. 11). Jamwal, et al. (2021, p. 16) suggest the following approaches to improve skillsets through continuous learning to avoid such a barrier in organizations:

1. *Development in technical skills*
2. *Virtual training programs*
3. *User's view-centered processes*
4. *Development in digital and soft skills*
5. *Manufacturing systems*

# 4 Research Method and Process

This research is conducted as a systematic literature review. Systematic literature review aims to identify, evaluate, and interpret all available research that is relevant and related to a particular research question, topic, or phenomenon of interest. (Kitchenham & Charters, 2007.) This method is selected as a research method for its suitability to elucidate extensively the answer to the research question of this research and to summarize past and current research related to the objectives of this research. Systematic literature review makes it possible to identify potential gaps in current research and minimizes prejudices about published and unpublished studies through a thorough literature search (Kitchenham & Charters, 2007; Tranfield, et al., 2003, p. 209).

Originally systematic literature review with its phases was developed for health science and medical research (Fink, 2005; Kitchenham & Charters, 2007). On this basis, Okoli (2015) developed tailored guidelines for information systems science research to better meet the goals and objectives of the research field. The tailored guidelines of SLR methodology are systematic to follow a methodological approach, explicit to explain the process it is conducted by, comprehensive to include all relevant research material, and reproducible by others to mimic the review process. (Okoli, 2015, p. 880.)

The eight sub phases of the SLR of this research are divided into five main phases. The main phases are as follows: planning the review, conducting the search, search assessment, analysis and synthesis, and reporting results. (Okoli & Schabram, 2010, p. 9; Ghanbari, et al., 2018, pp. 4-6; Kitchenham & Charters, 2007, pp. 884-885.) The main and sub phases are shown in figure 4.

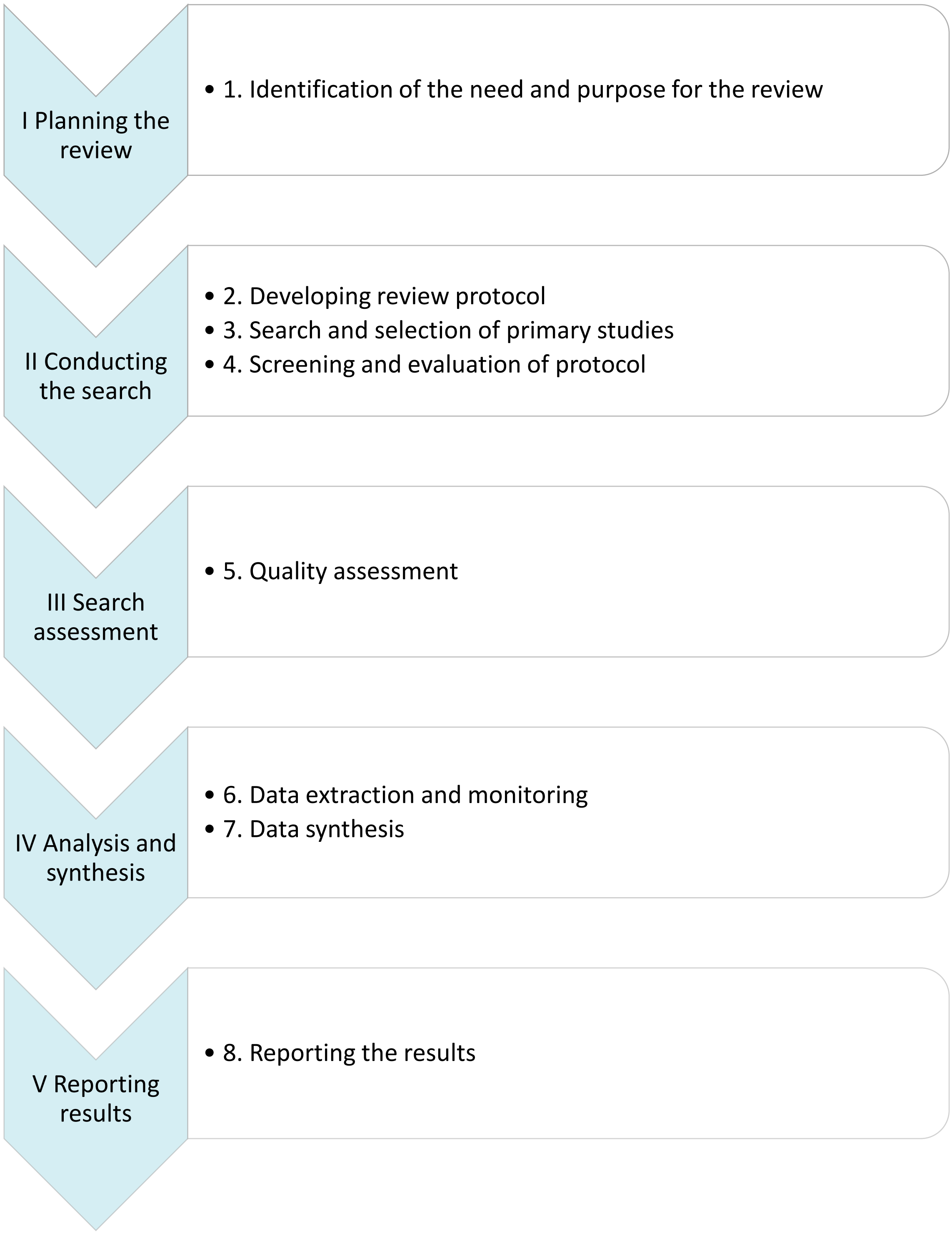



**Figure 4.** The main and sub phases of the systematic literature review (Okoli & Schabram, 2010, p. 9; Ghanbari, et al., 2018, pp. 4-6; Kitchenham & Charters, 2007, pp. 884-885.)

## 4.1 Planning the Review

The first main phase of the research involves the sub phase of *identification of the need and purpose for the review.* The need for a systematic review stem from the demand for researchers to summarize all pre-existing data on a phenomenon thoroughly and objectively. This makes it easier and clearer to draw general conclusions about a phenomenon than from individual studies. The desired goals and purpose are accurately identified so that the purpose of the research is explicitly stated to the readers of the research. (Kitchenham & Charters, 2007, p. 7; Okoli & Schabram, 2010, p. 7.)

## 4.2 Conducting the Search

The second main phase involves several sub phases that are *developing review protocol, search and selection of primary studies*, and *screening and evaluation of protocol*. Developing review protocol involves formulating and setting the research questions which is the most important part of a systematic literature review as they define the entire literature review process. The search identifies research material that specifically answers the research questions set for the research. In the data collection phase, the necessary information is extracted to answer the research questions and in the analysis process, the synthesis must be designed so that the research questions can be answered. In addition to formulating and setting questions, the development of a protocol defines the methods used to systematically review data. A pre-defined protocol is necessary to view the data objectively. (Kitchenham & Charters, 2007, pp. 8-13.)

When searching for literature, it is important to find as many primary studies as possible that is related to the research question. The literature search should be described in detail and the research material should be documented. The search must be explicitly explained and justified as to why it was executed in this specific way. Setting up a practical screen gives the search inclusion and extraction criteria. (Kitchenham & Charters, 2007, p. 14; Okoli & Schabram, 2010, p. 7.)

In this research, the terms in table 2 are used as keywords for the search. The search terms selected are thought to give a broad arrange of articles as e.g., “AI” has more than one suitable definition as the term meaning has varied through decades by the development of technology and what is seen as artificial intelligence. The search terms “circular business model” and “sustainable business model” are thought as synonyms in the search as circular business models are also sustainable business models.

Three databases are chosen for this research: Scopus, EBSCO, and Science Direct to identify relevant studies. A manual search is conducted by using Google Scholar and four articles, that are identified as relevant, are added to the total amount of retrieved articles. The results of performing the search on the selected databases are described in table 3. The search is conducted on 21st of August in 2021. Admission criteria for the articles included all English language studies, but other language studies were excluded. Other than “open access” publications are excluded. All publications published until August 30$^{th}$, 2021, are included. After the screening, the results are combined into an Excel spreadsheet including a total of 563 rows of records.

**Table 2.** Identified search terms based on research objectives

| | |
|---|---|
| Primary search terms | AI, Artificial intelligence, Industry 4.0 |
| Secondary search terms | Circular business model, Sustainable business model |
| Search string | *(“AI” OR “Artificial intelligence” OR "industry 4.0") AND (”Circular business model” OR "Sustainable business model")* |

**Table 3.** The results of the search conducted in August 2021

| Database | Total number | Date range |
|---|---|---|
| Scopus | 1289 | 2007 – 2021 |
| EBSCO | 22 | 2016 – 2021 |
| Science Direct | 319 | 2017 – 2021 |
| Manual search | 4 | 2000 – 2021 |
| Total | 1634 | 2000 – 2021 |
| Total after screening | 563 | 2000-2021 |

*Note. Manual search was conducted in Google Scholar.*

## 4.3 Search assessment

The search assessment phase includes a sub phase of *Quality assessment* in which the searched studies is mechanically reviewed by hand with more precise inclusion and exclusion criteria. The more detailed criteria provide the researcher to critically assess the quality of primary studies. (Kitchenham & Charters, 2007, p. 20.) The quality assessment is divided into three rounds. In the first round, the title and abstract of each study is read. In the second round, the introduction and summary of each study is read. In the third round, each study is read completely. The quality assessment of this research is conducted in the end of August 2021 and during September 2021.

After removing the duplicate records and reviewing the titles and abstracts, 90 articles were identified and selected for second round of quality assessment. 473 articles were excluded from further analysis due to being unrelated to CE or AI or did not relate to the research question in any viewpoint. After second round of quality assessment, 26 articles were selected to be fully read. By reading introductions and conclusions in the second round, papers that had too narrow viewpoint to AI and CE or did not have relative research agenda were excluded. After reading 26 full texts in the third round, 11 of them were identified as eligible for the research. The selected 11 articles were selected due to their specific viewpoint to CE or AI, relative content of sustainable/circular business models, and the relevant case studies. Table 4 below shows the evaluation process in summary.

**Table 4.** The three rounds of evaluation for selected primary studies

| Round | Number of articles | Excluded articles | Evaluated based on |
|---|---|---|---|
| 1st | 563 | 473 | Title and abstract |
| 2nd | 90 | 64 | Introduction and conclusions |
| 3rd | 26 | 15 | Entire study |

## 4.4 Analysis, Synthesis, and Reporting Results

After conducting and evaluating the search, sub phases of *Data extraction and monitoring* and *Data synthesis* can begin. During the data extraction and monitoring, information that is relevant and applicable to the research objectives should be systematically extracted from each article to be included in the study. Table 5 presents the data extraction attributes that were extracted from each primary study.

**Table 5.** The data extraction attributes

| ID | Data extraction attribute | Attribute description |
|---|---|---|
| A1 | Article title | The title of the primary study |
| A2 | List of authors | All authors listed of the primary study |
| A3 | Publication year | The year in which the primary study was published |
| A4 | Journal | The journal in which the primary study was published in |
| A5 | Research focus | The phenomenon under study in the primary study |
| A6 | Research method | The method used in research |
| A7 | Paper type | Empirical or conceptual |

| | | |
|---|---|---|
| A8 | Research data collection method | The description of how data was collected in the empirical research |
| A9 | Keywords | The keywords of the primary study |

The synthesis is formed by combining the data of the research material with appropriate techniques for the research. The techniques can be either quantitative, qualitative, or both. The data of this research will be synthesized with qualitative method. (Okoli & Schabram, 2010, pp. 29-31.) By qualitative method, the synthesis is developed with concept-centric focus. With one point of view, the qualitative method can be seen as means of interpretation and explanation of literature. A narrative synthesis represents the collected literature in a descriptive manner. (Okoli & Schabram, pp. 31-32.) Table 7 gives and overview of all material collected through search assessment -phase of SLR. Each selected article is presented, and all relevant information will be systematically collected from each one. The collected information will be synthetized with narrative synthesis method.

In the last sub phase of the systematic literature review, the results are reported. The literature review process must be reported in sufficient detail to allow the results of the study to be independently reproduced by other researchers. (Okoli, 2015, p. 884; Okoli & Schabram, 2010, p. 7.) From the search phase before first screening, 11 articles were selected as primary study of a total of 1634 articles. The articles forming the primary study are presented in Appendix 1.

# 5 Results and Synthesis

All selected articles answer to the research question from either AI or CE point of view. Some of the articles use more of an AI point of view and some of the articles use more of a sustainable and circular approach to topic. Part of the papers relate to only AI and part of the papers only to sustainability and circular business models. Chapter 5 reviews the results collected from the selected articles and a synthesis is formed based on the collected data. Found results are further discussed in chapter 6.

The selected papers are published from 2000 to 2021, with five of all the selected papers being published within 2021, four papers published in 2020, one paper published in 2019, and one paper published in 2000. As depicted in table 6, according to journals, "Journal of Business Research" with three selected articles and "Sustainability" with two selected articles were the most prominent source of the selected articles. The journals with only one selected article are listed in table 6.

**Table 6.** Number of selected papers in journals

| Number of papers | Journal name |
|---|---|
| 3 | Journal of Business Research |
| 2 | Sustainability |
| 1 | Energies, European Journal of Information Systems, Heliyon, Journal of Innovation and Entrepreneurship, Matériaux & Techniques, Social Sciences, The Journal of Technology Transfer |

The findings point to the topic being rather fresh in the academic field. New research is constantly being published and more empirical research is executed to represent theory in concrete business and industry study cases. The relevance of article publication years must be considered in this topic as the concept of AI is constantly evolving. What was earlier seen as AI, may not be seen as “intelligent” any longer due to development of technology. The selected papers are recently published which entail the current views and descriptions of AI. Table 7 below provides an overview of the selected research papers. The focus of each selected study was extracted to describe the content of primary studies. The content of primary studies circulates around the themes of industry 4.0 and sustainability and within the concepts of business models and artificial intelligence.

**Table 7.** An overview of the primary studies

| ID | Reference | Focus |
|---|---|---|
| PS1 | Sætra, 2021 | Sustainability related impacts of AI in companies (viewpoint of SDGs). |
| PS2 | Mishra & Tripathi, 2021 | The different ways of utilizing AI in business models and practices. |
| PS3 | Di Vaio, Palladino, Hassan, & Escobar, 2020 | The relationship of AI and sustainable business models (viewpoint of SDGs). |
| PS4 | Haftor, et al., 2021 | The role of machine learning in business model from a sustainable viewpoint. |
| PS5 | Garcia-Muiña, et al., 2019 | The use of eco-design to advance transition to circular business model with the help of IoT and Industry 4.0 technologies. |
| PS6 | Jayashree, et al., 2021 | Impact of implementing industry 4.0 and sustainability (TBL) in SMEs. |
| PS7 | Kristoffersen, et al., 2020 | Adopting circular strategies in industry and the process of utilizing digital technologies e.g., AI. |
| PS8 | Edwards, et al., 2000 | Utilizing AI (expert systems) in decision making. |
| PS9 | Colla, et al., 2020 | The role of AI and ML in exploiting sustainability in steel production processes. |

| | | |
|---|---|---|
| PS10 | Cucculelli, et al., 2021 | The impact of family leadership and external support to companies adopting Industry 4.0 business models. |
| PS11 | Brozzi, et al., 2020 | The advantages of implementing industry 4.0 in companies with a viewpoint of sustainability. |

Table 8 below provides an overview to the gathered research data from the primary studies. As can be seen from the table 8, approximately 55% (6) of the selected articles are empirical research and rest five selected articles are conceptual. Four out of the six empirical research combined sustainability and industry 4.0 and AI in some level. This result implies the topic being still more in the level of conceptual research and supports the fact of more empirical research needed in order to be able to study the phenomenon itself and to understand the implications and development needs.

**Table 8.** Research data of the primary studies

| ID | Year | Research method | Paper type | Data collection method |
|---|---|---|---|---|
| PS1 | 2021 | Framework | Conceptual | No empirical data. |
| PS2 | 2021 | Case study | Conceptual | No empirical data. |
| PS3 | 2020 | Bibliometric | Conceptual | No empirical data. |
| PS4 | 2021 | Case study | Empirical | A case study of using ML algorithms and big data was conducted in a large international firm that produces heavy vehicles which is headquartered in Northern Europe. The study was conducted for 38 months from |

| | | | | |
|---|---|---|---|---|
| | | | | February 2015 to June 2018. Also 245 interviews were conducted with 86 respondents. |
| PS5 | 2019 | Case study | Empirical | A case study of using eco-design as a tool was carried out in a ceramic tile manufacturer that is in top 10 Italian companies in the sector. |
| PS6 | 2021 | Survey | Empirical | A questionnaire sent to Malaysian SMEs' managers. A total of 900 questionnaires sent and 206 was returned with 7 incompletes. For analysis, 199 responses were used. |
| PS7 | 2020 | Framework | Conceptual | No empirical data. |
| PS8 | 2000 | Experiment | Empirical | An experimental testing of two created AI (expert systems) roles in decision making in a business game as sort of "laboratory" experiments. |
| PS9 | 2021 | Case study | Conceptual | No empirical data. |
| PS10 | 2021 | Survey | Empirical | A survey sent to 3000 Italian manufacturing firms with at least five employees. They survey was conducted using CATI method by a professional contractor to gather qualitative and quantitative data of companies. |
| PS11 | 2020 | Survey | Empirical | A survey conducted with an online tool called "Digital Check" with 26 questions. Data sample included 65 Italian companies, with a 70% of them being SME. |

The content of selected articles is presented in table 9 below based on the most occurring keywords selected to describe the articles. As can be seen from the keywords, the content of primary studies can be analysed to be mostly related to industry 4.0 and artificial intelligence. Sustainability is selected as a keyword to three articles out of 11 which is approx. 27% of the primary studies. The content analysis based on keywords of primary study presents the main concept of this research, sustainable industry 4.0 that includes the themes of industry 4.0 and circular economy as well as sustainability.

**Table 9.** The most occurring keywords in primary study

| Keyword | Occurrence |
| --- | --- |
| Industry 4.0 | 6 |
| Artificial Intelligence (AI) | 5 |
| Sustainability | 3 |
| Digitalization | 2 |
| Circular economy | 2 |
| Sustainable business model | 2 |

## 5.1 Artificial Intelligence Technologies

Mishra and Tripathi (2021, p. 2) present the key hubs of AI in their research that have a remarkable impact to businesses nowadays: data and knowledge, learning from experience, reasoning and planning, safe human AI interaction, multi agent systems, secure and private AI, and machine vision and language. The key elements of AI are presented in figure 5. Among these presented elements of AI, data intelligence combines AI and data analytics to collect statistics, buying behaviours, colour choices, etc. to help companies to adjust their services and products. Kristoffersen, et al. (2020, p. 248) conclude how artificial intelligence can be used in data analysis to understand the occurring patterns and to provide insight and foresight of the data.

As presented, AI has many technologies the organization can utilize in their business model. More than once, the combination of AI and big data has been mentioned in the primary studies. This implies it is beneficial for the organization to consider combining these two technologies. After all, artificial intelligence works as the engine to process all big data that could include thousands of data rows and is able to e.g., cluster similar data and notice patterns from the data (Mishra & Tripathi, 2021, p. 3). Thus, data intelligence can be considered beneficial for the organization to notice more sustainable patterns in its business areas and harness the AI provided insights of more sustainable areas to its business model. Colla, et al. (2020, p. 8) note how IoT solutions enable goals for AI to achieve by ensuring e.g., data to flow seamlessly in the IS architecture.

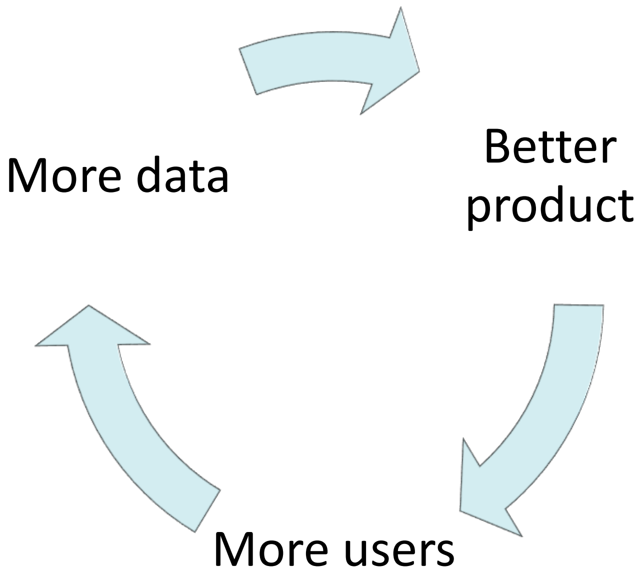

**Figure 5.** Key elements of AI in business domain (Mishra & Tripathi, 2021, p. 3.)

However, to focus on AI technologies, Mishra and Tripathi (2021, p. 2) present how AI and ML algorithms have become omnipresent to solve business problems. According to the authors, automated ML solutions are predicted to decrease the need of going through the emblematic development of training the ML models when addressing complex state of affairs (Mishra & Tripathi, 2021, p. 6). Kristoffersen, et al. (2020, p. 250) suggest how ANN could be paired with maintenance logs and failure data to improve fault diagnosis and decision support.

As the neural networks (ANN) are supposedly copying the human brains, the synthetised suggestion based on the research results is to use ANN e.g., in maintenance logs and failure data, which could potentially provide information of the product’s lifecycle. The more the measuring equipment gather history data of maintenance logs and failure, the more information there is of how often the product needs maintenance. Or how often the product has failures in its operations. ANN would pick up any patterns showing up in the data and could imply the upcoming faults. To add sustainability in the matter, if ANN provides insights of the needed maintenance frequency, the organization could be able to anticipate the need for maintenance early on and prevent the need to purchase e.g., a new product in the event of the original product breaking. After all, extending the product lifecycle by maintenance is one of the ways for the organization to utilize circular business model as in slowing resource loops. The extended lifecycles of products can be presented as a potential benefit for organizations through the usage of AI technology.

AI can also have a positive impact directly in products. This is presented in so called “cycle of AI” that connects user generated data into a better product in a cycle as presented in picture 2 (Mishra & Tripathi, 2021, p. 12). After all, products and services are an important part of the business model, so it is important to consider business models holistically. Haftor, et al. (2021, p. 199) discuss of using ML algorithms to predict based on historical data and a set of examples. This continuous learning technique generates continuous data points which loops into a continuous pattern identification and analysation. The more the continuous learning goes on, the more accurate predictions it produces.

Haftor, et al. conclude how these predictions help to develop and adjust the services and products into creating additional value for customers.




**Picture 2.** Cycle of AI (Mishra & Tripathi, 2021, p. 12.)

The presented result of research discussing of continuous learning and cycle of AI proposes a rather simple idea for the organizations to utilize. This idea presents an opportunity for the organizations to experiment with products and services. This continuous learning technique is extremely merciful for the organization as the users generate data of using the product or service which enables the organization to further develop the product or service. The organization can request expectations or development ideas from the users so that the product is developed to the right direction. This iterative process enables the organization's ability to try out different abilities of AI into different products and services and at the same time, helps the organization to implement AI into their research and development processes. This result presents the holistic potential benefit of AI to the organization to its different business areas.

## 5.2 Artificial Intelligence in Business Models

Currently AI is not utilized in businesses and business models as widely as it potentially could be. According to Mishra and Tripathi (2021, p. 11) AI is mostly used for enlightening customer amenities, exploring and analysing data, and envisage performance to computerize amount of work, transaction, and trading. Developed countries have good infrastructure for AI-based business as companies have enough software developers with sufficient enough skillsets to work with and develop AI.

Cucculelli, et al. (2021) studied business models with the industry 4.0 paradigm. The results of the conducted survey resulted in finding how family-owned companies are more likely than non-family companies to plan and adopt business models that relate to industry 4.0. The results also show how combination of universities and public institutions have a major role in for companies to adopt new business models of industry 4.0. What can be synthetised of this, is how public and institutional support enhance the adoption of new business models.

Although AI is old technology, the current state of AI can be seen intimidating to be used, and organizations might not understand all the variations and possibilities of AI how they could potentially utilize it. As previously presented by Mishra and Tripathi's research, there are 7 key hubs of AI that have an impact in businesses. Organizations ought to map their current business model and actions and add parts of different AI technology into their business model to gather data how the business reacts to AI. If the correspondence is good, the organization can easily enhance AI even more. If the correspondence is negative, the organization could examine their business model holistically and add AI into some other parts of business model. Continuous learning can be adapted into this viewpoint as well to add the value what business model creates for the company.

Brozzi, et al. (2020, p. 2) conducted a survey to identify how Italian companies interpret industry 4.0 as an advantage related to economic, environmental, and social sustainability. Companies identified advantages such as time savings, reduction of errors, lower physical stress felt by the employees, reduction of costs, and sustainability that was considered as lower environmental impact. However, the authors identified a holistic result how SMEs and large companies do not understand holistically the opportunity of an advantage industry 4.0 offers in a sustainable paradigm. Brozzi, et al. stress the importance of expressing and raising awareness of industry 4.0 provided opportunities to increase sustainability and performance in companies.

### 5.2.1 Sustainable Framework for Business Model

As business frameworks change, AI is able to adapt to phenomena and changes while changing the business culture to operate in the digital age. In essence, it is not only the changes done by AI in the business culture but the fundamental renewals of traditional thinking, alliance and cooperation, intense competition, and digital and enriched innovation. (Mishra & Tripathi, 2021, p. 13.) Altogether, here lies the basics to the model of strategic development that leads to new sustainable and circular business models. Di Vaio, Palladino, Hassan, and Escobar (2020, p. 285) describe business model providing a *"concise representation of how a related set of decision variables in the areas of business strategy, architecture and economics are addressed to create sustainable competitive advantage in defined markets".* Therefore, sustainability and AI can be seen as complementing to each other. AI accelerates the transition when sustainability provides a multifaceted platform for AI to operate.

Sætra (2021, p. 3) implies the meaningful role of SDGs in transitioning to sustainable business models. As investors, business partners, and customers demand more actions in terms of corporate responsibility than what is required by law alone, it tends to lead into companies and organizations to becoming more sustainable through strategic business development and new sustainable business models. The author stresses the beneficial advantage that sustainable business models provide for the company in the markets. Not to mention the advantage when adding AI to the equation through SDGs.

Di Vaio, Palladino, Hassan, and Escobar (2020, p. 287) conducted a bibliometric analysis where they studied the correlation between keywords in database. The authors found connections in words “model, cognition, big data, consumption, decisions” as well as in words “performance, determinants, AI methods, competencies, business strategy, critical success factors” and “integration, technology, agent-based framework, customer satisfaction, circular economy”. The authors summarize by this co-occurrence index that how closely AI links to business models; AI can affect business performance as well as ensure customer satisfaction in CE.

The results of these studies create a sustainable framework for business models where AI has a holistic approach to the entire organization. What can be synthetised from these results to answer the research question is to firstly understand the multifaceted concept of sustainability and secondly, to see the holistic potential of AI to work in that multidimensional sustainability creating added value to the organization in multiple levels. The potential benefits need to be seen and measured by the company performance to see how well AI adds up the competitive advantage and by the organization culture to evaluate how well the employees and management level adapts into digitalization and sustainability.

### 5.2.2 Circular Business Models

Garcia-Muiña, et al. (2019, pp. 1-2) present in their article a different point of view to business models. The authors view business models from the product perspective and introduce eco-design as a tool to find equilibrium between sustainability, circular economy, and manufacturing in a company. Eco-design’s ideology includes the product’s entire Life Cycle Assessment (LCA). This offers the company a possibility to choose lowimpact resources and waste minimizing technological solutions. Eco-design also considers highly of the ability to recycle the product in the end of its lifecycle.

Empirical research is done by Garcia-Muiña, et al. (2019, pp. 6-7) in which the authors study eco-design as a tool in the manufacturing environment of ceramic tile production to demonstrate how CBM enhances new business opportunities. The study uses LCA as a methodological tool to configure eco-design holistically and systematically. Data from manufacturing processes and phases were collected with the help of intelligent IoT technology. LCA is able to also assess and manage the complex supply chain and its impacts to the business model. With the results of the study, the company was able to optimize the supply chain of the ceramic tile company and transform the business model to more cyclical as supply of raw materials has the greatest impact to the product's lifecycle.

The empirical study of using eco-design to transform business model to more towards CBM with conducting LCAs of the products proved to be effective. By using a tool that assists the lifecycle holistically, the company is able to find the equilibrium point between sustainability and circular economy and thus able to replace a linear business model with a circular one. The results of the study implicate the importance of positive management approach and technical skills to adopt circular economy paradigm. (Garcia-Muiña, et al., 2019, pp. 15-16.)

### 5.2.3 Using Artificial Intelligence for Decision Making

The authors Di Vaio, Palladino, Hassan, and Escobar (2020, p. 284) discuss of knowledge management systems (KMS) that utilize AI for operational processes development and business models. It promotes "the management of intelligent work" that connects human, organizational, and technological elements whilst creating value through knowledge sharing. The authors conclude the essence that is to connect innovation and sustainability in a way in an organization that aims to integrate AI into decision-making processes to achieve the SDGs. Through KMS, AI can be seen more approachable by managers than ever before, as it considers AI as a tool for integrating human reasoning and knowledge management rather than replacing the human resources. This bibliometric study identifies a potential benefit of AI that the organization is able to gain through knowledge management systems.

Edwards, et al. (2000, p. 44) discuss the varying roles of AI in decision making where AI systems are used as to either support or assist the human resources in decision-making or to completely replace the human decision makers. Six accurate roles are identified: assistant, critic, second opinion, expert consultant, tutor, and automation. These AI roles (expert systems) were studied in three organizational decision-making levels of strategic, tactical, and operational decisions. The findings were following:

- *Expert systems in a replacement role are effective at the operational and tactical decision levels but have limitations at the strategic level.*
- *Expert systems in a support role can help users make better decision at all three decision making levels, but their effectiveness can only be fulfilled through their users.*
- *An expert system acting in a support role does not necessarily save a user's time, but an expert system in a replacement role does improve the efficiency of decision making.*
- *The users of expert systems in a support role did not believe that they had learned from using the system.*

Findings of using AI (expert systems) in decision making shows how human decision makers can be replaced by AI for structured or semi-structured decisions. Unstructured decisions have the best outcome when AI is used as a decision support tool at the strategic level in organizations. (Edwards, et al, 2000, p. 44.)

The studies present an outcome that ensures the state of human decision making in an organization when the decision and situation include major unexpected changes. There is two viewpoints how AI can be seen in decision making: it's seen either as replacing the human or it can be seen as a support tool to save up valuable time of the managers and decision makers. If AI is used in minor structured or semi-structured decisions, this saves time for the managers and other decision makers to focus in the key areas of business. Therefore, AI adds value to the work in which the managers of organizations are able to focus on and thus, can be considered as a potential benefit for the organization.

## 5.3 Prerequisites to Combining Artificial Intelligence and Sustainability

Sætra (2021, pp. 12-13) comments the necessity of connecting ESG reporting more closely to AI ethics research to genuinely provide useful insights to stakeholders of the actual threats and opportunities companies have when using AI based systems. The author stresses the importance of using SDGs as the foundation of the analysis of AI impacts. However, the possibility of a company using SDGs more actively in their sustainability reporting to "greenwash" their business, is rather high.

Therefore, the author has presented a framework that has an easy approach but strict structure and demands regarding evaluation of ESG related AI impacts based on SDGs. The advantage of such a framework is the transparency it provides for the company. Analysation of sustainability related AI impacts can be built more systematically and with more structure. And as mentioned earlier, the more the company implements important measures of SDGs into their strategic development, the more it leads the company towards new sustainable and circular business models. (Sætra, 2021, pp. 1, 12-13.)

Empirical research was utilized by Jayashree, et al. (2021, pp. 5, 8-9) in which the authors conducted a survey to measure the impact of industry 4.0 determinants and its implementation to achieve SDGs in Malaysian SMEs. The initial response rate was 23% of a total of 900 questionnaires sent to SME's managers. Three capabilities were considered: top management commitment, supply chain integration, and IT infrastructure. The survey results were analysed by conducting an analysis using SPSS version 22, an analysation tool. The results of the survey indicate a positive relationship of top management commitment and IT infrastructure with "effective implementation" of industry 4.0. The relationship regarding supply chain integration was left as not significant.

The empirical study by Jayashree, et al. (2021) implies the importance of top management commitment and IT infrastructure in implementing industry 4.0 to achieve sustainable development goals in an organization. Without the commitment of top management, the organization may not be able to achieve the SDGs as implementing a strategic development to aim to achieve SDGs, can be done by top management. And without effective implementation of IT infrastructure, the organization may not be able to pursue with industry 4.0 technologies to advance the aim of achieving the SDGs.

Jayashree, et al. (2021, pp. 10, 12) conclude implementation of TBL sustainability, that means the sustainability dimension of triple bottom line, with industry 4.0 to be prominent. The results highlight the importance of top management commitment and IT infrastructure when implementing industry 4.0 and adopting technology in a company. Therefore, the study suggests prioritizing the implementation of IT efficiently to prepare the organization to adopt e.g., artificial intelligence. The authors imply the company to be able to adopt TBL sustainability only after the IT infrastructure is proficiently developed.

These results provide a viewpoint for the organization of the first steps to achieve potential benefits of AI when adopting sustainable and circular business models. Firstly, the organizations ought to prioritize the IT infrastructure in order for the AI to begin enabling the benefits it provides. Secondly, without the realization of understanding the meaning and concept behind SDGs, the organization lacks the ability to gain potential benefits of AI in the sustainability paradigm. This may result in the organization "greenwashing" its business and misleading the consumers. Top management is in charge to channel the knowledge of combining AI and sustainability through the organizational levels so that the entire organization can adopt sustainable and circular business models.

When the organization has finished the first steps and laid the foundation for AI to accelerate benefits, it can lead to e.g., competitive advantage in the markets. To sum up the synthetized potential benefits for organizations to utilize and transfer into sustainable and circular business models which AI enables through sustainability, is to describe the benefits with words such as increasing performance, reducing costs, and most importantly, balancing the dimensions of economic, environmental, and social of the organization. According to the research, AI has holistic impact to the entire organization through the business model. It creates possibilities for the management level to focus on meaningful work which will enhance the business and develop the strategies, enables the employees through the entire organization to be part of continuous learning, and accelerates the usage of different tools which will support the business to become resilient.

# 6 Discussion and Conclusions

Artificial intelligence is one of the prominent industry 4.0 technologies to advance businesses. In recent years, studies of AI and its utilization in businesses have increased which entails growing interest towards AI and its impacts. This research studied how utilizing AI could support the business to become more circular and transfer into a circular business model strategically. The research was conducted with systematic literature research to answer research question of the benefits which AI potentially brings to the organization in utilizing circular business models (CBMs). One of the potential benefits was hypostatized to be competitive advantage against rivals in the markets.

The two topics – circular economy and artificial intelligence – are separately researched broadly but when combined, there is only little research done. The conducted research aimed to increase and clarify the knowledge and context of a circular business model as also to provide knowledge of circular economy and its potential from the economic and environmental viewpoints. The research provided knowledge of circular economy through sustainability, sustainable development goals (SDGs), and sustainable and circular business models. As AI illustrates the other viewpoint in the conducted research, it bases a complimentary foundation for the two major topics as one – sustainable industry 4.0.

Sustainable industry 4.0 as a concept is rather young as there is not many studies that have attempted to define the concept or term. This research added the value to the concept by using it as a roof term for combining industry 4.0 and sustainability. Sustainability includes circularity which is the reason for the conducted research to be using terms “sustainable business model” and “circular business model” interchangeably. By discussing of sustainable circular models, the circular models are included. By discussing of circular business models, the sustainable models are referred to as well, as circular models are sustainable. The debate of using sustainability related terms interchangeably, exists and the debate will continue with great probability for decades to come as the concepts are all related to each other from different viewpoints. Sustainability needs to be understood as multidimensional concept that can be viewed from several different perspectives.

## 6.1 Implementing Circular Business Models with Artificial Intelligence

The results of this research provided information from different viewpoints of business model. Results included viewpoint from products level to strategic level of decision making, and most importantly, multiple solutions were found how AI potentially creates added value and benefits for the organization. The results presented how AI is closely linked to sustainability through SDGs which leverage the organization to transfer into circular business models. The results pointed a fact of how easily sustainability and circularity can be adapted into the business once the organization takes the first step and implements the first SDG into their strategic development. AI is able to accelerate the implementation of SDGs which enhances the circularity of a business model.

Bocken, et al. (2016, p. 309) and Antikainen, et al. (2018, p. 46) introduced the three groups of circular business models: slowing resource loops, closing resource loops, and narrowing resource flows. The results of this research provided examples of the role of AI in these business models. For example, the CBM of slowing resource loops focuses on extending the product lifecycle by design and maintenance, in which ANN could be used in maintenance and failure data to offer insights into the frequency of needed maintenance and analyse the lifecycle of a product. Duan, et al. (2019, p. 65) conducted a literature review to result in ANN not currently being utilized broadly in organizations. The potential of ANN providing insights based on maintenance data of lifecycles and maintenance needs, is one of the potential benefits what AI offers when used in organizations to transfer into circular business models.

The second example and result of this research of the role of AI in CBMs is the use of eco-design in business. According to Antikainen, et al. (2018, p. 46) the three presented groups of CBM support each other and thus, a company's CBM can include multiple groups of CBMs. By using eco-design, the company is able to assess their products' entire lifecycle with LCA which enables the company to consider circularity in more depth. As eco-design aims to recycle the product in the end of its lifecycle and focuses to find a solution to use less resources to find the equilibrium between sustainability, CE, and manufacturing, it combines two groups of CBMs: closing the loop and narrowing resource flows. According to Antikainen, et al. (2018, p. 46) closing the loops focuses on efficient recycling of materials and narrowing resource flows targets using less resources, which can be significantly boosted through intelligent technologies.

Cricelli and Strazzullo (2021, p. 4) identified in their literature review economic sustainability metrics associated with AI that enhances the organization's opportunities to gain competitive advantages in the markets. When AI is utilized and implemented into business models, the results pointed the organization gaining a direct impact of competitiveness and market share when indirect impact is e.g., considering product lifecycle, customization, consumption of water and other resources, and waste control and the costs. According to the economic sustainability metrics, AI benefits the organization holistically when replacing the linear business model with a circular one. Conducted research by Di Vaio, Palladino, Hassan, and Escobar (2020, p. 287) resulted in identification of correlation between keywords related to AI and circular economy. AI is closely linked to business models and CE which indicates the potential of AI benefitting organizations in utilizing circular business models.

All in all, as Mishra and Tripathi (2021, p. 17) conclude in their article: "*Businesses that effectively take advantage of AI can make an unsettling revolution from side to side their new digital business models and practices, empowering them to possibly transmute the worldwide economical business landscape.*" AI has resulted to entail potential to utilize circular business models whilst creating competitive advantage to the organization with the many benefits it provides to business models. However, as the research results present, IT infrastructure perform as a needed foundation for the organization to be able to adopt sustainability. In order for the organization to savour the benefits of AI in their circular business model, it is suggested for the organization to prioritize implementing IT infrastructure efficiently to prepare the organization to adopt AI.

### 6.1.1 Benefits of Artificial Intelligence

In the literature review, artificial intelligence is noticed to open opportunities for organizations to e.g., increase the added value that the organization produces. AI is seen as the technology that provides the organization the opportunity to implement digitality into the organization. Jamwal, et al. (2021, p. 9) identified how ML approaches and AI algorithms provide major benefits for manufacturing units that aim to improve sustainability. Through utilizing ANN, lifecycles of products can be extended which is a potential benefit for organizations for using AI technology and at the same time, it enhances the products' environmental value. Weichhart, et al. (2015) noticed a beneficial path for organizations to thrive as competitive in the changing environment – organizations ought to be "sensing, smart, and sustainable".

AI is described as "computational agents that act intelligently", "humanlike intelligence", and "associated with human intelligence" in the literature review. How is the "intelligence" measured to make AI beneficial in circular business models? The results of the research provided an insight to understand the scale in which AI can positively impact the organization through changes in business model.

Mishra and Tripathi (2021) conducted a case study to understand different ways of utilizing AI in business models and practises. The results presented the scale in which AI is able to adapt to phenomena and changes while changing the business culture to operate in the digital age. Fundamentally, to understand the impact of AI, it is important to see the impacts besides the positive changes made in the business. AI has great impact also to the fundamental renewals of traditional thinking, alliance and cooperation, intense competition, and digital and enriched innovation. Holistically AI reaches a further circle of potential benefits than just the inner circle of business model. The conducted research was therefore able to identify the basics to the model of strategic development, that leads to new sustainable and circular business models. And as synthetised, the benefits need to be seen and measured by the company performance to measure how AI impacts the competitive advantage, and by the organization culture to evaluate the level of adaptation into digitalization and sustainability in group of employees and management level.

As the literature review identified AI to create added value to the customer, the results of this study can confirm this fact. Authors Di Vaio, Palladino, Hassan, and Escobar (2020, p. 284) conducted a bibliometric study to analyse the relationship of AI and sustainable business models. Knowledge management systems were identified to create added value through knowledge sharing with connecting human, organizational, and technological elements. The key in KMS was to connect innovation and sustainability in such a way that the organization aims to integrate AI into decision-making processes to achieve sustainable development goals. The study results presented AI creating added value to the organization through KMS not only in managing the work intelligently and supporting in the decision-making processes but also in the sustainability dimension of the organization.

Edwards, et al. (2000) conducted empirical study of utilizing AI, that were called as expert systems in the research, in decision making. An experimental testing of two created expert systems (artificial intelligence) roles in decision making in sort of laboratorial environment was conducted. The results presented how human decision makers can be replaced by artificial intelligence for structured or semi-structured decisions. Unstructured decisions, though, were identified to have the best outcome when AI is used as a decision support tool at the strategic level in organizations.

Therefore, this can be considered as AI creating added value for the management level in organization as AI saves time for the managers to focus in the key areas of business rather than making minor decisions with minor impact to the business. The literature review conducted by Duan, et al. (2019, p. 63) agree on the found results of this research as the authors have concluded how AI is used in organizations to intensify decision making, reinventing business models, and improving customer experience.

### 6.1.2 Challenges

The literature review identified multiple challenges in sustainable industry 4.0 that are related to using artificial intelligence in organizations. To conclude the found barriers found by Paschen, et al. (2020, p. 7) and Rajput and Singh (2021, pp. 1725-1726) most of the identified barriers were regarding combination of other industry 4.0 technology and artificial intelligence. Whether the barrier is regarding connectivity and compatibility of IoT technology and AI or big data and AI, the issue is the same: how to ensure the accessibility, data security, and functionality of technology in an organization.

Other than that, the literature review also identifies investment costs for IT infrastructure and cyber security of infrastructure as barriers. However, Rajput and Singh (2021, pp. 1725-1726) declare that once the organization has identified the barriers and challenges the organizations face with industry 4.0 integration to circular economy, overcoming them could be the next major step towards achieving circularity.

The above statement of Rajput and Singh (2021, pp. 1725-1726) indicates the challenge of increasing the knowledge of combining industry 4.0 and circular economy high enough to understand the barriers and challenges throughout the organization that could present itself as a challenge or barrier to achieve circularity. To avoid barriers regarding lack of skills or knowledge, Jamwal, et al. (2021, p. 16) identified in their literature research how continuous learning minimizes the risk in organization for the employees to lack sufficient skillsets related to industry 4.0 technologies.

The research of this thesis included conducted empirical research by Jayashree, et al. (2021, pp. 5, 8-9) which resulted presenting a positive relationship of top management commitment and IT infrastructure with "effective implementation" of industry 4.0. The synthesis resulted in concluding how without effectively implementing IT infrastructure, the organization may not be able to pursue with industry 4.0 technologies to advance the organization's aim of achieving sustainable development goals. Jayashree, et al. (2021, p. 12) implied the company being able to adopt sustainability and dimension of the TBL ideology only after the IT infrastructure is proficiently developed.

## 6.2 Key Findings

The key findings of this research are regarding the drivers and benefits for organizations what AI provides through circular business models and the prominent AI technology that can be utilized in order to support the organization to transfer into circular business model from the linear business model. As this research studies the potential of AI, the most prominent AI technology is presented and proposition of how it could be utilized in circular business models will be suggested. Many AI provided benefits that were found through this research are presented in chapter 6.1. Here the benefits will be concluded by how they impact the organization in a larger scale. Lastly, limitations and further research are presented.

### 6.2.1 Drivers and Benefits for Organizations

Firstly, savings and cost reductions are one of the drivers for organizations to utilize AI through CBM. As previously presented the three groups of CBMs, when organization aims to design products that have a sustainable lifecycle and can be recycled afterwards, find a solution to reduce the number of used resources, or recycle materials efficiently, it generates savings e.g., in materials and waste management. Research and development -teams in organizations are one focus group to develop material components to products that are easily recycled after the end of product lifecycle. Based on the found results by this research, I suggest organizations to get an expert to build up the IT infrastructure if there is not enough knowhow in the organisation itself already. Without the IT infrastructure base and enough employees with good technology skill sets, it would be rather difficult to implement AI in its full potential.

When organization increases its technological professionalism through industry 4.0 technologies, especially AI, it provides holistic benefit for the organization. As Sætra (2021, pp. 1, 12-13) presented the holistic framework modelled, it gave an insight how by increasing the transparency, the organization is able to create its path towards sustainable and circular business models. With transparency, the organization avoids to "greenwash" its business which otherwise has a rather high possibility when using SDGs to report the state of sustainability in organization. Therefore, the second driver for the organization is the increased transparency and trust from the consumers because of the visibility of their true actions.

The third driver, according to the results of this research, is to gain sustainable competitive advantage in defined markets. AI renews business culture towards SDGs, adapts to different phenomena and changes, affects business performance, and ensures customer satisfaction in circular economy. By letting AI to accelerate the transition to circularity whilst sustainability providing a multifaceted platform for AI to operate, the organization is a forerunner to achieve SDGs and to work as an empowering role to expedite the sustainable change globally.

### 6.2.2 Prominent Artificial Intelligence Technology

The research results presented multiple different AI technologies that could be used in an organization to gain sustainability and circularity. After comparing the research results and literature review, the most prominent AI technology in utilizing circular business models was ML and AI algorithms that are used in decision-making. Di Vaio, Palladino, Hassan, and Escobar (2020, p. 284) presented the knowledge management system that allows the managers to focus on the key business while also contributing the organization to become more sustainable and circular.

Edwards, et al. (2000, p. 44) conducted research resulted also in finding AI creating added value for the managers and thus to the entire organization with supporting in decision making. The literature review by Duan, et al. (2019, p. 63) stated how AI is mostly used to intensify decision making. The decision-making process includes AI and ML algorithms to gather and process the data, in where AI can give insights of the business based on the historical data. With supporting decision-making, AI can analyse the business' performance and give foresights based on previous performance when the managers are able to get a holistic viewpoint to the business.

## 6.3 Limitations and Further Research

One of the limitations of this research is how the research search was conducted using only three databases. With more databases in use, there could have been more potential articles providing empirical data to the research. One of the admission criteria for the articles were to be "open access" which is a limitation for this research limiting the number of articles included to the screening. With different search terms and search string, there could have been more potential articles to this research. As the terms related to sustainability are used interchangeably, the number of potential articles found from the databases depends on the terms used in the search string. With only one person doing the screening of articles and analysis, there might be human errors with not noticing relations to the research question, in which case the paper has been excluded.

The greatest limitation regarding this research is the small amount of conducted research directly studying the impacts of AI to circular business models. Most studies consider industry 4.0 technologies in one holistic concept and does not separate the impacts individually per technology. As this research comments how at least big data and AI as well as IoT technology and AI are likely to be combined to achieve more beneficial results of utilizing industry 4.0 technologies, it should be pointed out, how AI as one industry 4.0 technology is a major technology itself including a great deal of various AI technologies that need to be addressed in order for the organizations to realize the potential behind them. Therefore, for further research it is suggested to study deeper the various AI technologies in combination to CE and CBM. This enables the holistic value creation of AI in the sustainability paradigm for the organizations. An important viewpoint of this future research suggestion is how this would map the various AI technologies into the business model and lowers the barrier for the organization to implement the AI technologies.

From all the technologies of industry 4.0, AI was chosen to be focused in as it provides interesting data when combined with sustainability. However, Jamwal, et al. (2021, p. 10) discuss how control systems, sensors, and other IoT technologies help to bridge the gap between internet technology and operational technology. As AI is able to analyse great amount of structured or unstructured big data, sensors and other systems are often in the main role of producing this data. Mishra and Tripathi (2021, pp. 6-7) continue the argument with adding that software used in decision-making is powered by AI models and deep learning business model and AI-based algorithms take pivotal actions by using data produced by IoT sensors. If empirical research was to be conducted in e.g., manufacturing units to holistically measure the impact of AI towards sustainability, IoT sensors and other devices generated data would be in key focus. Therefore, it is important to continue and add IoT technology generated data from systems to AI research to fully reach the potential of AI.

One of the limitations in this study is how narrowly the research discusses of sustainable development goals. This study presents the SDGs from a holistic point of view and does not present them individually. As SDGs are identified to be accelerating for the company in transforming the business model into circular, the SDGs could be studied in more detail. Therefore, it is suggested for further research to identify potential benefits of AI in reference to every SDG in order to holistically evaluate the impact in an organization.

This would enable the organization to identify the imbalances between economic, environmental, and social dimensions through the SDGs that can be divided into these three groups according to their content of goal. By identifying the imbalances, the organization can create strategies to adapt AI in selected areas to achieve balance. This research focus would also benefit the academia into understanding more of the environmental viewpoint in utilizing AI via SDGs. For example, the research of Sætra (2021) and Vinuesa, et al. (2020) regarding the relationship of AI to SDGs could be used as theory base to conduct empirical research to examine the relationships and impact of AI towards individual SDGs.

Another great limitation of this research is to discuss the negative impacts holistically of AI when utilized in organizations. Nishant, et al. (2020, pp. 7-8) recognize the rebound effect of using AI in organizations. The authors stress that as AI is strongly dependent from data, it therefore indirectly contributes to IT's global carbon footprint. Hence, the authors suggest that there is a need to approach AI for sustainability from a design thinking perspective in order to develop effective, net zero emission AI applications. As Zink and Geyer (2017, pp. 593, 600) also note the circular economy rebound, it is necessary to research more deeply the net impact of combining industry 4.0 technology into circular economy. Therefore, it is suggested for further research to study more holistically the negative impacts of AI and whether it has more positive or negative impact in the end when utilized in organizations to aim in achieving sustainability. This would contribute the entire academic field of sustainable industry 4.0 to understand more holistically the impact of industry 4.0 to the environment.

All in all, the below list concludes the suggested research topics by this conducted research to be further researched to fully understand the state of AI in circular economy and whether it offers truly positive impacts regarding environmental sustainability:

- More profound research of artificial intelligence to individually evaluate the impact behind different AI technologies in combination to circular economy and circular business models
- Empirical research of AI impacts towards sustainability in organizations with the addition of IoT technology generated data
- Studying the impacts of SDGs to an organization more individually with a viewpoint of utilizing AI to achieve them
- Conducting research of negative impacts and net impacts of AI when utilized in an organization to achieve sustainability and circular economy

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# Appendices

## Appendix 1. A List of the Primary Studies

| ID | Title | Year | Author(s) |
|---|---|---|---|
| PS1 | A Framework for Evaluating and Disclosing the ESG Related Impacts of AI with the SDGs | 2021 | Sætra |
| PS2 | AI business model: an integrative business approach | 2021 | Mishra and Tripathi |
| PS3 | Artificial intelligence and business models in the sustainable development goals perspective: A systematic literature review | 2020 | Di Vaio, Palladino, Hassan, and Escobar |
| PS4 | How machine learning activates data network effects in business models: Theory advancement through an industrial case of promoting ecological sustainability | 2021 | Haftor, Climent, and Lundström |
| PS5 | Identifying the Equilibrium Point between Sustainability Goals and Circular Economy Practices in an Industry 4.0 Manufacturing Context Using Eco-Design | 2019 | Garcia-Muiña, González-Sánchez, Ferrari, Volpi, Pini, Siligardi, and Settembre-Blundo |
| PS6 | Industry 4.0 implementation and Triple Bottom Line sustainability: An empirical study on small and medium manufacturing firms | 2021 | Jayashree, Reza, Malarvizhi, & Mohiuddin |
| PS7 | The smart circular economy: A digital-enabled circular strategies framework for manufacturing companies | 2020 | Kristoffersen, Blomsma, Mikalef, and Li |

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|---|---|---|---|
| PS8 | An analysis of expert systems for business decision making at different levels and in different roles | 2000 | Edwards, Duan, and Robins |
| PS9 | Environment 4.0: How digitalization and machine learning can improve the environmental footprint of the steel production | 2020 | Colla, Pietrosanti, Malfa, and Peters |
| PS10 | Filling the void of family leadership: institutional support to business model changed in the Italian Industry 4.0 experience | 2021 | Cucculelli, Dileo, and Pini |
| PS11 | The Advantages of Industry 4.0 Applications for Sustainability: Results from a Sample of Manufacturing Companies | 2020 | Brozzi, Forti, Rauch, and Matt |