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The role of digital transformation in transitioning towards a circular economy

A study of the Swedish automotive industry

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by

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Abstract

This thesis discusses digital transformation as an enabler of the circular economy in the Swedish automotive industry. Circular economy has gained awareness lately, and many companies want to implement this sustainable strategy. In doing so, digital transformation is often needed to succeed. However, academic literature on digital transformation and its impact on the circular economy is limited. This thesis aims to answer the research question: *“How are Swedish automotive organizations leveraging digital transformation to transition towards a circular economy?”.* The research is done through a survey of the Swedish automotive industry based on literature regarding the subjects. The authors identify five key findings regarding how the Swedish automotive industry leverages digital transformation to transition toward a circular economy. The findings are (01) the driving forces of digital transformation-driven circular economy, (02) the need to raise awareness regarding the impact of various digital technologies, (03) to continue the use of technologies that have a great impact on sustainability, (04) the need to raise awareness regarding the impact of digital technologies on sustainability, (05) the need for organizational awareness and involvement of employees in the circular economy strategy.

Keywords

Swedish automotive industry, Digital Transformation, Digitalization, Circular Economy

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Digitala transformationens roll i övergången till en cirkulär ekonomi

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Godkänt	Examinator	Handledare
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Sammanfattning

Denna uppsats diskuterar digital transformation som ett hjälpmedel att uppnå cirkulär ekonomi inom den svenska bilindustrin. Cirkulär ekonomi har den senaste tiden fått mycket uppmärksamhet och många företag vill genomföra denna hållbara strategi. För att lyckas med detta behövs ofta digital transformation. Akademisk litteratur om digital transformation och dess påverkan på cirkulär ekonomi är begränsad. Denna avhandling ämnar besvara forskningsfrågan *"Hur använder svenska bilindustrin digital transformation för att övergå till cirkulär ekonomi?".* Forskningen utförs genom en undersökning av den svenska bilindustrin baserad på litteratur om ämnena. Avhandlingens författare identifierar fem viktiga observationer angående hur den svenska bilindustrin använder digital transformation för att övergå till cirkulär ekonomi. De fem observationerna är (01) de drivande krafterna bakom digital transformationsdriven cirkulär ekonomi, (02) behovet att öka medvetenheten om olika digitala teknologiers påverkan, (03) att fortsätta användningen av teknologier med stor inverkan på hållbarhet, (04) behovet att öka medvetenheten om digitala teknologiers inverkan på hållbarhet, (05) behovet av organisatorisk medvetenhet och engagemang av anställda i cirkulär ekonomi-strategi.

Nyckelord

Svensk bilindustri, Digital Transformation, Digitalisering, Cirkulär Ekonomi

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Foreword

This thesis paper is written as a part of the Master's programme in Entrepreneurship and Innovation Management, at the Royal Institute of Technology in Sweden (KTH). We would like to express our gratitude to our supervisor Vladimir Koutcherov, for the continuous guidance and valuable feedback. We would also like to thank our fellow students for the peer-review and feedback. Finally, we would also like to thank our survey respondents for their involvement.

- Christoffer Stenvall and Hazim Hazim

1. Introduction

This chapter consists of six sections, starting with chapter *1.1 Background*, where a brief background of the research subject is given. After the background follows chapter *1.2 Research Gap,* where the gap in extant literature that this thesis aims to address is described shortly. In the following chapter, *1.3 Aim and Research Question,* the aim of the thesis and the research question are introduced. In chapter *1.4 Delimitations*, a short description of how and why certain delimitations have been set follows. Chapter *1.5 Sustainability* describes the sustainability aspects of digital transformation-driven circular economy. In the final section of this chapter, *1.6 Thesis Outline,* a description of the thesis structure is presented.

1.1 Background

Organizations have gone through different transformations since the dawn of the digital age. Electronic Data Interchange (EDI) systems introduced in the 1960s and 1970s are considered one of the earliest digital transformation implementations. Later in the 1980s, the introduction of Enterprise Resource Planning (ERP) systems and the adoption of digital technologies drove the transformation to paperless procedures (Heilig, Schwarze, and Voss, 2017).

The second generation of digital transformation appeared in the 1990s and early 2000s when the trend of treating IT as a fundamental part of the organizational processes. Digitalization made the transformation to automated processes and a high degree of automation possible. Later on, since the 2010s, the transformation to intelligent procedures has been considered the third generation of digital transformation (Heilig, Schwarze, and Voss, 2017).

Even though organizations have been using digital technologies to transform their business operations, “Digital Transformation” started gaining popularity in 2016 and 2017 (Heilig, Schwarze, and Voss, 2017). It has been increasing ever since, as seen in the google search trends for “Digital Transformation” (Figure 1.1).

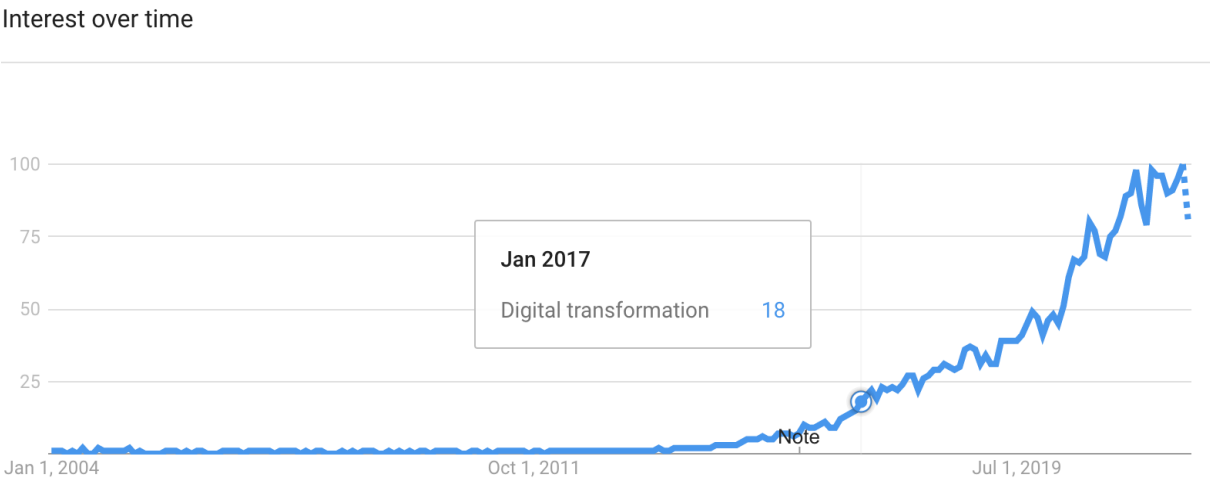

Figure 1.1: Google Search trends for the topic: “Digital Transformation” (Google Trends, 2022)

A circular economy, which can reap benefits from digital transformation, is a concept that is supposed to replace the traditional linear economy where products made of virgin materials reach end-of-life. In a circular economy, the product´s end-of-life is replaced with a circular flow or a so-called closed-loop (Morseletto, 2020).

It is not a new concept as, e.g., Boulding (1966) talks about closed systems and circular flow already in the 1960s, and according to Korhonen et al. (2018), the concept dates back to the 18th century.

However, the idea of a circular economy and other related ideas such as closing the loop and cradle-to-cradle have recently gotten more attention due to economic analysis showing the possible benefits of circular resource management. As environmental and social value creation can co-occur as economic benefits, the concept has been welcomed as a sustainable economic proposition (van Buren et al., 2016).

1.2 Research Gap

Despite extensive research published about digital transformation and circular economy as separate concepts, there is not much literature investigating the relationship between the two concepts. The five articles found on the relationship of these concepts are by Antikainen, Uusitalo and Kivikytö-Reponen (2018), Bressanelli, G., Adrodegari, F., Perona, M., and Saccani, N. (2018), Chauhan, Parida and Dhir (2022), Ingemarsdotter, Jamsin and Balkenende (2020) and Ranta, Aarikka-Stenroos and Väisänen (2021). To the knowledge of the authors, none is to

be found connecting the digital transformation-driven circular economy to the Swedish automotive industry.

As this is a technology driven industry in need of sustainable solutions, the authors of this paper believe that the Swedish automotive industry could reap benefits from digital transformation-driven circular economy. Therefore, this thesis intends to address this gap in extant research.

1.3 Aim and Research Question

The aim of this thesis is to investigate the relation between digital transformation and the circular economy. The paper will focus on how digital transformation tools and processes are helping organizations achieve a circular economy in the Swedish automotive industry. The research will be based on a literature review on digital transformation and circular economy as well as data from experts collected through a quantitative survey. All experts are from the Swedish automotive industry. With this aim and in order to close the identified research gap, the research question is defined as:

“How are Swedish automotive organizations leveraging digital transformation to transition towards a circular economy?”

1.4 Delimitations

The scientific articles reviewed are chosen based on topic relevance and focused on medium-large organizations. The articles are almost exclusively academic papers, and in the case of several articles on the same topic, the newest or most cited one has been used. The literature review is not limited to Sweden, as extant literature focusing on only Sweden is scarce.

At the time of writing this thesis, minimal research work correlating digital transformation and the circular economy was found. Moreover, the research work related to the correlation was also relatively new. No literature was found correlating these concepts to the Swedish automotive industry.

The automotive industry consists of various fields such as manufacturing, maintenance, after-sales services, etc. Although digital transformation and the concept of circular economy are relevant for all areas, this thesis mostly focuses on the area related to the manufacturing of vehicles in the Swedish automotive industry.

However, the aim is not to discuss details specific to an energy type, such as fossil fuels, biofuels, or electric batteries. In this paper, the role of digital transformation in achieving a circular economy concerning the processes in the automotive industry is discussed. This is not to be confused with achieving a circular economy through electrification of vehicles or efficient usage and recycling of batteries. Furthermore, this thesis paper will not consider the economic feasibility of different tools and processes.

Each digital transformation technology will not be introduced separately, nor will the Circular Business Models be considered.The survey was distributed only in Swedish organizations from the automotive industry, within Sweden.

1.5 Sustainability

As awareness about climate change, inequality, and other problems has increased among consumers, politicians, organizations, and others, the need for sustainable development has come to light. In 2015, the United Nations (UN) introduced the Sustainable Development Goals (SDGs) for 2030 to ensure and guide the sustainable development of the world's nations. The Sustainable Development Goals consist of 17 goals (Figure 1.2) and 169 targets covering most aspects of society and sustainability. All United Nations member states have committed to the goals (United Nations, 2015).

Figure 1.2: Sustainable Development Goals (United Nations, 2015)

All 17 Sustainable Development Goals are connected, and action within one will affect the results and outcomes in other areas. The nature and goal of a digital transformation-driven circular economy is sustainability in all aspects. It concerns all Sustainable Development Goals in various depths and widths depending on the application. With this in mind, the Sustainable Development Goals that the research area of this paper is mostly connected to are the following:

- **SDG 7 - Affordable and clean energy**

  73 % of human-caused greenhouse gasses come from the energy sector, making it the main contributor to human-caused greenhouse gasses (United Nations Development Programme, 2021). Due to this, it is a crucial area for development and improvement.

  This paper links to this SDG as renewable energy is crucial for the digital transformation-driven circular economy. Especially the target 7.a; “enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology” (UN, 2015). This target is of interest as it is both a condition for and a result of the digital transformation-driven circular economy.

- **SDG 8 - Decent work and economic growth**

  As the concept of a circular economy creates more work locally, the possibilities to meet the demands of this goal are many. The Covid-19 pandemic will also increase youth not in training, school, or employed, making it even more important to address. Also, women are likely to be affected twice as hard as men by this. (UN, 2021).

  Target 8.2; “Achieve higher levels of economic productivity through diversification, technological upgrading, and innovation, including a focus on high-value-added and labor-intensive sectors” (UN, 2015) is a target that digital transformation of different sorts can address.

  Digital transformation-driven circular economy also goes hand in hand with target 8.4; “Improve progressively, through 2030, global resource efficiency in consumption and production and endeavor to decouple economic growth from environmental degradation [...]”(UN, 2015).

- **SDG 9 - Industry, innovation, and infrastructure**

  Innovation is an integral part of digital transformation, and target 9.2, “Promote inclusive and sustainable industrialization [...]”(UN, 2015), is closely linked to digital transformation, especially in combination with a circular economy.

  “[...] retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes [...]” (UN, 2015), which is target 9.4, also goes hand in hand with the digital transformation-driven circular economy. Digital transformation allows established industries to retrofit processes and innovations to increase efficiency while increasing sustainability.

- **SDG 11 - Sustainable cities and communities**

  Target 11.6; “By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management” (UN, 2015) goes under the ambition of circular economy not to create any waste, and to reuse and recycle potential waste - giving a cleaner and more sustainable cities and communities.

- **SDG 12 - Responsible consumption and production**

  To prevent further climate degradation and pollution, human well-being and economic growth must be decoupled from environmental impact and resource use. Changes in production patterns and consumption habits can promote and help this change (UN, 2021).

  By the year 2050, a tripling of the use of materials globally can be expected compared to the base year 2000, according to the International Resource Panel (2011), making it important to address quickly. The potential reduction in virgin raw materials makes the possibilities to address this goal through a circular economy substantial.

  As materials will be used and reused more locally and within a circular flow, the environmental benefits of the concept are significant (van Buren et al., 2016), which is in line with target 12.5; “By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse” (UN, 2015).

Digital transformation can play a big part in target 12.6; “Encourage companies, substantial and transnational companies, to adopt sustainable practices and integrate sustainability information into their reporting cycle” (UN, 2015) as digital tools can facilitate such practices.

- **SDG 17 - Partnerships for the goals**

  Thanks to its sustainable benefits, the circular economy concept has become popular among businesses and politicians (Chizaryfard, Trucco, and Nuur, 2020). As a result, the circular economy is now promoted by businesses and governments worldwide and the EU (Korhonen, Honkasalo, and Seppälä, 2018), addressing the target 17.16.

  Target 17.16 is “Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology, and financial resources, to support the achievement of the sustainable development goals in all countries[...]” (UN, 2015). Interestingly, practitioners i.e. business consultants and foundations among others have developed the circular economy and led it, not scholars. Due to this, there is a need for more scientific analysis and research (Korhonen et al., 2018).

1.6 Thesis Outline

This thesis is divided into six main chapters with subheadings, starting with the *Introduction* chapter. Chapter two consists of the *Theoretical Background* containing the literature review regarding digital transformation and circular economy. The third chapter is *Research Methodology,* where the process and ways of doing this research are described. Potential benefits and barriers are presented for the two concepts in this chapter. Based on the literature review, a questionnaire is designed to investigate the actual situation in the Swedish automotive industry. The results and data from this survey are presented in chapter *4. Research Findings*, followed by chapter *5. Discussion.* The thesis closes with chapter *6. Conclusion*.

2. Theoretical Background

This chapter consists of three sections and five subsections, starting with chapter *2.1 Digital Transformation*, where the concept of digital transformation is described in more detail. Opportunities and effects of digital transformation are presented in subchapters. Then follows chapter *2.2 Circular Economy,* where the concept of circular economy is described in more detail. Differences between linear and circular economy as well as circular economy in organizations are presented in subchapters. In the final section of this chapter, *2.3 Digital Transformation-driven Circular Economy,* barriers and capabilities are presented.

2.1 Digital Transformation

To formally define “Digital Transformation”, G. Vial (2019) reviewed 282 works related to Digital Transformation and found 23 unique definitions. Analyzing these definitions by the rules offered by Wacker (2004), Vial defined digital transformation as:

"a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (G. Vial, 2019, p. 121)

This definition focuses on "improvement" as an expected process outcome. It benefits from digital technologies and tools to create value by creating new or improving existing operations, business processes, or customer experiences (Morakanyane, Grace, and O'Reilly, 2017). Due to its value-creating nature, digital transformation helps organizations stay relevant to the market and competition (G. Vial, 2019).

2.1.1 Opportunities created by Digital Transformation

Digital technologies include technologies such as SMACIT (social, mobile, analytics, cloud, and Internet of things - IoT) (Sebastian et al., 2017), platforms, internet, software, and blockchain (G. Vial, 2019).

Adoption of such technologies, when used within a specific context, has created many opportunities for firms to enhance their businesses. According to G. Vial (2019), the four major areas related to value creation affected by digital transformation are:

1. **Value Propositions:**
   Digital technologies allow firms to create new value or enhance existing value by offering services connected to their products. They also help in gathering data to enhance it further.

2. **Value Networks:**
   Using digital technologies, close collaboration and complex relationships become easier to manage. It also enables firms to grow their network and increase customer engagement.

3. **Digital Channels:**
   Organizations can create direct channels with customers to communicate effectively using social media. Supply chain efficiency can also increase (G. Vial, 2019; Klötzer and Pflaum, 2017).

4. **Agility and Ambidexterity:**
   With digital technologies, firms can stay agile by quickly detecting opportunities and adapting to change. They can also help firms become ambidextrous as the digital part of their business can become a significant part of the overall business. Or, in some cases, even become their primary business. For example, the shoe manufacturer *Nike* now also owns a digital platform that provides fitness services based on data (Günther et al., 2017).

The use of digital technologies allows firms to disrupt their markets (G.Vial 2019; Mithas, Tafti, and Mitchell, 2013) and create value via new forms of business (G.Vial, 2019). For example, *Netflix* operated as a disc rental service that used physical mail as their primary channel for their subscribers. However, with the help of digital transformation, they were able to disrupt the market (Foss, Gertsen, and Helle Vesti, 2018) and focus on the actual value they create instead of the physical product (i.e., discs). Netflix achieved this by using digital technologies to innovate its distribution channels and observe behavior and statistics to a finer degree (Lycett, 2013).

The widespread use of digital technologies has significantly impacted consumer behavior. Consumers with access to such technologies expect firms to provide improved services. This has made digital transformation necessary for firms to stay relevant to their competition. Since data is easier to collect and analyze using digital technologies, firms can better understand customer needs and offer them greater value (G.Vial, 2019). *The New York Times* and *Netflix* are examples of organizations that use digital technologies to understand their customers better. *Netflix* uses big data to provide dynamic recommendations based on their patterns, whereas *The New York Times* uses data to engage readers (Günther et al., 2017).

On the other hand, the disruption created due to digital technologies can pose a threat to firms and make them irrelevant (G.Vial, 2019). For example, the digital disruption created by *Netflix* put its competitor, "*Blockbuster"*, out of business (Foss, Gertsen, and Helle Vesti, 2018).

2.1.2 Effects of Digital Transformation on Organizations

To stay competitive and relevant, organizations may need to embark on a digital transformation journey. Often, this results in change and transformation in their organizational structure and values (Gupta, S.,2018).

Creating an independent unit focused on digital transformation within the organization is a strategy used by various medium-large firms. (G.Vial. 2019; Maedche, 2016; Sia, Soh, and Weill, 2016) e.g., creating business units separate from their traditional organizational structure helped *Audi AG* follow an IT-driven approach to develop analytics capability (Dremel et al., 2017; G.Vial, 2019).

An organization's culture has a significant impact on its digital transformation process. Organizations must be willing to take risks and perform experiments. Agile principles from software development practices can help them learn through small and incremental changes. Cooperation between business and IT functions helps organizations align their objectives with the digital technologies used by them (G.Vial, 2019).

2.2 Circular Economy

According to Yuan, Bi, and Moriguichi (2008), the circular economy lacks a commonly accepted definition, which can lead to a collapse of the concept (Hirsch and Levin, 1999). Furthermore, the circular economy research is somewhat chaotic and shallow and "seems to be a collection of vague and separate ideas from several fields and semi-scientific concepts" (Korhonen, Honkasalo & Seppälä, 2018a).

The definition used in this paper will be the definition by Kirchherr, Reike, and Hekkert (2017), based on their overview of 114 definitions of the circular economy concept. The concept of circular economy is defined as:

"A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro-level (products, companies, consumers), meso-level (eco-industrial parks) and macro-level (city, region, nation and beyond),

with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations." (Kirchherr, Reike and Hekkert, 2017, p. 224).

2.2.1 Differences between Circular Economy and Linear Economy

In figure 2.1, a brief and simplified visualization of the differences between the traditional linear economy and circular economy has been created by the authors. In a linear economy, there is a linear flow from virgin raw material extraction to residual waste, with no reuse or recycling of materials, i.e., the product and the materials used reach end-of-life.

There is a circular flow in a circular economy where recycled material and renewable energy are used to produce products. After usage, the products are reused or recycled, replacing the end-of-life with a closed-loop. An example of such an effort is Adidas's fully recyclable shoe Futurecraft Loop, made of plastic waste from the ocean without glue and can easily be remade into a new pair (Morgan, 2020).

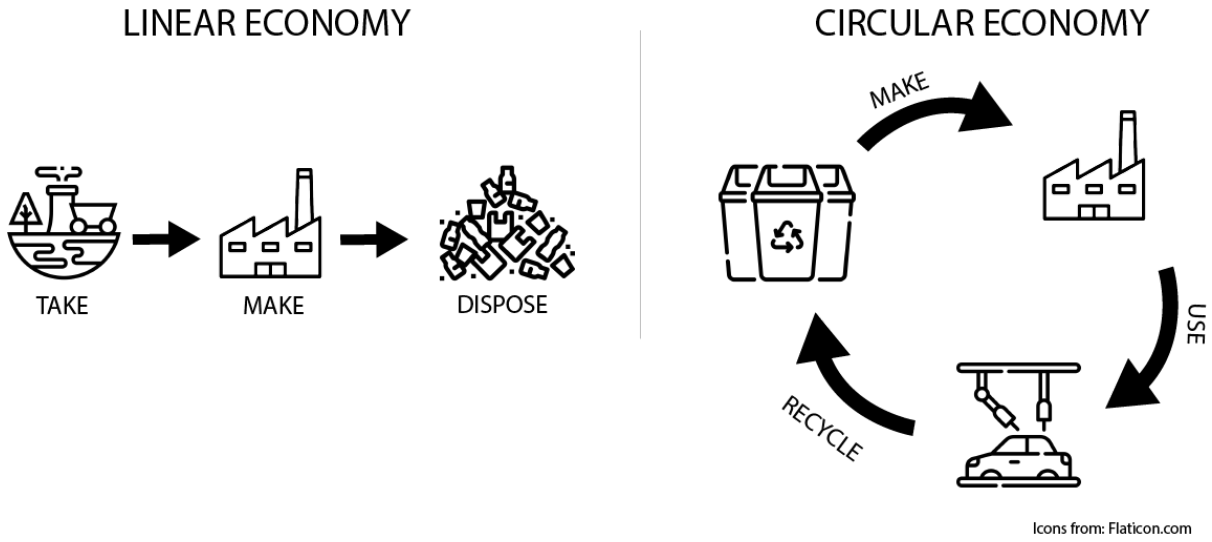

Figure 2.1: Differences between linear economy and circular economy.

The recycled materials match their original quality in an ideal circular economy scenario, i.e. ultimate circularity. This means that the material can be used in a similar product again and again. No products become waste, and no natural resources are additionally needed. Such a closed product chain, which is the aspiration of a circular economy, is, however, probably not feasible in practice (Potting et al., 2017).

There are also exceptions to sustainability in circular economy. For example, car sharing may lead to people using a car in situations they typically would not. Recycling contaminated plastics through a chemical process often requires large amounts of energy, usually from fossil fuels (Potting et al., 2017).

2.2.2 Circular Economy in Organizations

By implementing a circular economy, the dependency on imported goods and materials decreases for e.g. companies, countries, and regions (van Buren et al., 2016). By retaining resources in the regional production-consumption chains, the control of material supply increases, and the dependency on other regions decreases. As reusing, repairing, remanufacturing, and recovering materials through recycling is done locally, new job opportunities within the region occur. These activities have traditionally often been carried out in low-wage countries due to their low wage costs. (van Buren et al., 2016)

According to Kirchherr, Reike, and Hekkert (2017), emphasis on business models is needed in discourses to ease the transition towards a circular economy for the private sector. However, the government also has a vital role in implementing the circular economy for the short and long term. This is due to the companies being more willing to change their investment strategies if the policies are long-term and last longer than a cabinet term (van Buren et al., 2016).

In order to guide and ease the process, there are different types of frameworks of strategies for the circular economy. Many of them are based on a certain number of Rs, and the most extensive one of those is the 10R framework (i.e., recover, recycle, repurpose, remanufacture, refurbish, repair, reuse, reduce, rethink, refuse), as seen in figure 2.2.

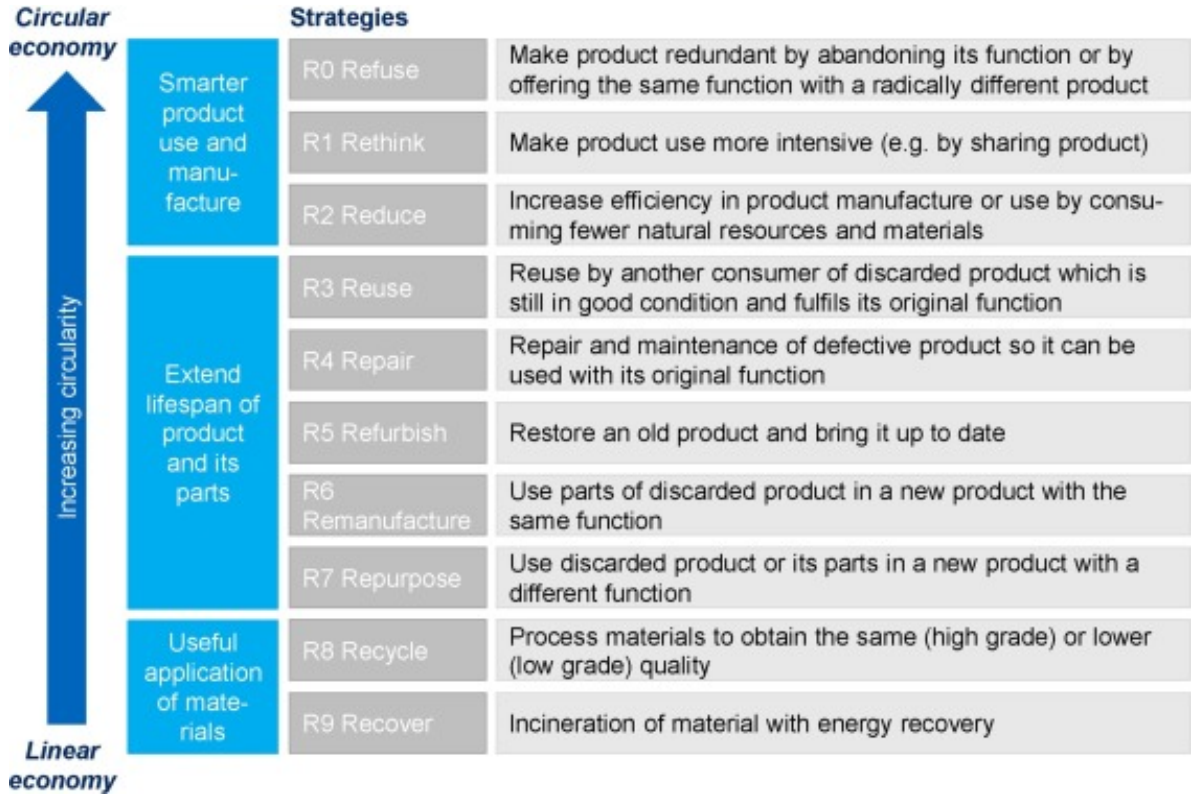

Figure 2.2: 10R framework, Source: Kirchherr, Reike and Hekkert (2017) (Adapted from Potting et al. (2017)).

The 10R framework prioritizes ten circularity strategies according to their circularity levels. R9 Recover, which refers to energy recovery from the incineration of materials, is prioritized last in the circular economy. R9 Recover has the lowest priority as the materials from the product are incinerated and no longer possible to use in new products. R0 Refuse, referring to offering a radically different product with the same function, alternatively abandoning it altogether, is the top priority. R0 Refuse is the top priority as resource extraction and material production is avoided, which is an environmental benefit as fewer natural resources are needed (Potting et al., 2017).

An example of a reuse effort (R3) is IKEA's buyback service. In exchange for store credit, they buy furniture in usable condition back and resell it in their bargain section, giving the product another life (Duffy, 2021).

2.3 Digital Transformation-driven Circular Economy

According to recent findings by Chauhan, Parida, and Dhir (2022), digital transformation can help organizations enable a circular economy. Digital technologies play a vital role in circular economy transformation as they help organizations develop and focus on sustainable value creation and well-being (Antikainen, Uusitalo, and Kivikytö-Reponen, 2018; Chauhan, Parida, and Dhir, 2022).

2.3.1 The Swedish automotive industry

During the last few decades, the Swedish automotive industry has gone through significant changes from nationally-owned money machines to internationally owned investment objects. Even though parts of the manufacturing have been outsourced or moved to low-cost countries (Andersson, Poldahl, and Widegren, 2018), the industry and its suppliers employed around 155 000 people in Sweden in 2019 (Business Sweden, 2020). Also, the Swedish automotive industry is significant for Sweden's economy, accounting for 15% of total exports in 2018 (Business-Sweden, 2020).

However, it is also a significant source of waste and pollution. 292 546 motor vehicles, i.e. 257 733 cars, 28 732 trucks and 6 081 buses were produced in Sweden in 2021 (ACEA, 2022). Based on the EU average of waste per unit produced car, which is 81,71 kg/car (ACEA, 2021a), the total amount of waste from the Swedish car production alone is 21 059,4 tons.

Furthermore, based on the EU average of CO2-emissions per unit produced car, which is 0,56 ton CO2/car (ACEA, 2021b), the total amount of CO2-emissions from the Swedish car production alone is 144 330,5 tons CO2.

Lastly, based on the EU average of energy used per unit produced car, which is 2,54 MWh/car (ACEA 2021c), the total energy used within the Swedish car production alone is 654,64 GWh.

As the digital transformation-driven circular economy aims at reducing waste, energy use and emissions, the Swedish automotive industry could benefit from the digital technologies and their capabilities mentioned in the next sub-chapter.

2.3.2 Capabilities

Antikainen, Uusitalo, and Kivikytö-Reponen (2018), as well as Chauhan, Parida, and Dhir (2022), have presented how certain technologies can facilitate organizations in their journey towards a circular economy. Their works discuss different digital technologies and their applications for the circular economy. Below, in table 1.1, a summarization of findings from the literature regarding digital transformation technologies and their capabilities to achieve a circular economy can be seen. The summarization is based on findings from Antikainen, Uusitalo, and Kivikytö-Reponen, 2018; Chauhan, Parida, and Dhir, 2022; Dremel, C., Herterich, M., Wulf, J., Waizmann, J.-C. and Brenner, W., 2017; Ingemarsdotter, E., Jamsin, E. and Balkenende, R., 2020

Table 1.1 shows a list of findings related to digital technologies and their capabilities from literature:

Digital Transformation Technology	**Capabilities to achieve Circular Economy**
Sensors	- Object identification and tracking - Sensing parameters
Big Data	- Integration of diverse data - Enhanced product lifecycle - Data-driven sustainable insights
Robotics	- Productivity - Reduce mistakes - Replace manual processes
Blockchain	- Supply chain performance - Transparency and communication - Incentive mechanism - Group decision-making
Digital Twin	- Supply chain-input - End-of-life management of products
3D-printing	- Product development and design
Mobile and 5G	- Connectivity - Communication
Digital Marketing	- Marketing communication
Cloud Technology	- Data storage - Computing power - Reusability of technology

Virtual and Augmented Reality (VR and AR)	- Virtual presentation and accessibility
Machine Learning (ML)	- Forecast demand - Manage inventory - Improve quality - Cut costs
Internet of Things (IoT)	- Optimization - Tracking and assessment - Supply chain integration - End of life management - Automation of manual processes
Artificial Intelligence (AI)	- Decision support system - Information mining and integration - Identify hidden patterns - Productivity
API Based System Integration	- Connectivity - Reusability of technology - Efficiency of automation through communication

Table 1.1: Digital transformation technologies and their capabilities to achieve Circular Economy based on findings from Antikainen, Uusitalo, and Kivikytö-Reponen, 2018; Chauhan, Parida, and Dhir, 2022; Dremel, C., Herterich, M., Wulf, J., Waizmann, J.-C. and Brenner, W., 2017; Ingemarsdotter, E., Jamsin, E. and Balkenende, R., 2020.

2.3.3 Barriers

There are many barriers to digital transformation and circular economy alone, but they face another set of barriers combined. These barriers can according to Antikainen, Uusitalo, and Kivikytö-Reponen (2018) be divided into the following sets of barriers:

- Technological barriers: Integration of digital technologies and product design
- Attitudinal barriers: Risk aversion and perception of sustainability
- Operational barriers: Supply chain management and infrastructure
- Structural barriers: Unclear responsibility distribution and missing exchange of info
- Financial barriers: Financial profitability and measuring financial benefits

For example, policy-related problems and the lack of predictability are often a couple of the barriers to digital transformation-led circular economy. Ingemarsdotter, Jamsin, and Balkenende (2020) also mention the inconvenience of developing IoT-enabled products and the lack of structured data management processes as barriers when implementing a digital transformation-driven circular economy.

According to Čábelková et al. (2021), technology approval and social awareness are the most critical factors for transitioning towards a circular economy using digitalization. Low pressure from the market is one of the bigger barriers and relates to the lack of social awareness. In addition, cost-related concerns, lack of technology strategy, information vulnerability and psychological issues are also mentioned as barriers (Chauhan, Parida, and Dhir, 2022).

3. Research Methodology

This chapter outlines the research methodology for the thesis. The chapter consists of six sections, starting with chapter *3.1 Research Approach*, where a brief explanation of the research process is given. Then follows chapter *3.2 Data Collection* where an explanation of the data collection through a survey as well as a literature review is presented. The following chapter, *3.3 Recruitment of Participants,* explains the survey participant selection. In chapter *3.4 Questionnaire Design* follows a description of how and why certain elements of the survey have been set. Chapter *3.5 Data Analysis* describes the procedure of how the results were analyzed. In the final section of this chapter, *3.6 Research Ethics,* a description of the thesis ethics is presented.

3.1 Research Approach

This research paper follows an inductive approach in order to establish a link between the area of study and qualitative data gathered from the industry (Thomas, 2006).

The literature review is used to set a foundation for digital transformation and circular economy knowledge. The aim is to clarify the two concepts and look into their possible relations.

Qualitative and secondary data consisting of twenty-nine articles were reviewed, out of which twelve were related to digital transformation. The keywords “digital transformation”, “digitalization”, and “digital technologies” were used to retrieve these works. In addition, twelve articles related to the circular economy were reviewed, which were retrieved using the keyword "circular economy". Only five of the research papers related to both digital transformation and circular economy. A complete list of the literature reviewed can be found in Appendix 1.

Primary data was collected from experts through an interview survey in the form of a questionnaire. The experts were carefully chosen, as a large population would make it impractical or inconvenient to collect data (Collis and Hussey, 2014). The analysis section contains results from the survey. The findings from the literature review are mapped to the results in the discussion.

The limitations of the chosen approach and research method are mentioned at the end in 6.4 Limitations.

3.2 Data Collection

In the literature review, existing qualitative and secondary data in the form of twenty-nine manually chosen articles is analyzed. The findings from the reviewed literature is used to create a survey to collect primary data from experts.

The survey questionnaire comprises eighteen questions divided into five sections. A descriptive survey was chosen to investigate relevant people's views and find out what they think or feel (Collis and Hussey, 2014). According to Collis & Hussey (2014), the main problems with questionnaire surveys are "questionnaire fatigue" and "non-response bias" i.e participants, finding it difficult to answer the questionnaire due various reasons. In order to overcome these issues, some of the participants were asked for their willingness to respond beforehand. Reminder emails were sent out to the people that did not respond.

3.3 Recruitment of Participants

The participants selected have worked with digital transformation or the circular economy in their respective organizations. The quantitative and qualitative data collected from experts and professionals gives an insight into the current and actual situation of digital transformation and sustainability within the Swedish automotive industry.

It was sent out to 41 people affiliated with the Swedish automotive industry in digital transformation or circular economy projects. These people were identified through the authors' professional contacts while working in the industry, and through LinkedIn. Out of the 41 people, 17 participated in the survey, giving a response rate of 41,2 %. The target number of responses was set between 10-20, for successful research to be possible with tight experimental controls (U Sekaran, 2000). The survey concluded when an adequate number of responses was recorded.

94.1 % of the respondents thought that digital transformation is a great enabler of circular economy. 41.2 % of respondents had over 10 years of experience. 41.2 % had 5-9 years of experience whilst 17.6 % had 1-4 years of experience.

Table 2.1. shows the list of participants of the interview survey, along with their positions/titles and number of years of experience in the industry.

#	Position / Title	Years of experience
1	Head of digital transformation group	Over 10 years
2	Product Owner digitalization for sales and marketing	Over 10 years
3	Cloud Developer / digitizing Vehicle systems	Over 10 years
4	Product Owner in digital transformation projects	5-9 years
5	Cloud Developer in digital transformation projects	5-9 years
6	Information Manager & Quality Responsible for a digital transformation project	5-9 years
7	Senior Architect for digital transformation projects	Over 10 years
8	Head of product development (digitalization)	Over 10 years
9	Product owner in a digital transformation project	1-4 years
10	Associate professor, Vehicle engineering	Over 10 years
11	Assistant professor, Vehicle engineering	Over 10 years
12	Data Scientist (digitalization)	5-9 years
13	Researcher for digital transformation projects	5-9 years
14	Lead Cloud developer in a digital transformation project	5-9 years
15	Developer digitizing “Availability”	5-9 years
16	Software Engineer	5-9 years
17	Backend Engineer, Micromobility	5-9 years

Table 2.1: List of participants with their position/title and number of years of experience

3.4 Questionnaire Design

The survey questionnaire was based on the literature findings and designed in accordance with the steps provided by Collis and Hussey (2014) (figure 3.1).

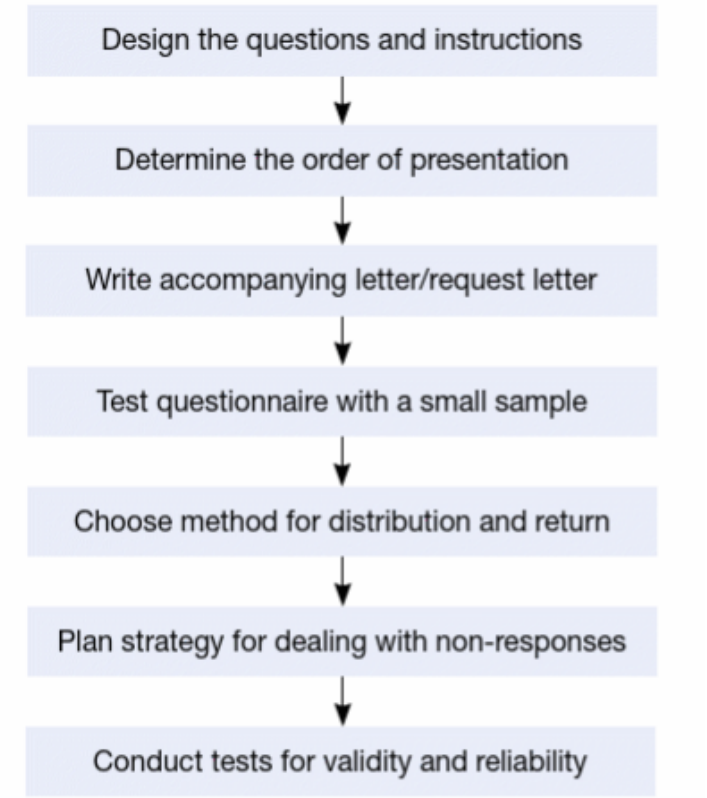

Figure 3.1: Designing a questionnaire (Collis and Hussey, 2014)

The questions were carefully designed and divided into five sections. They were ordered from general to specific questions in each section. The digital transformation section was based on the technologies found to be of importance in the literature (**Table 1.1 in chapter 2.3**). This section was followed by questions and statements concerning circular economy, sustainability and effects of current world-situation.

To describe the purpose of the study, a cover letter was attached while sending it to the participants. The questions consisted of both closed and open but optional questions. After testing the questionnaire with the first few participants and getting feedback, the open questions were removed in favor of closed questions. Questions related to the impacts of global events were also removed. However, the responses of all questionnaires were also included as part of the final data, as all relevant data was present.

The sections of the survey questionnaire along with their questions and respective answer options are given in the Table 2.2 below:

#	Section	Question	Answer options
1	Digital transformation	Is your organization actively implementing digital transformation?	Yes / No
2		Which of the following technologies are you/your organization currently implementing/using?	List of technologies
3		Which three (3) of the following technologies have made the greatest impact towards sustainability at your organization to date?	List of technologies
4		Which of the following technologies is your organization currently in need of to move further towards sustainability, but lack?	List of technologies
5		Which three (3) of the following technologies do you think will have the greatest impact on the transition towards a circular economy within the Swedish automotive industry?	List of technologies
6	Circular Economy	It is important to achieve circularity in every aspect of the lifecycle of a product – from raw material extraction to recycling.	Scale: 1 to 5 (disagree or agree)
7		The Swedish automotive industry is currently taking tangible steps towards a circular economy.	Scale: 1 to 5 (disagree or agree)
8		Digital transformation is a great enabler of circular economy.	Scale: 1 to 5 (disagree or agree)
9		Is your organization actively working towards sustainability?	Yes / No
10		Does your organization have a clear roadmap regarding achieving a circular economy ?	Yes / No / Not aware

11	UN Sustainable Development Goals	Are you familiar with the UN SDGs?	Yes / No
12		How well has the Swedish automotive industry achieved progress toward the UN SDGs in general?	Scale: 1 to 5 (poor or excellent)
13		Which three (3) of the UN SDGs has the Swedish automotive industry made MOST progress towards?	List of SDGs
14		Which three (3) of the UN SDGs has the Swedish automotive industry made LEAST progress towards?	List of SDGs
15		Which three (3) of the UN SDGs do you find most important to address within the Swedish automotive industry?	List of SDGs
16	Participant Data	Position / Title	Open
17		Years of Experience	1-4 / 5-9 / Over 10
18		General Comments	Open (Optional)

Table 2.2: Questions in the Survey Questionnaire

The questionnaire was created using Google Forms, which helped in the distribution process. It was distributed online through email and by contacting people through Linkedin. The non-respondents were contacted again as a reminder.

3.5 Data Analysis

The questionnaire for the interview surveys was created using Google Forms. The data analysis tools provided by Google were used which facilitated the representation of responses in the form of bar charts, histograms and pie charts. The responses to the optional open questions were manually cleansed and normalized. All responses were exported in Google Sheets and information such as percentage scores for the answers were calculated using this data.

The extracted information is used and presented in the Research Findings chapter.

3.6 Research Ethics

The survey participants were informed about anonymity, confidentiality, and privacy both in the beginning of the survey as well as in the initial contact through email or LinkedIn. This was considered important as confidentiality and anonymity in a survey can lead to more honest answers as well as a higher response rate (Collis and Hussey, 2014).

No names or personal info was collected and the data was analyzed in summarized form through Google Forms, with no insight into individual answers. The survey was voluntary in every aspect and the participant had the possibility to pause or abort at any time if they wanted.

The research was performed in the short period of three months. Hence, the literature reviewed was limited. Reviewing more literature could give deeper knowledge about the concept. Due to the time limitations of this research number of participants for the survey were also limited. Distributing the survey to more participants could result in more rich and accurate data.

4. Research Findings

In this chapter, the results and findings from the survey are presented. This chapter consists of five sections, starting with chapter *4.1 Digital Transformation* where the survey results regarding digital transformation are presented. In the following chapter, *4.2 Circular Economy,* the survey results regarding the circular economy are presented. In chapter *4.3 The Swedish Automotive Industry and the UN SDGs*, the survey results regarding the UN SDGs are compared to the SDGs mentioned in the introduction.

4.1 Digital Transformation

The participants were asked which of the listed digital transformation technologies they or their organization were currently using. This question was asked in an attempt to get an overview of the technologies currently implemented by the industry. As seen in figure 4.1, 94.1 % of the survey respondents claimed to be using *Cloud Technology*, making it the currently most used. The second most used technology is claimed to be *API Based System Integration,* which 82.4 % of the respondents claim to be using. In a shared third place, *Sensors* and *Machine Learning* can be found with 64.7 % of the respondents claiming to be using these. The technologies that the respondents were using the least were *Blockchain, 3D-printing,* and *Augmented Reality* with one respondent (5.9 %) each, closely followed by *Virtual Reality* with two respondents (11.8 %) using it (figure 4.1).

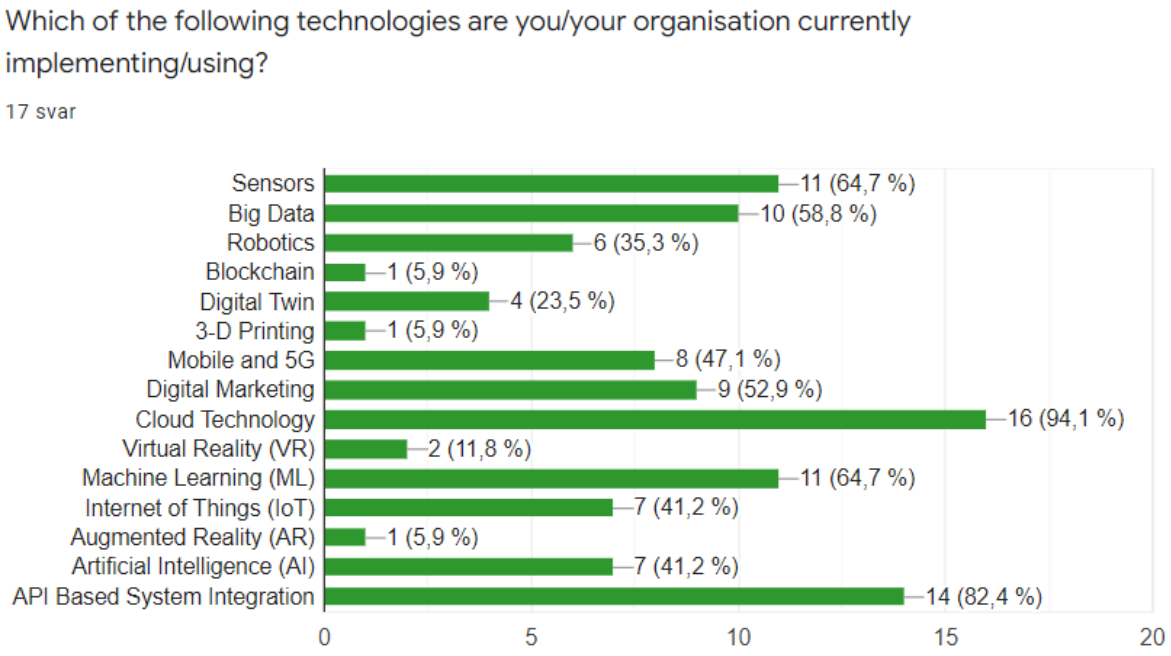

Figure 4.1: Currently used technologies

The following question was asked to get an overview of which technologies the respondents believed to have had the most significant impact on sustainability. When asked which three of the technologies had made the greatest impact on sustainability in their organization to date (figure 4.2), *Cloud Technology* once again stands out in the list of options as number one, with 70.6 % claiming it to be one of the top three most important technologies. After *Cloud Technology* comes *API Based System Integration* with 58.8 %. At a rate of 29.4 %, the respondents considered *Internet of Things* as having had the third greatest impact on sustainability.

Robotics was used by 35.3 % (figure 4.2) but chosen by none of the respondents as one of the top three in regards to sustainability impact. Another interesting finding is that *Digital Marketing* is used by 52.9 % (figure 4.2) but chosen by 11.8 % as one of the top three in regards to sustainability impact.

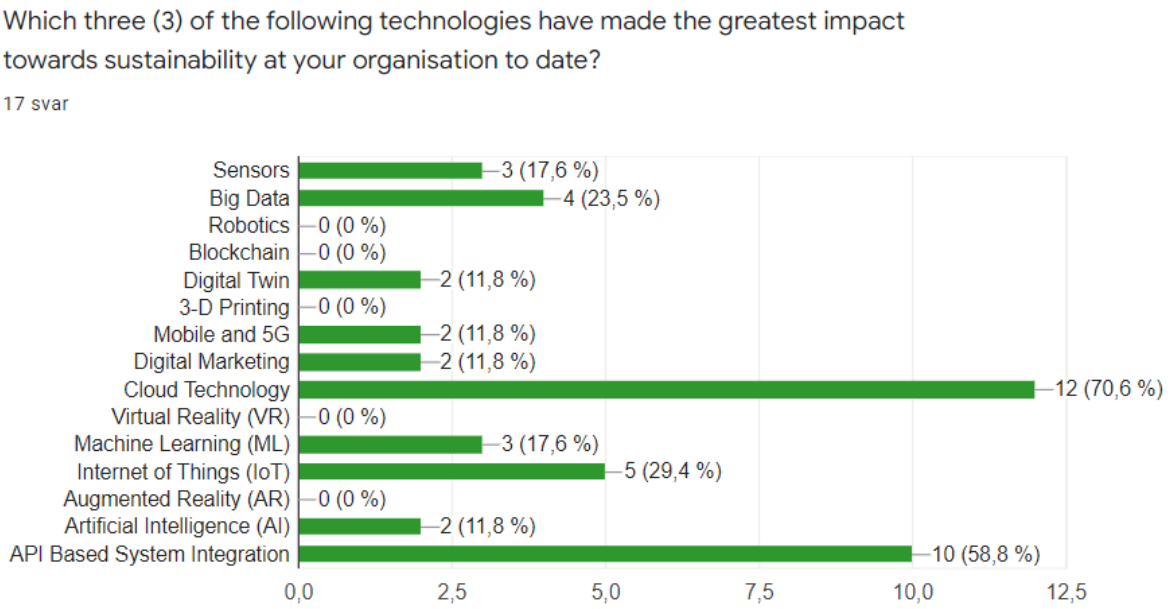

Figure 4.2: The greatest impact on sustainability to date

The technologies that the respondents think will have the greatest impact on the transition towards circular economy within the Swedish automotive industry are *Machine Learning* (58.8 %), *Big Data* (47.1 %), and *Artificial Intelligence* (41.2 %) (figure 4.3). These three technologies were also the top three mentioned when the respondents were asked which of the technologies their organizations currently are in need of to move further towards sustainability, but lack (appendix 2).

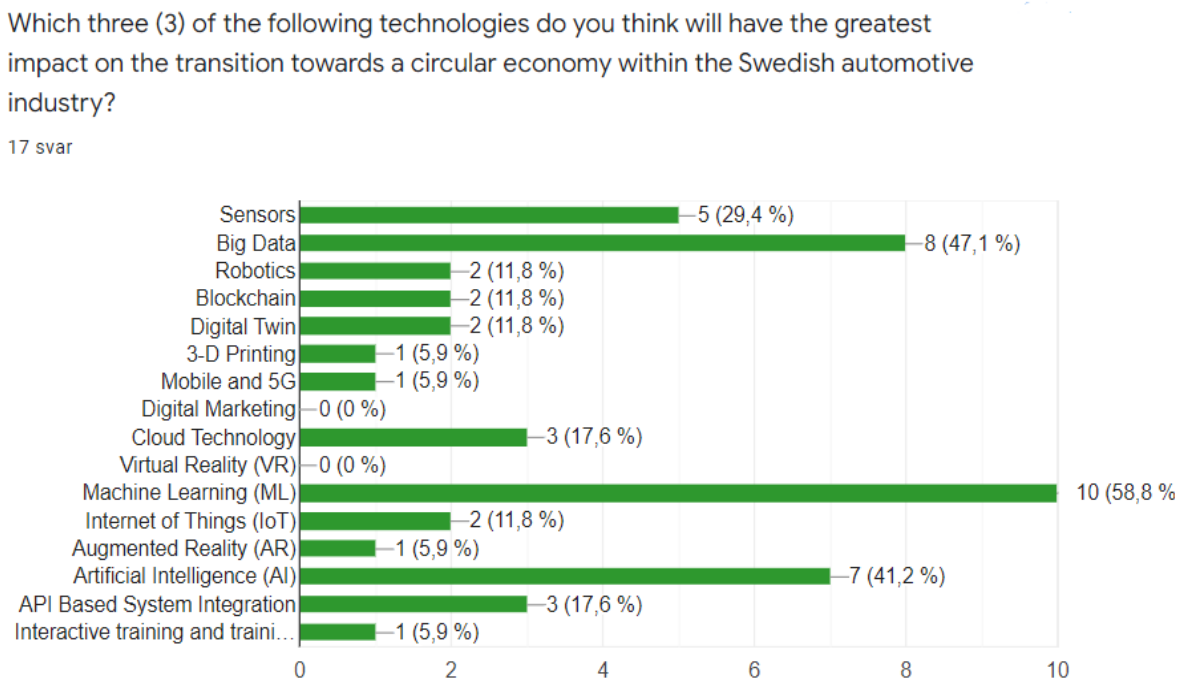

Figure 4.3: The greatest impact on the transition towards circular economy in the Swedish automotive industry

4.2 Circular Economy

While all (100 %) of the respondents stated that their organization is actively working towards sustainability, only 41.2 % stated that their organization has a clear roadmap regarding achieving circular economy. 94.1 % of the respondents thought that digital transformation is a great enabler of circular economy (appendix 2).

When presented with the statement “It is important to achieve circularity in every aspect of the lifecycle of a product – from raw material extraction to recycling”, the respondents were asked to state their opinion on a scale of 1-5 (1 = Completely disagree, 2 = Disagree to some extent, 3 = Do not know, 4 = agree to some extent, 5 = Completely agree). 76.5 % of the respondents fully agreed, while 17.6 % agreed with the statement to some extent and 5.9 % of the respondents did not know (figure 4.4).

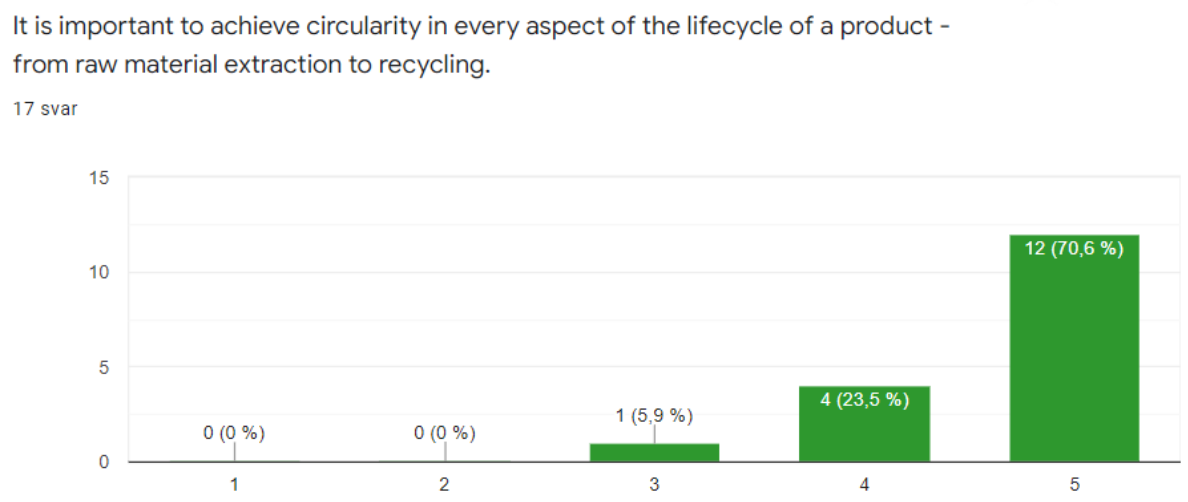

Figure 4.4: The importance of circularity according to the respondents.

The respondents were a bit more negative when answering the next statement, “The Swedish automotive industry is currently taking tangible steps towards a circular economy” as seen in figure 4.5. 41.2 % of the respondents answered either “disagree to some extent” or “do not know”. while only 29.4 % of the respondents answered, “completely agree”.

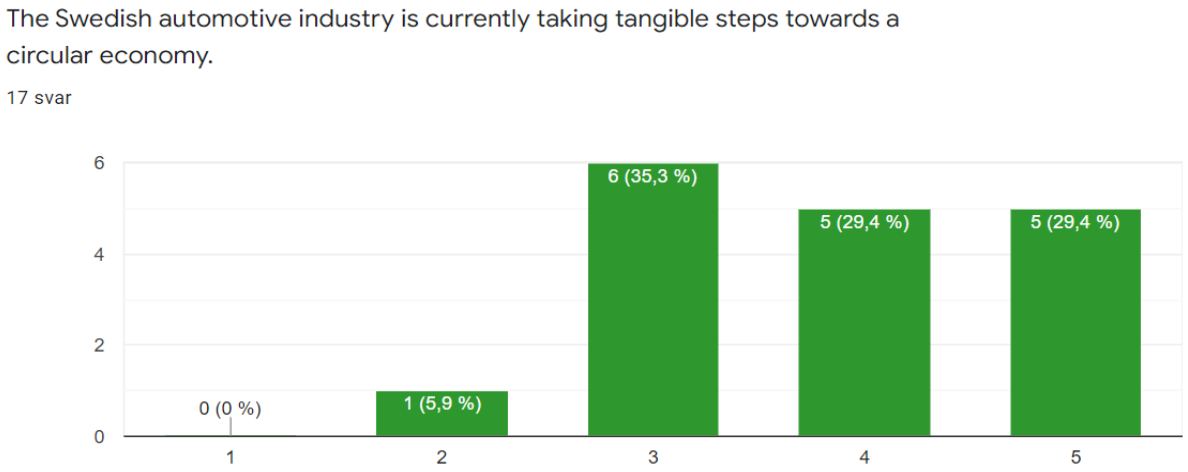

Figure 4.5: Swedish automotive industry and circular economy

4.3 The Swedish Automotive Industry and the UN SDGs

64.7 % of the respondents claimed to be familiar with the UN SDGs from before. All participants were given the opportunity to get familiar with the SDGs through a link before moving onwards in the survey.

On the question “Which three of the UN SDGs do you find most important to address within the Swedish automotive industry?” *SDG: 13 Climate action* is considered to be the most important with 47.1 % of respondents choosing this option. Considered the second most important to address were *SDG 9: Industry, innovation and infrastructure* and *SDG 11: Sustainable cities and communities* with 41.2 % each. Third most important. According to the respondents, were; *SDG 7: Affordable and clean energy* and *SDG 12: Responsible consumption and production* with 35.3 % each (appendix 2).

5. Discussion

This chapter consists of one chapter which will discuss the findings in light of the academic literature and industry. The thesis has aimed to examine the relation between digital transformation and circular economy. More specifically, the aim has been to investigate how digital transformation tools and processes might help the Swedish automotive industry to achieve a circular economy. In chapter *5.1 Discussion of the findings,* the key findings of this research is presented.

5.1 Discussion of the findings

The first key finding from the survey is that *Cloud Technology, API Based System Integration, Sensors* and *Machine Learning* are the most used digital transformation technologies (figure 4.1), which leads to the conclusion that they are **the driving forces of digital transformation-driven circular economy (Key Finding 01).**

Another key finding from the survey shows that technologies such as *Blockchain, 3D-printing* and *Augmented Reality* were the least used, closely followed by *Virtual Reality (figure 4.1)*. As stated in *2.3.1 Barriers to Digital Transformation-led Circular Economy*, Čábelková et al. (2021) suggest that technology approval and social awareness are the most important factors of a digital transformation-driven circular economy. Since technologies such as *Blockchain, Augmented Reality* and *Virtual Reality* can play an important role in digital transformation (Chauhan, Parida, and Dhir, 2022), it leads to the conclusion that there is still a need to **raise awareness regarding the impact of various digital technologies (Key Finding 02).**

Furthermore, *Cloud Technology* stands out in the lists of options as number one of top three most important technologies to have an impact on sustainability. The other ones are *API Based System Integration* and *Internet of Things* (figure 4.2). These results indicate that organizations might be able to benefit even more, from technologies that have a greater impact on sustainability i.e. **Continue the use of technologies that have a great impact on sustainability (Key Finding 03)**.

Interestingly, Robotics was relatively well-used in the Swedish automotive industry, however, none of the respondents believed that this technology was in the top three in regards to sustainability impact. *Robotics* could arguably have a bigger impact on sustainability as it increases efficiency and minimizes human error. It shows that there is an opportunity to raise awareness and knowledge regarding the impact on sustainability of other technologies i.e. **Raise awareness regarding the impact of digital technologies on sustainability (Key Finding 04)**

Another interesting finding is that the respondents believe that *Machine Learning, Big Data,* and *Artificial Intelligence* will have the most significant impact on the transition towards a circular economy within the Swedish automotive industry (figure 4.3). These three technologies were also the top three mentioned when the respondents were asked which of the technologies their organizations currently are in need of to move further towards sustainability, but lack. This finding further supports **Key Finding 03.**

Furthermore, all of the respondents stated that their organization is actively working towards sustainability. However, less than half of the respondents stated that their organization has a clear roadmap in terms of achieving circular economy (appendix 2). As earlier mentioned, Čábelková et al. (2021) claims that social awareness is crucial for digital transformation-driven circular economy. This suggests that a clear roadmap and heightening awareness and involving employees in the circular economy strategy can help achieve a digital transformation-driven circular economy. This leads to the conclusion that there is a need for heightened awareness and involvement of employees in this matter i.e. **Organizational awareness and involvement of employees in the circular economy strategy (Key Finding 05).**

Key Finding 05 is further underlined by the results shown in figures 4.4 and 4.5 where it is made clear that people within the Swedish automotive industry find it important to achieve circular economy, but that there is a lack of involvement and knowledge from the automotive industry**.**

The UN SDGs that the respondents found most important to address within the Swedish automotive industry was *SDG: 13 Climate action*, *SDG 9: Industry, innovation and infrastructure, SDG 11: Sustainable cities and communities, SDG 7: Affordable and clean energy,* and finally, *SDG 12: Responsible consumption and production* (appendix 2). This corresponds well to the SDGs that are argued in chapter 1.5. *Sustainability aspects of the digital transformation-driven circular economy.*

During the research it was found that global events such as pandemics and conflicts did not have a substantial negative effect on the organizations' efforts towards digital transformation or their journey towards a circular economy. Organizations should continue to make themselves more stable against external factors, in order to continue their journey.

6. Conclusion

This chapter consists of four sections and will conclude this thesis. In the first chapter, *6.1 Conclusion,* the key findings from the research are listed and the research question is answered. In chapter *6.2 Recommendations* the different technologies recommended are presented. Chapter *6.3 Future Research* possible research areas and angles in relation to this topic is mentioned. The final section, *6.4 Limitations*, ends the thesis by mentioning the limitations.

6.1 Conclusions

Circular economy has many benefits, and economic prosperity (Kirchherr, Reike, and Hekkert, 2017) is one of them. Circular economy could lead to a €1.8 trillion valued benefit in Europe by 2030 (Bresanelli et al., 2018).

Digital technologies have been increasingly considered to enable circular economy (Ranta, V., Aarikka-Stenroos, L., & Väisänen, J. M., 2021). However, what is needed for circular economy to be fully realized is, according to Chizaryfard, Trucco, and Nuur (2021, p. 495), a "systemic change throughout the firm, industry or economy, and requires a radical shift in societal values, norms, and behaviors. Thus the circular economy is also about understanding and overcoming tensions that might bring transformative pressures". Still, more circularity leads to a decreased use of natural materials and resources, making less negative impact on the environment. Furthermore, for implementing the circular economy concept, digital transformation often needs to occur, and it can also be used as a tool to achieve a circular economy.

In order to bridge the research gap, the five key findings identified from the results of the performed interview surveys and literature review are:

1. *Cloud Technology, API Based System Integration, Sensors* and *Machine Learning* are the driving forces of digital transformation-driven circular economy.

2. Raise awareness regarding the impact of various less used digital technologies on digital transformation, such as *Blockchain, 3D-printing Virtual Reality* and *Augmented Reality*.

3. Continue the use of technologies that have a great impact on sustainability, such as *Cloud Technology, API Based System Integration* and *Internet of Things.*

4. Raise awareness regarding the impact of digital technologies on sustainability.

5. Organizational awareness and involvement of employees in the circular economy strategy.

These findings are then used to answer the research question "*How can Swedish automotive organizations leverage digital transformation to transition toward a circular economy?",* and present the suggestions.

With the help of digital transformation, the Swedish automotive industry can leverage the capabilities created by digital technologies. Such capabilities allow them to create opportunities, better visualize markets, understand customer needs, behaviors, and interactions, close loops, make networking and communication efficient, optimize utilization of resources and cut costs. All of which contribute to the journey towards a more circular economy.

Although the road to a circular economy is long, and there are many significant shifts in the habits and values of people and organizations that need to change, industry policies and innovative business model implementation also contribute. Recommendations to facilitate these shifts to happen are presented below.

The Swedish automotive industry can use digital technologies such as *Machine Learning* and *Artificial Intelligence* to find hidden patterns and analyze real-time data. This data can be used to predict uncertainties or for forecasting purposes, which can help enable circularity.

They can use *Blockchain* to make product lifecycles traceable and transparent. The use of *Internet of Things* technology can monitor and control products. Information gathered from products using IoT and sensors can determine product conditions and predict maintenance to improve its lifetime. *Big Data* can help process high volumes of data and present it as valuable information. This information can be used to make decision-making simpler and quicker. It can also be used to better understand the products' usage and increase their quality. *Digital Marketing* can help promote circular economy and make communication between stakeholders, customers, and markets more efficient.

Many of these technologies combined can help in analyzing, reducing resource consumption, mitigating risks, increasing accessibility, and minimizing costs which together contribute to enabling circular economy. In addition, digital transformation facilitates organizations in closing material loops, increasing recycling possibilities, and sharing resources. Communication and co-creation can also be increased by using digital technologies.

6.2 Future research

As the thesis results are based on Sweden as a geographical area and English as a literature language, future research could examine the situation in other countries or more globally, including or excluding other languages. Future research could also investigate the situation between different companies and organizations using in-depth case studies.

6.3 Limitations

The first limitation of this thesis is the focus on articles written in English found through Google Scholar. The authors are aware that there is likely relevant studies and material that they have not found. Due to this strict criteria, future research could include material in other languages and from other databases. Moreover, organizations in the Swedish automotive industry have limited public data available. Collaborating with organizations to gain in-depth knowledge could further enhance this research.

The research was performed in a limited time of three months. Due to the limit, both the number of articles reviewed and number of survey participants were limited in number. The thesis focuses on a narrow geographical area with a small group of people interviewed. Moreover, online survey research includes ambiguity regarding the validity of data (Wright, 2017). Sampling, design, implementation and evaluation of such surveys may affect the quality of data gathered (Wright, 2017).

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Appendix

Appendix 1.

Literature Reviewed:

Author	**Title**	**Area of Study**
Antikainen, M., Uusitalo, T. and Kivikytö-Reponen, P.	Digitalisation as an Enabler of Circular Economy	Digital Transformation & Circular Economy
Boulding, K. E.	The economics of the coming spaceship earth	Circular Economy
Bressanelli, G., Adrodegari, F., Perona, M., & Saccani, N.	Exploring how usage-focused business models enable circular economy through digital technologies. Sustainability,	Digital Transformation & Circular Economy
Čábelková, I., Strielkowski, W., Streimikiene, D., Cavallaro, F., & Streimikis, J.	The social acceptance of nuclear fusion for decision making towards a carbon free circular economy: Evidence from Czech Republic. Technological Forecasting and Social Change	Circular Economy
Chauhan, C., Parida, V. and Dhir, A.	Linking circular economy and digitalisation technologies: A systematic literature review of past achievements and future promises.	Digital Transformation & Circular Economy
Chizaryfard, A., Trucco, P. and Nuur, C	The transformation to a circular economy: framing an evolutionary view	Circular Economy
Dremel, C., Herterich, M., Wulf, J., Waizmann, J.-C. and Brenner, W.	How AUDI AG established big data analytics in its digital transformation	Digital Transformation
Foss, A., Gertsen, F. and Helle Vesti	A definition and a conceptual framework of digital disruption	Digital Transformation

Günther, W.A., Rezazade Mehrizi, M.H., Huysman, M. and Feldberg, F	Debating big data: A literature review on realizing value from big data	Digital Transformation
Gupta, S.	Organizational Barriers to Digital Transformation	Digital Transformation
Hirsch, P.M. and Levin, D.Z	Umbrella Advocates Versus Validity Police: A Life-Cycle Model	Circular Economy
Ingemarsdotter, E., Jamsin, E. and Balkenende, R.	Opportunities and challenges in IoT-enabled circular business model implementation	Digital Transformation & Circular Economy
Kirchherr, J., Reike, D., & Hekkert, M.	Conceptualizing the circular economy: An analysis of 114 definitions.	Circular Economy
Klötzer, C. and Pflaum, A.	Toward the Development of a Maturity Model for Digitalization within the Manufacturing Industry s Supply Chain.	Digital Transformation
Korhonen, J., Honkasalo, A. and Seppälä, J.	Circular Economy: The Concept and Its Limitations.	Circular Economy
Korhonen, J., Nuur, C., Feldmann, A. and Birkie, S.E.	Circular economy as an essentially contested concept	Circular Economy
Lycett, M.	“Datafication”: making sense of (big) data in a complex world	Digital Transformation
Maedche, A.	Interview with Michael Nilles on “What Makes Leaders Successful in the Age of the Digital Transformation?”	Digital Transformation
Mithas, S., Tafti, A. and Mitchell, W.	How a Firm’s Competitive Environment and Digital Strategic Posture Influence Digital Business Strategy	Digital Transformation

Morakanyane, R., Grace, A. and O'Reilly, P.	Conceptualizing Digital Transformation in Business Organizations: A Systematic Review of Literature. Digital Transformation	Digital Transformation
Morseletto, P.	Targets for a circular economy.	Circular Economy
Potting, J., Hekkert, M.P., Worrell, E. and Hanemaaijer, A.	Circular Economy: Measuring innovation in the product chain	Circular Economy
Rli.	Circular Economy: From Wish to Practice	Circular Economy
Ranta, V., Aarikka-Stenroos, L., & Väisänen, J. M.	Digital technologies catalyzing business model innovation for circular economy—Multiple case study.	Digital Transformation & Circular Economy
Sebastian, I.M., Moloney, K.G., Ross, J.W., Fonstad, N.O., Beath, C. and Mocker, M.	How big old companies navigate digital transformation	Digital Transformation
Sia, S., Soh, C. and Weill, P.	How DBS bank pursued a digital business strategy.	Digital Transformation
van Buren, N., Demmers, M., van der Heijden, R. and Witlox, F	Towards a Circular Economy: The Role of Dutch Logistics Industries and Governments	Circular Economy
Vial, G.	Understanding digital transformation: A review and a research agenda	Digital Transformation
Yuan, Z., Bi, J. and Moriguichi, Y.	The Circular Economy: A New Development Strategy in China. Journal of Industrial Ecology	Circular Economy

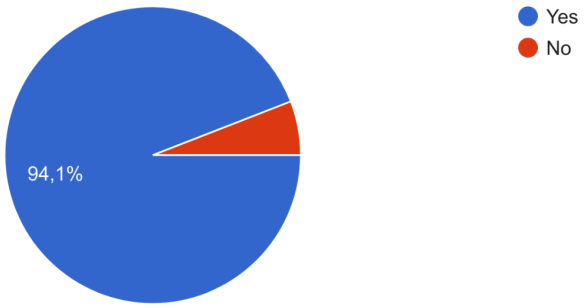
Table appendix 1: List of literature reviewed.

Appendix 2.

Full survey results:

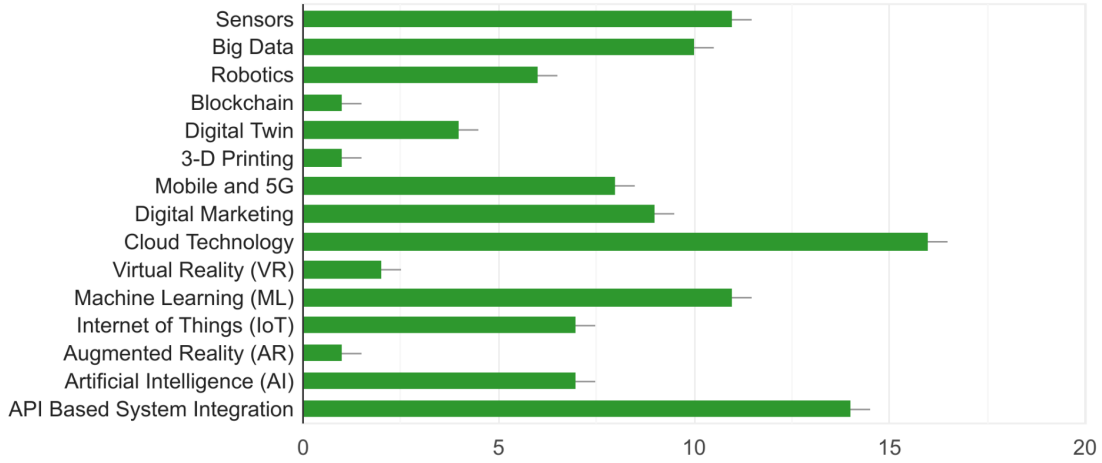
Is your organisation actively implementing digital transformation?

17 svar



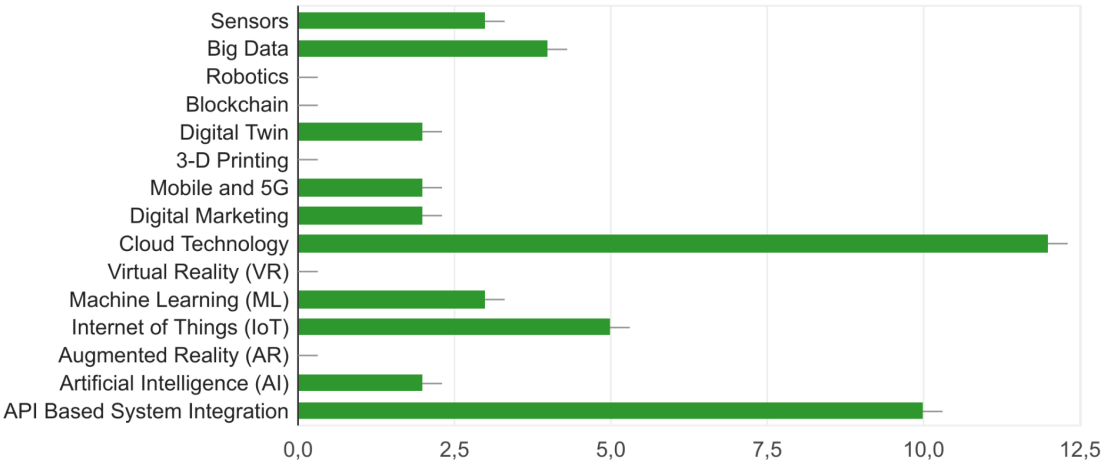
Which of the following technologies are you/your organisation currently implementing/using?

17 svar



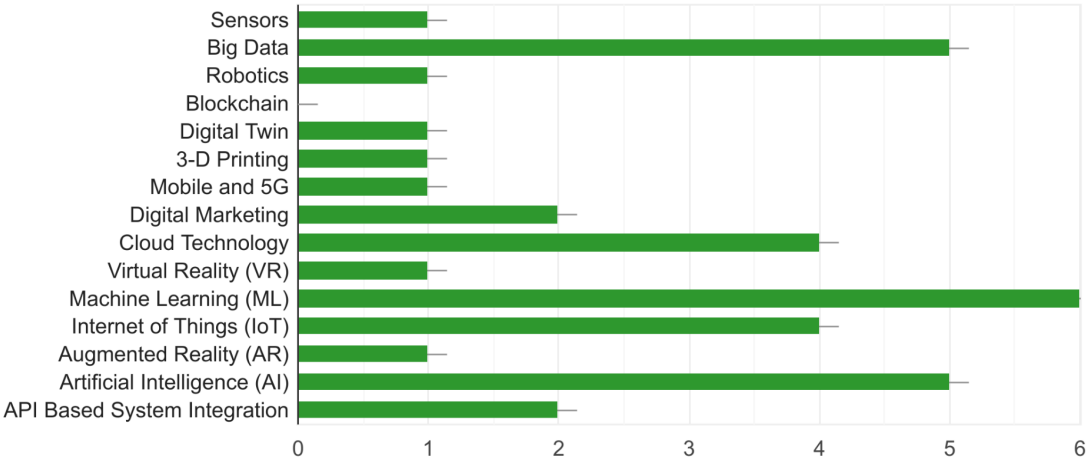
Which three (3) of the following technologies have made the greatest impact towards sustainability at your organisation to date?

17 svar



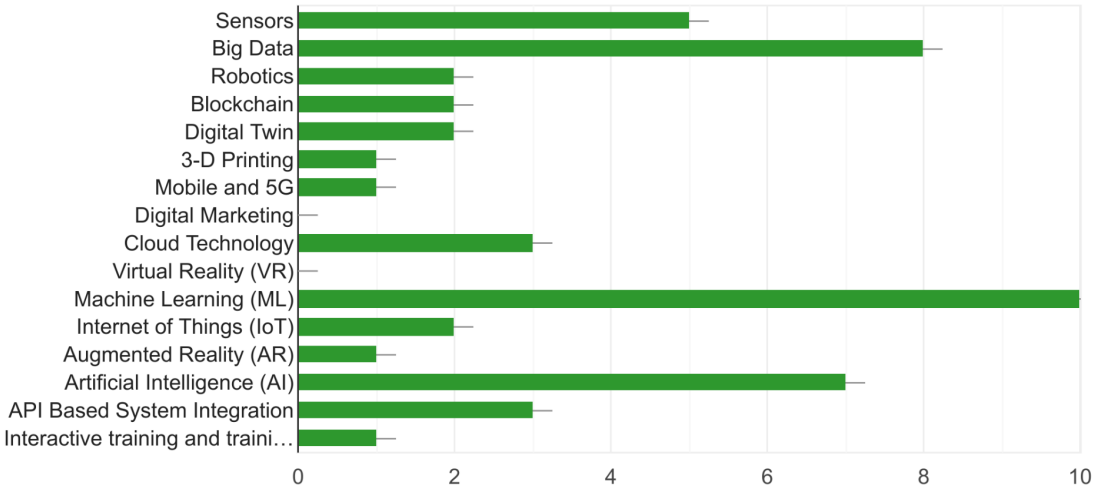
Which of the following technologies is your organisation currently in need of to move further towards sustainability, but lack?

17 svar



Which three (3) of the following technologies do you think will have the greatest impact on the transition towards a circular economy within the Swedish automotive industry?

17 svar



It is important to achieve circularity in every aspect of the lifecycle of a product - from raw material extraction to recycling.

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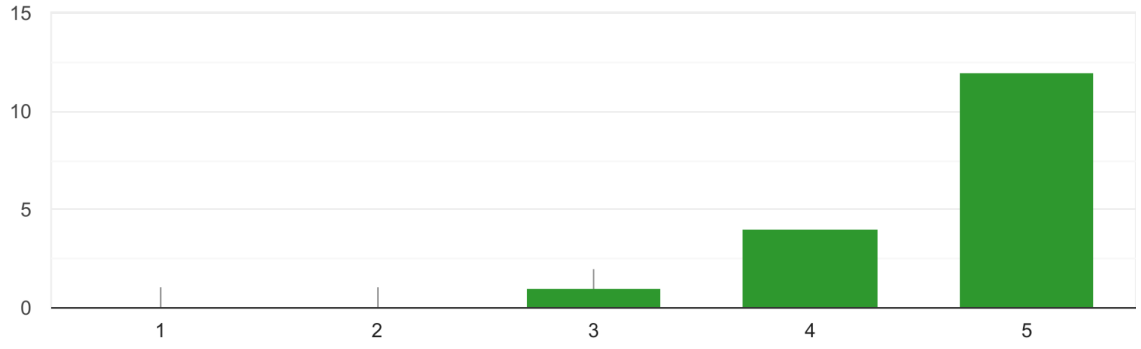

The Swedish automotive industry is currently taking tangible steps towards a circular economy.

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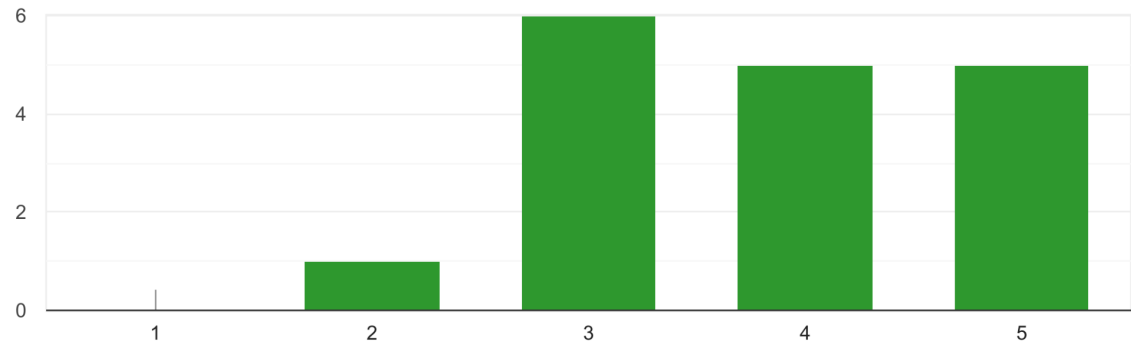

Digital transformation is a great enabler of circular economy.

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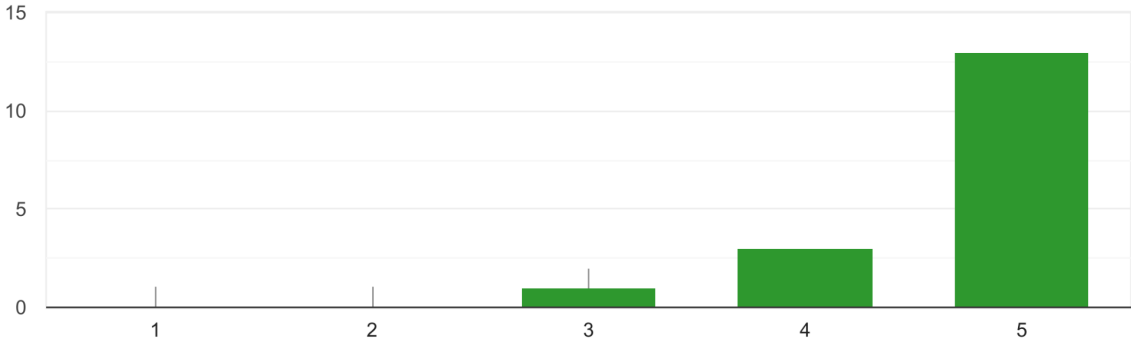

Is your organisation actively working towards sustainability?

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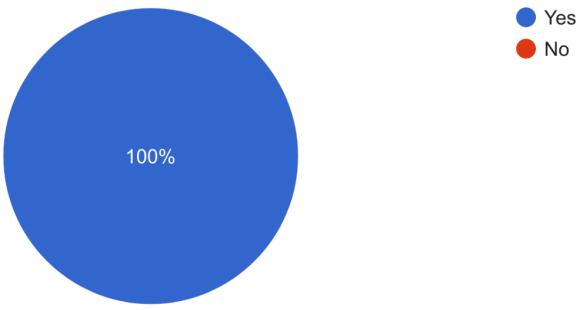

Does your organisation have a clear roadmap regarding achieving a circular economy ?

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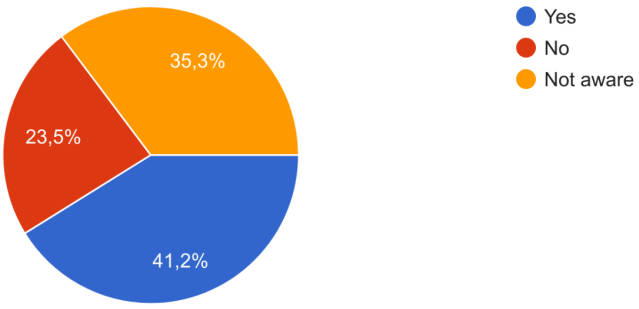
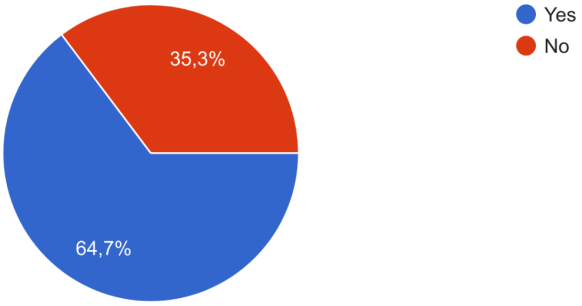


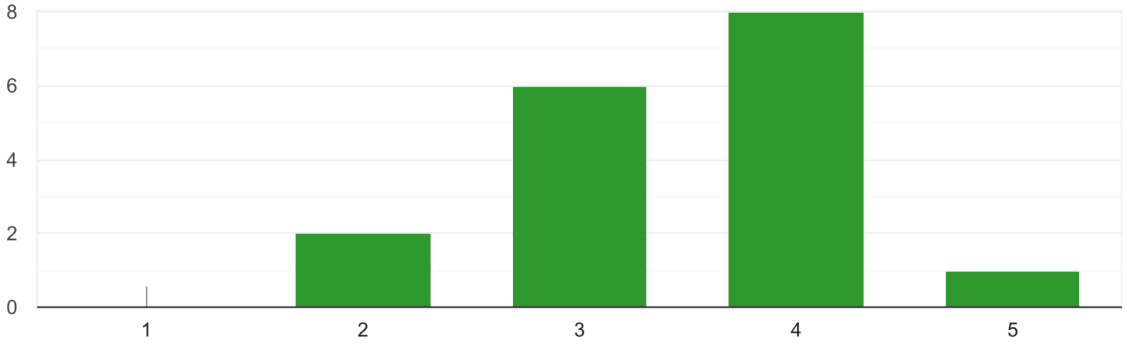
Are you familiar with the UN SDGs?

17 svar



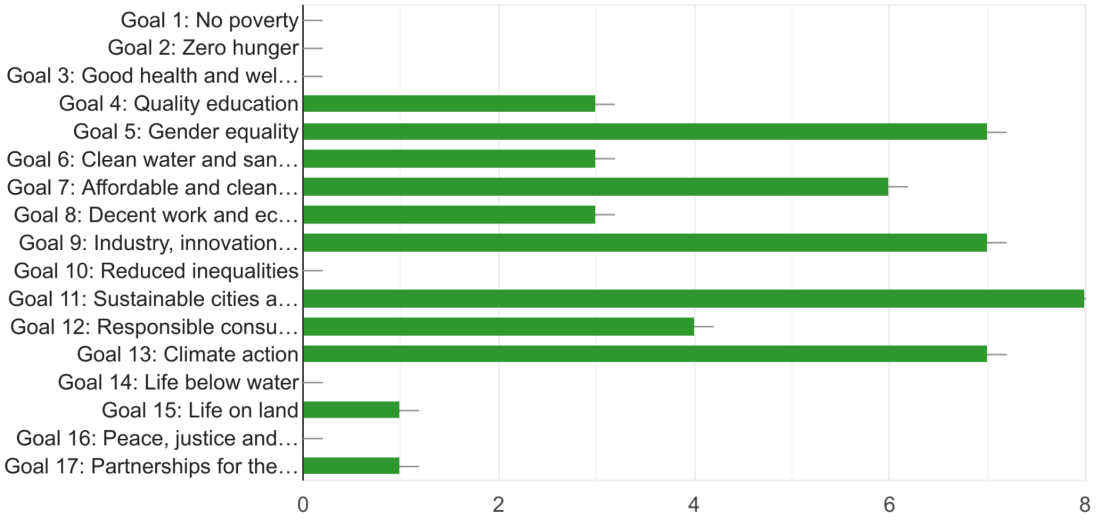
How well has the Swedish automotive industry achieved progress toward the UN SDGs in general?

17 svar



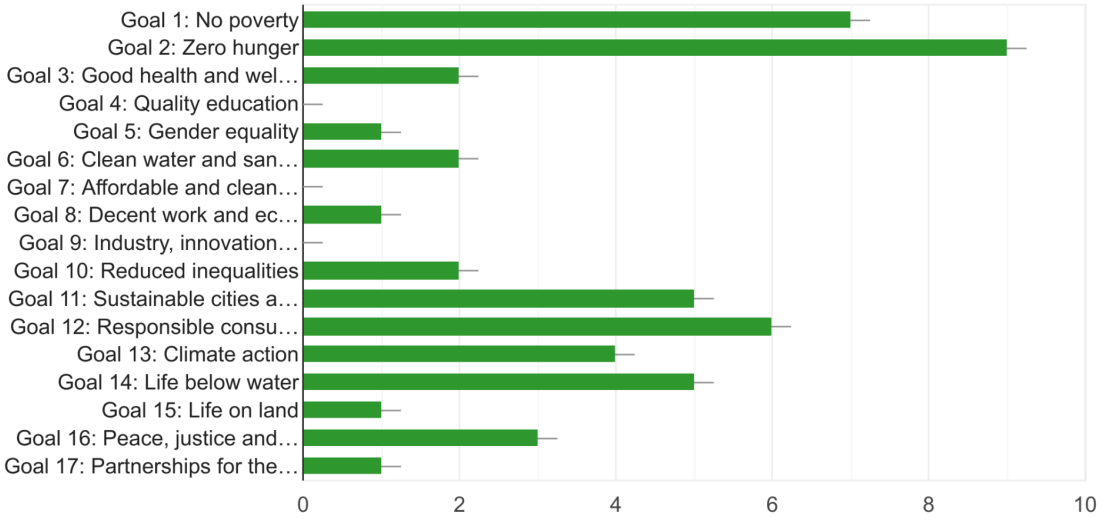
Which three (3) of the UN SDGs has the Swedish automotive industry made MOST progress towards?

17 svar



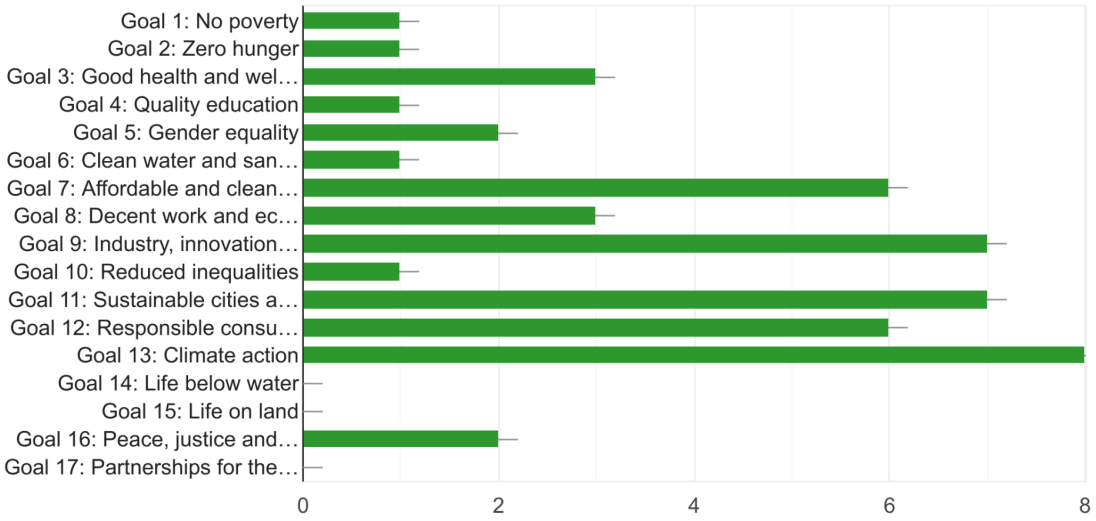
Which three (3) of the UN SDGs has the Swedish automotive industry made LEAST progress towards?

17 svar



Which three (3) of the UN SDGs do you find most important to address within the Swedish automotive industry?

17 svar



Years of experience

17 svar