Digitalization and sustainability in the automotive industry: The role of connected services

A qualitative case study at the example of the German Original Equipment Manufacturer BMW

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Abstract

English Version

Considering the fundamental changes in the automobile industry, connected services are playing an increasingly essential role for OEMs, as they enable new business models and income streams plus offer the prospect of differentiation from the competition. Furthermore, they are critical for meeting the industry's ever-changing customer expectations and can make a significant contribution to ecologically sustainable transportation. As a result, it is critical to understand the present state of connected services. The aim of the research of this master thesis is therefore to evaluate to what extent connected services can positively influence ecologically sustainable mobility in the automotive industry. For this purpose, the following research questions are posed: How can connected services contribute to more sustainable mobility? And which services can have the most significant impact? A qualitative empirical study concentrating on the German OEM BMW was conducted to answer those research questions. Specifically, the study investigates existing literature about connected services, analyses their current environmental impact and proposes a future forecast. The evaluation of these results shows that connected services positively influence sustainability by contributing to emission-reduced/energy-efficient mobility (due to improved driving behavior and efficient navigation) and by transparently visualizing the ecological footprint of individual mobility. In addition, the holistic ecological impact will grow in the future, since on the one hand connected services will be developed that will be focused on improved sustainability, and on the other hand, the overall usage of connected services will grow in the future, which increases their ecological impact.

Keywords: Sustainability, Automotive Industry, Digitalization, Connected Services

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Portuguese Version / Resumo

Considerando as mudanças na indústria automóvel, os serviços conectados desempenham um papel cada vez mais importante para os OEM, uma vez que permitem novos modelos de negócio e fluxos de rendimento, para além de oferecerem uma perspectiva de diferenciação em relação à concorrência. Além disso, são fundamentais para satisfazer as expectativas dos clientes numa indústria que está em constante mudança, contribuindo também de forma significativa para os transportes ecológicos. É importante compreender o estado atual dos serviços conectados. O objetivo desta investigação é, portanto, avaliar até que ponto os serviços conectados podem influenciar positivamente a mobilidade ecológica na indústria automóvel. Para este efeito, são analisadas as seguintes perguntas de investigação: Como podem os serviços conectados contribuir para uma mobilidade mais sustentável? Quais os serviços que podem ter um impacto mais significativo? De forma a responder a estas questões, foi realizado um estudo empírico qualitativo focado na empresa alemã BMW. No desenvolvimento deste estudo, foi analisada a literatura existente sobre serviços conectados, analisado o seu impacto ambiental atual, e por fim propõe-se uma previsão futura. Os resultados obtidos demonstram que os serviços conectados influenciam positivamente a sustentabilidade, contribuindo para uma mobilidade mais reduzida/eficiente em termos de emissões/energia (devido a uma melhor condução e navegação eficiente), bem como para uma pegada ecológica mais transparente. Além disso, o impacto ecológico global aumentará no futuro, uma vez que serão desenvolvidos serviços conectados que se concentrarão na melhoria da sustentabilidade e a sua utilização global aumentará no futuro.

Palavras-chave: Sustentabilidade, Indústria Automóvel, Digitalização, Serviços Conectados, Digitalização

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Abbreviations

BMW – Bayrische Motorenwerke AG

BEV – Battery Electric Vehicle

CAM – Center of Automotive Management

CAVs – Connected and Autonomous Vehicles

CSR – Corporate Social Responsibility

DSRC – Dedicated Short-Range Communication

EV – Electric Vehicle

GDP – Gross Domestic Product

ICE – Internal Combustion Engine

ICT – Information and Communication Technology

IoT – Internet of Things

MaaS – Mobility as a Service

OBU – Onboard Unit

OEM – Original Equipment Manufacturer

OS – Operating System

OTA – Over-the-air

PHEV – Plug-in Hybrid Electric Vehicle

RSU – Roadside Unit

SDGs – Sustainable Development Goals

VANET – Vehicular Ad-hoc Networking

V2E – Vehicle to Environment

V2I – Vehicle to Infrastructure

V2V – Vehicle to Vehicle

V2X – Vehicle to Everything

WAVE – Wireless Access in Vehicular Environments

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1. Introduction

The context of the research is visualized in the chapter that follows and the research statement, the research objectives, and the main research questions are explained and clarified further. Additionally, details on the thesis outline and overall structure are presented to improve the reading flow.

1.1. Problem Statement

The global automotive industry is currently experiencing a major structural transformation. Sustainability, which is implemented to improve the ecological performance of mobility and which has accelerated significantly in the past, is one of the most important drivers of change. Accordingly, the pressure on the automotive industry to become more ecologically sustainable and reduce negative effects on the climate has increased (Pohl, 2021). In addition to that, the automotive landscape is also changing because of the increased level of digitalization and connectivity, which enables in-car connected services (Speetjens, 2020). Moreover, megatrends (e.g., urbanization), shifting customer preferences, shifting market powers, and innovations such as autonomous driving, or mobility as a service (MaaS) are also reshaping the industry (Kleebinder et al., 2019).

Additionally, the competitive landscape in the automotive industry is reformed drastically by new entrants, which in some dimensions even have better capabilities and skillsets compared to traditional original equipment manufacturers (OEMs). For example, they are much more experienced in the area of operating systems (OS) due to software know-how. So, when it comes to digitalization, a potential lack of knowledge can be identified as a threat to OEMs, which may ultimately shift the bargaining powers of suppliers and make OEMs restructure their business models (Gao et al., 2018).

One key approach for the incumbent players to gain a competitive advantage in the current challenging environment is the so-called twin transformation, which describes the simultaneous advancement of digital and sustainability transformation. According to recent studies, businesses that tackle digitization and sustainability simultaneously have a 2.5-fold higher chance of becoming successful enterprises in the future (Sonnecken, 2021). However, too few businesses are still chasing the dual transformation's promise, wasting the potential opportunities (Ziegler, 2022).

All in all, the advanced use of digital technologies in combination with the trend of servitization makes the manufacturer restructure their product portfolios around connected services, which will take a very important role in satisfying (future) customer needs and improving the environmental sustainability of mobility. As the innovation cycle of connected services is still in the beginning, OEMs are required to consider potential future developments concerning the field of connected services and are faced with the challenge of prognosis, which kind of connected services will be required and valued by the customer in the future and how they may contribute to sustainability (Speetjens, 2020).

1.2. Research Objectives

The current state of the automotive industry, as well as its current transformation concerning digitalization, especially focused on the development of connected services and the increasing importance of ecological sustainability was analyzed in form of literature research. In addition to the literature research, expert interviews were conducted to further intensify the conducted research as well as include a practical-oriented point of view, while explicitly focusing on the combination of sustainability and connected services, future developments, and the importance of current services at the example of the company at hand, BMW. Thereby, the aim of this thesis can be considered as a combination of the analysis of the current situation as well as a prediction of the future when it comes to the ecological impact of connected services.

1.3. Research Questions

The following primary research questions are formulated to achieve the above-presented research objectives:

1. What are the current approaches of leading industry OEMs (in the example of BMW) regarding connected services? What are current trends looking like?
2. How can connected services contribute to more ecologically sustainable mobility? Which services can have the most important impact?
3. How will connected services appear in the future and how may they contribute to future sustainability?

1.4. Thesis Outline

This study follows a sequential approach which starts with a visualization of the outline and description of the research and its objectives. Afterward, the theoretical background summarizes the current state of research on the relevant topics at hand, namely sustainability, digitalization, connected services, and the automotive sector to provide the reader with the

required knowledge about all relevant aspects. Also, the case company is described. Furthermore, the elaborated input will be the foundation for the qualitative research in form of expert interviews, which are being conducted in chapter four. Prior to that, the overall methodology of the dissertation is explained in chapter three, while the following chapter five concludes the main findings and provides comprehensive answers to the presented research questions. Last but not least, the ending of chapter five also discusses contributions to practice and science while also taking into account potential limitations and suggestions for future study directions to round the dissertation up.

2. Theoretical Background

This chapter provides an overview of existing literature related to sustainability, digitalization, connected services and their combined impact on the automotive industry. Those areas are examined to understand the ongoing change in the industry and to emphasize the need for OEMs to adapt to the new circumstances, while furthermore visualizing the connection between digitalization and sustainability. Furthermore, the case company at hand (BMW) and its environment, the (German) automotive industry, are described.

2.1. Sustainability

2.1.1. History and Definition

Sustainability has been a trending topic in recent years as the world is facing some major challenges, including climate change, dwindling resources, and a growing population. Despite the recent emergence, the principle of sustainability originated in the 18th century, initially regarding forestry. In this context, "sustainable" means cutting only the number of trees that can grow back through reforestation to ensure the availability of the key resource wood (Agenda 21 Treffpunkt, 2007). However, since only individual resources were scarce, and one could not speak of a holistic problem, the term was only applied to individual industries (such as later the fishing industry). Sustainability did then become more widely known with the publication of the work "The Limits to Growth", which deals with the wasteful consumption of natural resources (Brugger, 2010). Nowadays, sustainability mostly refers to the co-existence of nature and humanity, including values such as respect, protection, or efficient resource allocation over a long range of time and with the future in mind. (Basiago, 1995; Constanza/Patten, 1995). In addition to that, sustainability can be seen as the development of human progress, while not disregarding the social, environmental, and economic dimensions and interaction at the same time (Munasinghe, 2004). From a corporate perspective, sustainability means maintaining long-term viable and intact ecological, social and economic systems at a global, regional and local levels (Volkswagen, 2021). When it comes to defining sustainability, the triple-bottom-line model of Elkington is very important and will be explained in the following sub-chapter.

2.1.1.1. Triple-Bottom-Line Model

A popular model to visualize the different dimensions of sustainability is the triple-bottom-line model by John Elkington from 1998, which considers three bottom lines when it comes to

sustainability: profit, people, and the planet (see fig. one). This model further describes that only simultaneous and equal implementation of environmental, economic, and social interests can lead to holistic sustainable development (Ulber, 2020).

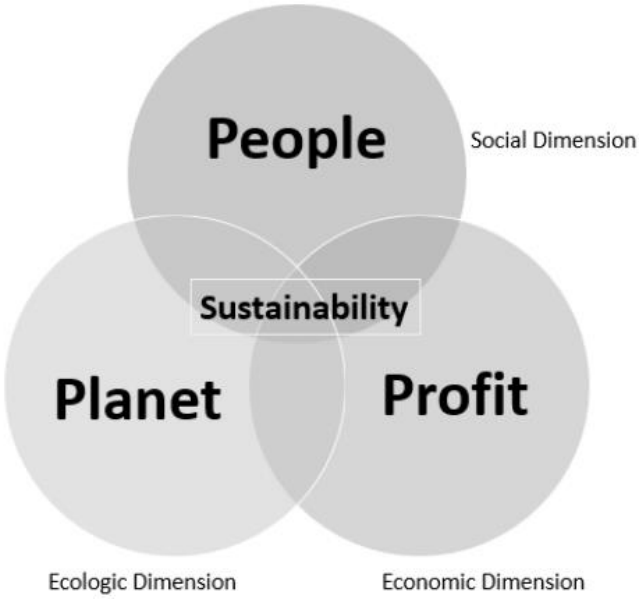

Figure 1: Triple-bottom-line-model by Elkington

The three dimensions of the triple-bottom-line model can be explained using the following approach: Economic sustainability (bottom-line profit) means the maximization of profits over time while efficiently and responsibly using available resources. Ecologic/ecological, or environmental sustainability (bottom line planet), describes perceiving and protecting the ecosystem (and its capacity) in the future. After all, the social dimension (bottom line people) talks about equity, community-wellbeing, ethical and fair behavior, and trust. This simultaneous and equal consideration of sustainability is immensely important since especially in the 1980s ecological sustainability has been over-prioritized (Osburg, 2017). This over-prioritization has ultimately led to conflicts of interest concerning the social and economic dimensions of sustainability (Bergman et al., 2018).

Also nowadays, failures in understanding the dependencies between the three columns and at the same time over-prioritization of one dimension above the others can cause harm and jeopardize success in implementing sustainability. In that regard, especially the economic dimension has gained most of the attention from for example industry decision-makers, which do not take social and environmental aspects into account as much as they should (Filho et al., 2022). Especially the perception, that economic and environmental values can only conflict, as the implementation of environmental concerns is supposed to lower profits and decrease productivity, can be a huge miscalculation (Söderholm, 2018).

However, there is also general criticism of the triple-bottom-line model, as the substitutability of an individual or several pillars appears to be possible (von Hauff, 2014). Like Elkington, also society and politics have a huge impact on the current understanding of the term sustainability.

2.1.2. Political Relevance

The concept of sustainability has lately been increasingly gaining attention throughout society and politics. Very important in that regard is the Brundtland Report, which defines sustainable development as follows: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Of similar importance was the 1992 United Nations Conference on Environment and Development (the RIO Conference), during which the leading set of rules aimed at sustainable development was developed (Kleine, 2017). During that conference, the Agenda 2021, which is a development and environment-oriented action program that contains active recommendations for action, was created. Primary goals of this agenda are for example the fight against poverty, sustainable use of resources (especially regarding water, soil, and forests), and the reduction of the greenhouse effect (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, n.d.).

Concerning the political impact on sustainability, the RIO conference adopted conventions, e.g., the Agenda 21, still provide an important basis for sustainability policy at present (Umweltbundesamt, n.d.). Also, very important in the implementation of the RIO conferences conventions is the Agenda 2030 for Sustainable Development, which can be seen as an extension of the Agenda 21, published in 2015 by the United Nations (UN). It is the most important political incentive and framework of regulations, aiming to achieve a positive future for the world and to tackle current key issues about sustainability (United Nations, 2015).

One of the main achievements of the agenda 2030 has been the introduction of 17 Sustainable Development Goals (SDGs) and 169 targets focusing on society, the planet peace or prosperity, which therefore can be seen as a roadmap for the future (Salvia et al., 2019; Kendrovski/Schmoll, 2019). Regarding the current level of achievement of the SDGs, it is important to mention that the global average SGD Index (an index deducted for the measurement of success) for 2020 has decreased from the previous years and the Covid-19 pandemic has jeopardized the sustainable development (Sachs et al., 2021). As another direct result of the Agenda 2030, the Paris Agreement was adopted in December 2015 during the World Climate Conference. The major focus of the Paris Agreement is to restructure the global economy in a climate-friendly way and therefore control climate change (Bundesministerium

für wirtschaftliche Zusammenarbeit und Entwicklung, n.d.). One main target of the Paris Agreement is the achievement of "greenhouse gas neutrality", which means that the amount of climate-damaging gases must be reduced to the level, to which they can be removed from the atmosphere by so-called carbon sinks, such as forests. Greenhouse Gas neutrality, however, can only be achieved if the global economy quickly and consistently reduces the amount of set-free carbon (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, n.d.). The strive of "greenhouse gas neutrality" also goes hand in hand with a significant impact on the global economy.

2.1.3. Economic Impact of Sustainability

As the value of any organization is affected by the interconnection of nature, society, and the economy, sustainability is not only a moral imperative anymore, but can also be counted as an economic one for businesses (Kiron/Unruh, 2018). It has grown significantly in attention from organizations, which are trying to implement sustainability into their business strategy (Opazo-Basáez et al., 2018). Thereby, the economy takes apart as one of the most important contributors and multipliers for more sustainability (Bundesministerium für Wirtschaft und Klimaschutz, n.d.). Furthermore, businesses are influenced by various factors to operate more sustainably as political regulations (for example the Paris Agreement), customers, and also investors are demanding verifiable sustainability (Essers, 2022). Consequently, the social and ecological impacts of corporate activities are being heavily observed by the public (Bundesministerium für Wirtschaft und Klimaschutz, n.d.). That's wherefore various corporations today publicly document how their actions contribute to sustainable development to inform business partners, the public, or investors about their activities and impact (Bundesministerium für Wirtschaft und Klimaschutz, n.d.). As one example of that documentation can the "Sustainability Report 2021" of the Volkswagen AG be cataloged, which contains information on the aspects of employee concerns, environmental concerns, social concerns, respect for human rights, and combating corruption and bribery (Volkswagen, 2021). Due to the above-mentioned incentives to improve transparency, Corporate Social Responsibility (CSR) is growing in importance for businesses. CSR refers to aspects such as social and environmental concerns that are voluntarily included in a business's operations and strategy (European Commission, 2013). To further emphasize the political influence, various national regulations in terms of green policy in combination with CSR have emerged, which mainly position themselves towards the achievement of the 17 SDGs. In Germany for example, the government brought a new sustainability strategy on the way by implementing a law about the EU-CSR Directive and introducing the National Plan on

Human Rights (Essers, 2022). One of the main industries, which are currently being restructured to improve sustainability, is the automotive industry.

2.1.4. Sustainability in the Automotive Industry

The automotive industry is also very much transformed by the concept of sustainability. When it comes to the social dimension of the triple-bottom-line model, topics as e.g., data security and privacy as well as other ethical questions are getting more and more relevant due to the increasing levels of automation and connectivity (Andorka/Rambow-Hoeschele. 2020). Furthermore, the economic dimension (generating profits) is essential too. But especially the environmental dimension of Elkington is very vital as it has become a strategic issue for automotive firms due to growing worries about climate change and environmental destruction. Governments, customers, and investors are currently pressuring car companies to improve their business practices, corporate cultures, and product offerings (Winkler et al., 2019; Pohl, 2019) so that OEMs constantly work to minimize the negative effects their production processes and goods have on the environment (Vaz et al., 2017; Martin- Peña et al., 2014). Those negative effects include, that the transportation area contributed 25% of global CO_2 emission (as of 2016) (International Energy Agency, 2018), the deprivation of natural ecosystems including water contamination and soil pollution (Whoriskey, 2016), an increasing carbon footprint due to required resources used in production (as energy and water) (SMMT, 2019; Opazo-Basáez et al., 2018) and the output of non-biodegradable waste (Winkler et al., 2019). Additionally, the majority of vehicles, which are powered by an internal combustion engine (ICE) need fossil fuels to run after they are built, which results in the discharge of harmful emissions (Pohl, 2021).

Previously discussed regulations as well as shifting customer preferences play a very important role in the current transformation. In fact, the automotive industry is constantly under pressure to address environmental risks, emissions, and safety. Regulatory bodies also require the industry to make constant technological advancements aimed at reducing waste, improving environmental performance, and ultimately enhancing sustainable operations (Koplin et al., 2007; Pohl, 2019). Current trends in the automotive industry are, for example, carbon-neutral productions, circular economy, or zero-emissions vehicles. For OEMs that development includes re-evaluating their products and value chains from a sustainable point of view. One of the key challenges will be to find a compromise between staying cost-effective and meeting the legislative requirements as well as customer preferences (Jursch, n.d.).

One major driver for sustainable transformation in the automotive industry is the transition away from fossil fuels, which is declared crucial for the achievement of many SDGs (Filho et

al., 2022). The main goal is the achievement of zero-emission mobility, which only can be achieved by innovations from the manufacturer side. The focus here will be to establish electric mobility and alternative drivetrains, which produce fewer emissions than the traditional internal combustion engines (ICE), which are driven by petrol or diesel and so electric-powered vehicles such as battery-electric-vehicles (BEVs) and Plug-in Hybrids (PHEVs) are at the forefront (see appendix C) (Seibt, 2022). Especially the expansion of the charging station infrastructure is elementary for the successful and holistic implementation of electromobility (Bundesministerium für Wirtschaft und Klimaschutz, n.d.). However, it is important to ensure that EVs (Electric Vehicles) really are sustainable, which would also include the utilization of renewable energy sources (Winkler et al., 2019).

In addition to that, the use of AI-based autonomous vehicles has also been demonstrated to reduce emissions and therefore lead to more sustainable mobility (Igliski & Babiak, 2017; Liu, Zhao, Liu, & Hao, 2019). All in all, sustainability must be pursued throughout the whole value chain and the complete product´s life cycle in order to satisfy the industry's ambitions (Winkler et al., 2019; Wu et al., 2015; Pohl, 2019). Furthermore, connected services contribute to improved sustainability. Their impact is going to be analyzed in more detail in chapter 2.3.4. Prior to that, the general importance of digitalization is going to be described.

2.2. Digitalization

Digitalization can be identified as one of the most important factors of influence regarding businesses and societies (Parviainen et al., 2017) and means the increase in the utilization of digital technologies (Speetjens, 2021). It can further be defined more preciously as "development and application of digital and digital technologies and methods" (WBGU, 2019, p. 5). This definition includes:

> The production, use and disposal of hardware (Information and Communication Technologies equipment, data centres, data transmission networks) as well as of software, digital technologies and applications – ranging from robotics, the Internet of Things (IoT), via distributed ledger technologies such as blockchain, to Artificial Intelligence (AI) (Liu et al., 2019, p.11).

Digitalization ultimately leads to a transformation of social life around the aspects of media infrastructures and digital communication. (Brennen/Kreis, 2016). According to Castells (2010), we can also speak of new economy, society and culture, highlighting the enormous effect digitalization has in current time. Furthermore, it can be described as one of the major forces in the current industrial revolution (Parida, 2018) and provides the opportunity for value creation due to product innovation and harmonizing services to businesses (Kyriazis/Varvarigou, 2013; Turber et al., 2015). The traditional barriers between the digital

and physical world are vanishing and the two dimensions are merging due to digitalization (Hanelt et al., 2015). Thereby, the acceleration of digital innovations in form of new technologies is reshaping the lives of consumers, the competitive environment of businesses as well as the orientation of companies overall (Fichman et al., 2017). Digitalization however not only has a significant impact on the economy, society, and political systems but also the planet as a whole. When it comes to sustainability, it is yet unclear if the positive effects of digitalization (e.g., energy efficiency and material savings) will be sufficient to offset information and communications technology's detrimental environmental effects (e.g., its enormous demand for critical raw material (Liu et al., 2019). The impact on businesses will be further discussed in the following.

2.2.1. Digitalization and Businesses

The competitive environment of traditional businesses is massively shaped by the emerging utilization of digital services. Hereby, digitalization will not only influence relationships with partners and customers of businesses but also shape business strategies in general (Speetjens, 2020). Especially in a business context, digitalization can lead to the optimization or creation of new business models or improved customer experiences (Paavola et al., 2017). That customer experience will be very important for businesses, as due to new service offerings there are many new ways of value creation, which then can attract new customers or enhance loyalty (Speetjens, 2020). So, because of digitalization and other global megatrends, manufacturing businesses are experiencing a faster-than-ever rate of transformation in their industrial ecosystem and as innovative technologies and new business models are continually being invented, the overall development is very dynamic, and organizations need to stay ahead of the curve (Trophschuh/Beck 2022).

To keep up with the fast-changing business transformation, corporations need to be agile and flexible. Furthermore, it is essential to place innovative technology at the center of all activities, products, and services. The main reason for that strong level of influence is the so-called Industry 4.0, which implies the use of digital factories, enabled by the Internet of Things (Parida, 2018). According to research, the main focus of IoT projects in the industry is on productivity increases, cost reductions, increasing sales or higher utilization of machines (Telefónica Germany, 2019). In general, new digital technologies could not only improve balance sheets in the corporate world but also align society's needs. For example, automated machines can reduce waste and environmental pollution (Bohnsack et al., 2014). Furthermore, digital technologies can facilitate the achievement of political regulations regarding

sustainability goals (especially regarding SDGs 6, 11, 12, 14 and 15), which can especially be valuable in the automotive context. On average, it is anticipated that the use of current digital technologies will help improve progress by 22% and reduce negative effects by 23% when it comes to achieving the main SDGs (GeSI/Deloitte, 2019).

2.2.2. Digitalization in the Automotive Industry

The digitalization also heavily impacts the automotive industry. So it is stated that the most relevant and innovative solutions and developments regarding digitalization are occurring in the automotive industry (Gao et al., 2016). Already in 2018, the CCOO de Industria acknowledged, that in-vehicle digital technologies stand for at minimum 50% of the aggregated value of a vehicle (LIopis-Albert et al., 2021). The automotive industry has also been highly influenced by digitalization with self-driving cars, connectivity (digitization is leading to connected vehicles that offer digital services to improve the customer experience in the fields of safety, navigation, information, comfort, and entertainment (Bosler et al., 2017)), social networks and big data being responsible for the revolution in the automotive industry. Organizations therefore must adapt their business models in order to follow emerging trends (Riasanow et al, 2017). Also, the electrification of the industry can be counted as a key driver for digitalization and digital transformation (Vermesan et al., 2021). Also, vehicles get more connected as well as more dependent on software, rather than mechanical components. (Dorrell et al, 2015). Thereby, software contributes to the customer experience and overall revenues. Current research, for example, has shown, that in 2025 45% of the overall profit will be generated from software (Krings et al., 2021). Furthermore, it is claimed by Keller and Hüsig (2009), that business performance can be increased by digital innovations as it leads to an improved user experience. Furthermore, digitalization in the automotive industry can boost sustainability as the development of new components, services, and technologies for future vehicles can contribute to ecological sustainability and the protection of the environment (Vermesan et al., 2021). The importance and development of connected services will be explained in the following.

2.3. Connected Services

2.3.1. Intro and Types of Connected Services

As the role of services increasingly grows in the global economy (service component of gross domestic product (GDP) above 70% in most OECD countries), service competition is rising in importance in many industries and the shift towards services has transformed the strategy of traditional manufacturers (Genzlinger et al., 2020). The automotive sector can be taken as a profound example of that development at hand as it is an industry, where the relevance of connected goods and services is strongly expanding and transforming competition, while it is focusing on producing connected vehicles (Segerstedt/Svedberg, 2021; Porter/Heppelmann, 2014). This advance in-vehicle connectivity can also be visualized by estimates, which state, that 50% of the total vehicle fleet is going to be connected in Europe by 2025, in the US by 2023, and in China by 2029 (Krings et al., 2019). Connected services can thereby provide a variety of functions such as real-time data collection, continuous communication, and interactive feedback while monitoring their state and surroundings (Wünderlich et al., 2015). Several different types of connected services can be categorized: *Data/Insights Services, Vehicle-Centric-Connected-Services, Vehicle Features as a Service,* and *Beyond Vehicle Services*. Furthermore, the main categories of practice are *Safety and Security, Convenience, Entertainment, and Infrastructure***.** The different services can be described as the following: *Vehicle-Centric-Connected Services* are related to the fields of autonomous driving, secure software updates, alarming, and assistance. Thereby, the integrated support will be offered by additional vehicle functions. Typical features are, for example, fatigue warning, traffic sign recognition, smart route planning, or music and media streaming. The category *Vehicle Features as a Service* refers to services, which can be activated on demand, as the required technical components are already built into the car. Those services are, for example, active cruise control (ACC), remote park assistance, or automatic emergency calling. *Beyond Vehicle Services* are services, which are offered outside the vehicle (often with the involvement of third parties). They include aspects such as e.g. fleet management, navigation, and traffic information as well as drive efficiency and safety. Most common services in that area are for example vehicle theft assistants, smart home connection, or gas and charging station searches. One profound example of the latter is the cooperation between the Chinese OEM Aiways and the application PUMP, which is a charging and navigation planning app (Aiways, 2022). Finally, OEMs offer *Data Insight Services*, which are mainly relevant in a B2B context and refer to cloud-supported vehicle analytics. Most important here are e.g., the diagnostics on-demand

function in combination with predictive maintenance, car-based insurance, or live traffic information. (Krings et al., 2021; Krings et al.,2022). The way those services are enabled (from a technological point of view) is going to be explained in the following.

2.3.2. Technological Background

2.3.2.1. Types of Data and Communication

In the following sub-chapter, the technological background of connected vehicles in the first place as well as for connected services specifically will be explained.

In that context, it is key to understand the complexity of big data. Connected vehicles can generate data in-car, about where they are used, who is using them, and the way they are used (Bertoncello et al., 2016). That in-vehicle generated data can accordingly be divided into the following categories: Local Vehicle Data, Vehicle-To-Vehicle Data (V2V), Vehicle-To-Infrastructure Data (V2I), and Vehicle-To-Connected-Device Data. Local Vehicle Data includes data such as instance, GPS location, browser data, temperature, speed, or driving patterns. V2V Data includes geolocation, travel routes, or upcoming hazards, whereas V2I Data combines, for example, the lane location, traffic signals, or weather information. Finally, Vehicle-To-Connected-Device Data takes phone contacts, website logins, remote diagnostics, or text messages into account. (Soley et. al, 2018). In order to gain valuable insights from those data, big data analytical skills will be required for OEMs (Porter/Heppelmann, 2015) as each fully autonomous vehicle will produce approximately 4000 GB of data per day in the future. The required network technology and data processing infrastructure will furthermore have a severe impact on the environment from a sustainable point of view. (Miller, 2017).

The different forms of data are generated while the car is communicating with its environment, for instance with its surrounding infrastructure, smart devices, or other vehicles. Therefore, several different forms of communication can be classified when talking about the delivery of information/data. Vehicle to Vehicle (V2V) communication is the first form of communication and means the data exchange between vehicles themselves (Vdovic et al. 2019). The V2V communication is thereby performed through a dedicated short-range communication (DSRC), meaning a wireless communication channel designed for use in an automotive context (also referred to as Wireless Access in Vehicular Environments (WAVE). Here, the communicating vehicles form a vehicular ad hoc network (VANET), which is dynamic. (Al-Sultan et al. 2014; Jian/Delgrossi, 2008). Also, the second form of communication, the communication between vehicles and infrastructure (V2I) is primarily enabled by wireless communication. Here the

communication relies on roadside units (RSUs) and onboard units (OBUs) which do transmit the relevant information. As the name may suggest, RSUs extend the range of VANET roadside units as they are installed throughout the road infrastructure, e.g., on traffic lights and road signs. On the other side, the term "onboard" means, that the units are mounted on the vehicle, (Al-Sultan et al. 2014). Last but not least, vehicles can communicate with the smart devices of their passengers through several solutions, such as e.g. Bluetooth, Wi-Fi, or a wire (usually USB-A or USB-C). Through the vehicle to device communication, features like hands-free calling, navigation, or the streaming of music can be used (Saxena, 2018). Some researchers don't even distinguish between the different communication forms of connected vehicles and simply refer to connection with the environment (V2E) or connection to everything (V2X) (Vermesan et al., 2021).

To conclude the technical construction of a connected car, it is helpful to visualize it as a layered model: client systems are modeled at the lowest level using embedded sensors and other auxiliary devices. At the connection level, Wi-Fi 802.11p, 3G/4G/LTE networks, and particular DSRC roadside communication protocols are used. Internet connection to public, private, or business cloud systems is located on top. Together, they offer a platform for connected cars (Golestan et al., 2015). Furthermore, for the display of Connected Car services in the cockpit, an infotainment system with a display including a head unit (processor, memory, operating system) and corresponding software is required (Johanning/Mildner, 2015).

2.3.2.2. Importance of Software

Due to the rise of on-demand functions as well as digital services in general, the operating systems, basically the software of the vehicles, are becoming very important (Krings et al. 2020). Automotive software development thereby is shaped by different trends, mainly from the social and technological environment. Social trends for example are the drive for energy and cost efficiency, the aim of reducing accidents, seamless connectivity, and the desire for individualization. In the technical sphere, the most important aspects, which need to be taken into consideration during the development process, are the use of centralized and scalable computing units, standardized communication forms across vehicles, connectivity and cooperation, and autonomous vehicle function, ultimately resulting in self-driving vehicles. So, the importance of software engineering as a capability of OEMs in the automotive environment is going to grow in the future, as software is becoming more and more complex. Also, OEMs need to provide the best possible software to not fall behind their competition (Vdovic et al., 2017).

To do so, not only software development skills, including software quality, remote software updates or update capabilities will be very important for OEMs, but also skills regarding electronics and communication need to be built or acquired (Traub et al., 2018). However, when it comes to car operating systems, traditional OEMs have to face new and fierce competition, as big tech companies are entering the market and can leverage their existing platforms (customized for navigation, infotainment, and individualization) due to adopting them to vehicle needs, which can result in a huge advantage (Burghard, 2020; Tian et al., 2016). Google for example is already able to offer services such as Google Maps and other Google applications via Google Automotive Services due to the introduction of their Android Auto OS and the Swedish OEM Polestar already relies on that form of application (Segerstedt/Svedberg, 2021). Software update capabilities play one of the most important roles, hence they are explained further in the following sub-chapter.

2.3.2.3. Over-the-Air Updates

Like software updates for smartphones, OEMs also move in the direction of over-the-air (OTA) Updates for their in-car software. Thereby, the latest software can be remotely provided to the vehicle, so without the owner having to have physical contact at for example at a garage or a dealership (Speetjens 2020). As mentioned, OTA already is a profound way of updating software remotely in the telecom industry (Dakroub/Cadena, 2004). Furthermore, they can be used to correct errors and update map materials (Bosler et al., 2017). However, there are some very distinctive differences between the OTA capabilities of smartphones and the OTA capabilities of vehicles, which ultimately restrict the download opportunities in the automotive sector. As a foundation and to support OTA, the existing software, as well as hardware on the vehicle side, need to be able to receive wireless data update packages (Speetjens 2020). The trend of OTA is in due course on the rise as according to Krings et al. (2021), more OEMs will be able to offer over-the-air updates soon. The business perspective of connected services is going to be explored further in the following chapters.

2.3.3. Impact on Businesses

From a business perspective, connected services are having various impacts on manufacturers in the automotive environment, starting with revenue streams.

2.3.3.1. Revenue Streams

Traditional OEM can generate revenue from five different revenue streams: Besides vehicle sales, aftersales, financial services, and mobility as a service, the car as a platform, which

includes data as a service and connected service sales can also be identified as a revenue stream (Schiller et al., 2020; Bosler et al., 2018). Due to the development of connected services, OEMs can support their traditional portfolio, which previously had been focusing on traditional products (Segerstedt/Svedberg, 2020; Kowalkowski et al., 2013; Bosler et al., 2018) and they are strategically investing in digital services and business models (Tian et al., 2016). This development can be related to the concept of servitization, which ultimately allows companies to improve customer relations, achieve differentiation, and secure revenue streams (Oliva/Kallenberg, 2003; Hanelt et al., 2015). In addition to that, engagement in the customers' everyday life can be improved by offering new touchpoints (Tian et al, 2016).

In his automotive value chain 2025+ prognosis report, Helbig et al. (2020) built a scenario that states that if connectivity should evolve as differentiating factor together with the establishment of electric mobility and autonomous driving, OEMs will be able to generate 20% of their revenues as well as 19% of the total EBITDA from mobility/connected services, as consumers seek additional infotainment solutions. However, this would require profound service development skills as well as strategic alliances with IT companies. On the other hand, other constructed scenarios indicate, that for example, the hype about connectivity could also vanish and ultimately would not result in a business model extension or, that OEMs will miss out on several revenue streams as they could become the hardware platform provider for the already mentioned tech-companies, which then put their software solutions on top. It is very important to point out that OEMs cannot influence their future (success) all alone. Instead, political and legal regulations, technological progress, or the moves of other players also have a significant impact. (Helbig et al., 2017). Nevertheless, connected services have the potential of becoming the main source of revenue when it comes to the automotive industry (Segerstedt/Svedberg, 2020). As a result, connected services not only bring the potential to improve the customers driving experience but on the other hand can also bring (returning) new revenue opportunities for OEMs (Krings et al., 2021). Currently, that revenue is captured by different pricing strategies, which especially vary regarding packaging and bundling on a geographical basis. German OEMs for example prefer to offer various individual services a customer can purchase, whereas American and Chinese competition follows the bundling approach and sells their services as packages, rather than individually (Krings et al., 2021). Moreover, there are different options when it comes to the moment of purchase. On the one side, the service/the package can be purchased together with the purchase of the vehicle, or on the other side via subscription or on-demand during car usage. Currently, the model of including the purchase of connected services is most of the time directly included in the vehicle purchase itself (Schiller et al., 2020).

As current research further indicates, the main target group and user profile of connected services is going to be Gen Y and onwards, which are willing to pay an additional 55€ maximum per month for connected services. The older generation has a significantly lower willingness to pay (Helbig et al., 2017). New studies by the Center of Automotive Management (CAM) suggest that in the year 2030 there is a recurring sales volume potential of approximately 900 to 1,000 euros per car and year for OEMs (Bratzel/Tellermann, 2022). It is important to mention, that consumers do not only pay via financial currencies but also with their data, which then can be used for example for further optimization of services. (Riasanow et al., 2017; Gao et al., 2014). In addition to that, due to discounts for specific services and customers, lock-in effects can be created by OEMs. Therefore, customers can be captured in the business ecosystem and further value can be captured. Ultimately, also cross-selling other products at a price premium could be achieved (Schiller et al., 2020).

The transformation of revenue streams also includes that regarding the connected car technology first-mover can set the tone for future business models (Krings et al., 2021). So, by becoming a holistic service provider, OEMs can leverage their profit potential by shaping the new mobility landscape. Thereby, the OEMs can also take control of the most important customer touchpoints (Schiller et al., 2020). Taking this into account, OEMs need to occupy all customer touchpoints, as customers nowadays value access to all relevant services, preferably from one provider (Schiller et al., 2020). Besides revenue streams and business models, strategic cooperation and differentiation are critical for OEMs regarding connected services.

2.3.3.2. Strategic Cooperations and Differentiation

Big tech companies are entering the automotive market, which can benefit from their existing customer-oriented software and disrupt the competitive environment of traditional players in the automotive market. To avoid the fierce competition with those new entrants, some OEMs choose to focus on strategic cooperation, which on the one hand provides the opportunity to present a familiar user interface to the customer and on the other hand allows those OEMs to reduce their potential competitive disadvantage due to the lack of know-how (Burgard, 2020). In addition to that, those collaborations can be further beneficial as they can merge several dimensions of knowledge into different value propositions, which single organizations with limited capabilities may not have been able to do so (Speetjens, 2020). On the other hand, cooperating with big tech companies (instead of developing software in-house) can lead to strong dependences, which can ultimately result in the OEMs only being the supplier of the hardware, missing out on revenues connected to software, and losing the power about the in-

car experience. Instead of fully committing to one side of the make-or-buy decision, either developing their own OS or relying on externally sourced software, some OEMs could try a middle path by incorporating third-party services into their in-house OS. Thereby, the OEM will maintain control over the infotainment and software itself but still can benefit from external partner's' know-how (Capgemini, 2020). Opening to new entrants can furthermore assist OEMs to gain valuable knowledge, which they then can use to increase innovation power (Hildebrandt et al., 2015)

Moreover, in the automotive environment, customer experience will always be one of the main differentiating factors, not only referring to the in-car driving experience but also concerning the aftermarket or the sales process. (Llopis-Albert et al., 2021). As part of the automotive software, connected services can be a main source of differentiation too, as customers are especially focusing on the user experience and functionalities provided by the software of vehicles in their purchasing-decision (Vidovic et al., 2019). For OEMs that implies, that providing an attractive service portfolio that does satisfy the customer needs can lead to a competitive advantage (Segerstedt/Svedberg, 2020).

So, while being creative in creating new digital services, OEMs can gain a competitive advantage (Llopis-Albert et al., 2021) due to the fact, that the addition of new digital services raises the value of the vehicle from a customer’s point of view.

2.3.4. Impact on Sustainability

There is general agreement that car connectivity features have the potential to offer consumers significant advantages (Andorka/Rambow-Hoeschele, 2020). Information and communication technology (ICT), also including connected services, can increase energy and cost efficiency (especially regarding Electric vehicles (EV), as well as comfort and safety (Vdovic et al., 2019; Andorka/Rambow-Hoeschele, 2020)). Furthermore, according to a recent analysis, connected and autonomous vehicles (CAVs) can be more fuel-efficient and emit fewer emissions because they make it easier to perform actions that reduce fuel usage (reduced amount of braking /accelerating and cold starts, intelligent speed adaptation and route selection that maximizes efficiency), which in turn lowers energy use and exhaust emissions (Taiebat et al., 2018). After all, connected services might also improve the accessibility of each person's ethical footprint, due to increased transparency and data collection, which may lead to an improvement in people's behavior in general (Andorka/Rambow-Hoeschele, 2020). So, connected services can directly contribute to ecological sustainability and can have a considerable influence on the environment (Liu et al., 2019). Furthermore, automobiles are anticipated to feature more green

services that increase their sustainability as they become more digitally enabled (Opazo-Basáez et al., 2018). The customer side will be highlighted next.

2.3.5 Impact on Customers

Consumers are transferring their expectations and experiences of service into the automotive world and therefore also the willingness to pay for connected services is on the rise (Schiller et al., 2020). However, according to recently conducted surveys, customers are still not convinced of the benefits that connected services may bring. Especially in the eurozone, where only 36% of respondents see value in connected services, securing future sales may be a huge challenge for OEMs (Schiller et al., 2020). One reason for that refusal to accept may be due to privacy concerns, as many people do not seem to be willing or prepared to adjust to technological developments (Rambow/Rambow-Hoeschele, 2018).

All in all, the development of connected services is driven by customers' expectations to experience a similar level of connectivity in their cars as e.g. at home or work (Kim et al., 2017). At the moment, connected services, which do improve navigation or safety are the most desirable services from a customer perspective in terms of willingness to pay (Capgemini, 2020). Regarding general preferences, security services are leading the line. Features, which do include time and money savings for customers, are also desirable (Bertoncello et al., 2016). In general, customer preference is shifting towards the use of connected services and individualism. Furthermore, customers do value pay-per-use offerings, rather than traditional payments - a development, of which OEMs should be aware (Schiller et al., 2020). In addition to that, connected services could contribute to the overall level of customer satisfaction. Furthermore, they can reduce the total cost of ownership (TCO) as well as being able to increase the uptime of vehicles (Speetjens, 2020).

2.3.6. Future and Trends

In the future, connected services will most likely be on the rise even more, as due to the development of fully autonomous cars, the passenger is going to be using connected services for entertainment, messaging, or other productive purposes even more (Segerstedt/Svedberg 2020). The future development of connected cars brings a huge number of opportunities for generating new revenue streams with for example services regarding infotainment, e.g., gaming or watching movies, which customers can use while the vehicle automatically drives to the required destination (Helbig et al., 2017). Also, a digital assistant that makes passenger life easier will be a significant connectivity element in the future (Andorka/Rambow-Hoeschele.

2020). In addition to that, 5G connectivity, which is currently emerging, is contributing to the next push for the further roll-out of connected services. As the European Commission declares, until 2025 all urban areas and key infrastructure (including railways and important roads) should have 5G coverage (Schiller et al., 2020)

2.4. The Automotive Industry

The automotive sector is one of the most important sectors of the global economy and is traditionally responsible for the production and sale of motor vehicles and their components. Thereby, engineering, design, or electronics have been the core competencies of OEMs (Athanasopoulou et al., 2016). Currently, it is experiencing a period of change.

2.4.1. Transformation of the Industry

The automotive sector is undergoing a huge transformation in recent years. Trends like connectivity or self-driving cars, as well as new mobility services such as e.g., car sharing are having a huge impact on the automotive industry and are responsible for new business models emerging. These new business models are favoring the entry of new competitors into the automotive market, which due to innovative and disruptive approaches are contributing to the transformation of the whole sector significantly (Riasanow et al., 2017; Bosler et al., 2018). Due to that transformation, also the value chains in the automotive sector need to be readjusted drastically (Helbig et al., 2017). Moreover, to compete in the new automotive environment, OEMs need to be willing to change (Helbig et al., 2017). Thereby the automotive industry (like many other industries) is shifting from an OEM-centric approach (as visualized in fig. two) towards a flexible ecosystem with open boundaries (IBM, 2015).

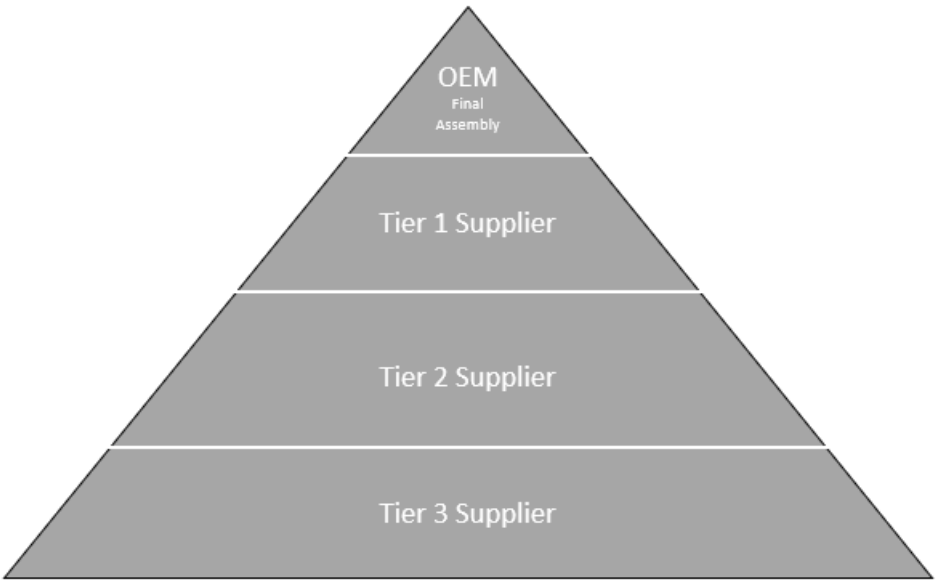

Figure 2: Traditional Supply-Pyramid in the Automotive Sector

The future development of the automotive sector mainly results from drivers of the areas of economic shifts, progress regarding technology, society, environmental sustainability, and legal/political regulation which, in sum, can be referred to as STEEP forces (Society,

Technology, Economics, Environment, and Politics) (Helbig et al., 2017). However, also from the customer side, the industry gets reshaped, as customer preferences and their perception of mobility, in general, are changing (Schiller et al, 2020).

Besides the previously described rising importance of connected services, the following aspects will have the most important impact when it comes to the future development of the automotive sector: First, alternative drivetrains will emerge more and more because of political regulations regarding the reduction of emissions of carbon. The spearhead here will remain the battery electric vehicle (BEV), however, there will be a coexistence between various forms of drivetrains. Furthermore, electric mobility leads to a decrease in production costs but requires an adequate charging network. A further main characteristic is the development of shared mobility. As the perception of the ownership of vehicle shifts in society, mobility services grow. As a result, the utilization rates of vehicles rise, and the absolute number of vehicles (especially in urban areas) will be reduced. Also, the ongoing development of autonomous driving will accelerate the rise of shared mobility too, as it may also include passengers who are currently excluded from driving a vehicle, e.g., children or the elderly. As already stated, also the development of autonomous driving itself, which indicates that the vehicle will be driving on "its own" and without human intervention, will shape the current state of mobility and requires additional adaptation by OEMs (Schiller et al., 2020). Finally, it is important to mention that in general the vehicle sales figures in the Euro5 region are declining due to a shrinking and parallel aging population, which reduces the total base of potential customers. Those shrinking numbers are also favored by increasing urbanization and present another challenge for OEMs (Schiller et al., 2020). The German Automotive industry is further described in appendix D, to enable a more detailed view of the importance of the industry for the German society/economy.

2.4.2. The Case Company – BMW

The case company at hand, BMW, will be introduced in the following sub-chapter.

2.4.2.1. History and Economic Situation

Bayerische Motorenwerke AG (BMW) was founded on the 7th of March 1916 and emerged from the Gustav Otto aircraft engine factory and Bayerische Flugzeug-Werke Ag. Having previously produced aircraft engines, brakes, or motorcycles, it was not until 1928 that the company entered its current core business, the manufacture of automobiles. After difficult years of reconstruction and repression (mainly caused by the 2nd World War), BMW achieves its breakthrough as a successful and modern automobile manufacturer in 1961 with the "new class" by occupying a niche in the automobile market. During the following globalization, BMW was

able to open new markets and built an international production network. Currently, the BMW Group (consisting of BMW, Mini, BMW Motorrad, and Rolls Royce) operates plants in South Africa, Austria, the USA, China, the UK, and Germany (BMW, n.d.). BMW's mission: "We stand for first-class individual mobility and contribute to the sustainable development of our planet we reconciled economy, ecology, and society. As a result, our customers enjoy outstanding products and demonstrate responsibility." Visualizes the customer-centricity of the brand and further emphasizes on the importance of sustainability (BMW, n.d.). To further introduce the case company, some more KPIs of the BMW Group are visualized in table one (as of 2021).

KPI	Amount
Number of Employees	118.909
Revenue	111.230M €
EBIT	16B €
EBIT Margin	14,4%
Cars delivered	2.5M
Percentage of EVs of total cars delivered	13%
Share price (as of EOB 19.12.2022)	82,97€
Share price ATH	116,75€
Connected services offered	14

Table 1: Key Performance Indicator of BMW

2.4.2.2. BMW and Sustainability

BMW has set itself ambitious sustainability goals and aims to be “the most successful and sustainable premium manufacturer for individual mobility.” BMW's sustainability strategy thereby mainly comprises the aspects of resource conservation, social responsibility as well as production, and value creation to make an effective contribution to the environment as well as climate protection. To meet these goals, BMW has, for example, only used renewable energy sources since 2020, recycles 99% of the production waste generated, or uses biogas on a pro-rata basis to operate its plants.

Regarding the core product of vehicles, the expansion of electromobility is a fundamental component of the corporate strategy about sustainability as BMW aims to launch fully or partially electric vehicles on the market by 2023 and to increase the proportion of electrified vehicles to 50% of the total number of vehicles delivered. Currently, the product portfolio includes 5 BEVs. The BMW iX, the i4, the i7, the iX1 or the iX3. BMW previously produced BEVS with the i3, Start of Production (SOP) 2013 and the i8, also SOP 2013. Both models, however, are currently no longer in production (BMW, n.d.).

2.4.3.3. BMW and Connected Services

In addition to sustainability, also digitalization has a major impact on the strategic orientation of the BMW Group and influences the entire value chain.

Connected Services, which were introduced in 1998 under the name "BMW Telematics", are also at the forefront of the company's digitalization strategy. As an extension, the BMW ConnectedDrive Store was introduced in 2014, allowing customers to book and pay for services directly from the vehicle. According to BMW, BMW Connected offers customers numerous touchpoints as well as the ability to use services anywhere. In this way, BMW creates a network between the vehicle and the driver and creates a 360-degree comprehensive digital customer experience. BMW describes Connected Drive as follows:

> BMW ConnectedDrive comprises all digital services that intelligently connect the vehicle with the outside world. In addition to telematics services, these also include driver assistance systems, connections for mobile devices, as well as entertainment offerings, and traffic services. Prerequisites for using ConnectedDrive: Your vehicle has a permanently installed and active SIM card (BMW, n.d.)

After logging in to the BMW ConnectedDrive Account, the account can also be connected to the “my BMW” mobile application, which offers more connectivity and digital services (BMW, n.d.). An overview of BMWs current connected services portfolio is provided in the attachment section of the dissertation (see appendix B).

3. Methodology

To ensure transparency and the reliability of the findings, this chapter outlines the research strategy and research design choices in addition to explaining the collection of primary and secondary data. The data analysis process as well as a critical reflection on the quality of the research are also discussed. Thereby the selected methodology choices were made to gain a deeper and more practical understanding of the subject at hand, the potential positive impacts of connected services to ecological sustainability in the automotive industry and to answer the presented research questions.

3.1. Research Strategy

A qualitative research strategy was adopted to create wholesome insights of the interconnection between digital services and sustainability in the automotive environment while focusing on connected services and ecological sustainability. The literature review offered a deep contextual understanding of the current state of research on the phenomenon. However, as the empirical data on vehicle-connected services (especially in combination with ecological impact) is thin, exploratory research is required as a useful addition and has been suitable to enhance the development of unexpected information (Bell et al., 2019). Then, the literature review was combined with the industry-internal perspective of experts in form of interviews. These two dimensions combined contributed to an increased practicability of the topic at hand. Due to the exploratory approach of the study, the results can be the foundation for potential upcoming exploration directions (Svedberg/Segerstedt, 2020).

3.2. Research Design

In terms of research design, a qualitative approach in form of a single case design over a cross-sectional time frame was adopted. A case study is an empirical examination that uses several sources of evidence to explore a phenomenon in its real-life situation (Yin, 1998). Here, the case study is focusing on a well-defined unit of analysis of an automotive original equipment manufacturer with the case company being BMW. Thereby, as the case study uses many sources of evidence, it provides good visualization and enables one to gain a holistic understanding of a phenomenon. So, the case study can lead to a detailed and specific understanding of the interconnection of sustainability and connected services at BMW. Qualitative data collection in general is most suitable for that kind of case study, as it emphasizes how individuals build and understand their social existence, hence allowing for differentiated points of views (Bell et al., 2019).

Concerning the case company, BMW is an appealing example since it is a long-established and great participant in the automotive industry, which nowadays must compete against its traditional competitors as well as new entrants. Hence the company finds itself in a challenging market situation and transformation concerning the strategic orientation, involving connected services. Furthermore, the automotive sector has been selected as the context for the analysis due to in chapter two described circumstances regarding sustainability and current innovations in connected services, it is a very dynamic environment.

3.3. Research Process

Regarding the research process, the thematic field of connected services and sustainability has been selected based on its importance to the current developments in the automotive industry and the lack of coverage in the existing literature. As emphasized in the literature review, digital and connected services as well as sustainability has enormous importance for OEMs and are therefore also very relevant to the case company BMW. The fact, that existing literature is scarce concerning the connection between digital services and ecological sustainability, as it has only been covered on a very superficial level, is also contributing to the selection of the topic and contribute to the overall progress of research in the area at hand. Moreover, the results of the research can be very valuable knowledge for decision-makers in the automotive industry, which further contributes to the relevance of the study.

So, after defining the subject and the case company, literature about the most relevant aspects in connection to the interconnection of connected services and sustainability has been examined. Those most relevant aspects include sustainability, digitalization, connected services, or the structural change of the automotive industry overall. The gathered insights helped to build the required knowledge to determine the research questions as well as the best-applicable methodology of research. In the following step, criteria for secondary data collection were constructed. These included evaluating the trustworthiness and relevance of sources. After completing that criteria catalog, the step of the literature review was conducted which then additionally played an important role in the following phase of formulating the interview guideline and script, which are based on the thematic assessment of theoretical discoveries. Simultaneously, the shortlist of potential interview partners was created, and potential interviewees were contacted (mainly using social media as LinkedIn or WhatsApp). Afterward, the interviews were conducted, and transcribed and the empirical findings summarized. Following, the primary data collection was completed, the analysis phase was performed. The relevance of that analysis was insured by taking the findings of the literature review into account

and connecting them to the empirical findings. In the last phase of the research process, the conclusion was built. and the dissertation was finished with a revision regarding its entirety and layout to offer high-quality and concise research. The research process is also visualized in figure three.

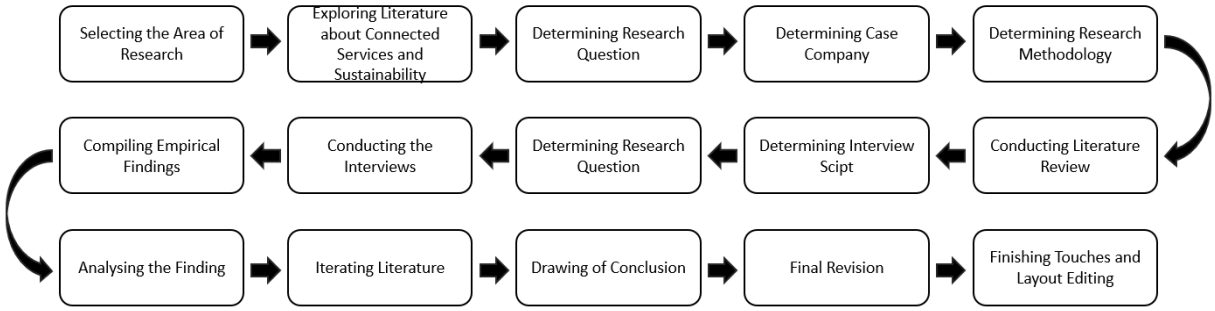

Figure 3: The Research Process

3.3.1. Secondary Data Collection

The secondary data used for the literature review was collected from various sources, with the main database to discover relevant information being Google Scholar. After identifying a relevant article, also the previously created articles cited by the article at hand as well as the following articles referring to the article at hand were investigated as well. To make up for the already mentioned scarcity of academic information regarding connected services and their impact on sustainability, further resources were required to gather a satisfactory foundation from the literature. Those further resources mainly consist of industry analysis and reports from management consulting companies such as Capgemini, PricewaterhouseCoopers, or McKinsey. Moreover, a extensive literature review guaranteed the set of relevant and extensive data. That review was mainly focused on keywords and search terms (based on the relevance of the dissertation) to achieve a complete and balanced information search.

3.3.2. Primary Data Collection

Regarding primary data collection, four interviews were conducted in semi-structured expert interviews to collect the empirical data. In this context, an expert can be defined as follows: "Expert describes the specific role of the interview partner as a source of specialized knowledge about the social issues to be researched. Expert interviews are a method of eliciting this knowledge." (Gläser/Grit, 2010, p.12). Since it is a guided interview, a list of prepared questions forms the basis of the conversation. In the context of a guided interview, it is important to plan a communication process that includes all information relevant to the study and is also oriented to the cultural context of the interviewee (Gläser/Grit, 2010). The interview guideline has thereby been created by orientating the most relevant keywords and the

knowledge collected in terms of the literature review and mainly covers the aspects of sustainability, connected services, and their interconnection in the automotive industry while also emphasizing the case company at hand. Furthermore, an outlook has been implemented as well. As the interview is furthermore conducted flexibly the focus is on exploring the interviewee's area of experience (Atteslander, 2003). To avoid losing data, the interviews were tape-recorded and transcribed, with the transcripts being attached to the dissertation.

3.3.2.1. Sampling of Respondents

The potential interviewees were selected by using a non-probability and therefore purposive sampling method as the respondents were chosen by the researcher´s judgment. The main criteria for selection are their potential to contribute to answering the research questions and to provide the necessary knowledge. Moreover, ease of contact and potential willingness to take part were further criteria for being selected.

3.4. Data Analysis

Regarding the analysis of data, an iterative process has been applied throughout the thesis, which means that both dimensions of findings (theoretical and empirical) were constantly revised and analyzed. After conducting the interviews, the results were color-clustered by using a thematic approach, consequently clustering the data into topics. So, the data could be categorized into thematic areas, also including sub-areas which ultimately facilitated the process of comparison and pattern discovery. The results of the interviews were also checked regarding connections to the outcomes of the literature review. Answers which did not match with the theoretical findings have been identified as most important, as they were processed as potential-new knowledge, not yet included in the literature.

3.5. Research Quality and Limitations

Since a qualitative research approach has been chosen, the following criteria (see table two), which were formulated by Lincoln and Guba (1985), can be used in the evaluation process and to analyze the quality of the conducted research.

Criteria	Explanation
1. Authenticity	Authenticity refers to the assurance that the behavior and assessment of research are credible
2. Trustworthiness	Trustworthiness refers to the accountability of the dissertation and explains, why the results are worth paying attention to. It includes the following four criteria:
2.1. Credibility	Credibility refers to the scale, to which the findings of the research are valid and truthful
2.2. Transferability	Transferability means to what degree the research design and the findings apply to other circumstances and further research.
2.3. Dependability	Dependability talks about the study/its results being consistent over time and under different circumstances and conditions.
2.4. Confirmability	Confirmability refers to the objectivity of the research

Table 2: Research Quality Evaluation Criteria

All these criteria will be confirmed in the following: In the dissertation, **the authenticity** was ensured as the form of semi-structured allows the respondents to share their experiences and opinions freely, due to open-ended questions. **Credibility** was achieved due to the fact, that interviewees were selected purposefully and about their level of expertise and knowledge. First and foremost, it is important to mention, that transferability is not the main goal of the dissertation, as it solely focuses on the company BMW. Even though, **transferability** is achieved the case study at hand may offer suggestions for OEMs in the auto sector, who are also looking to incorporate connected services into their offerings/or adapt their current approach. Additionally, due to the distinctiveness of the observed case company, it is uncertain whether the results can be valuable in other environments. When it comes to the **dependability** of the conducted research, it is important to bring forward the point that the social settings of case studies are very dynamic. In addition to that, the area of connected services and sustainability is hugely impacted by customer preferences as well as technological progress, with those two factors of influence also being flexible. That's why overall it is difficult to ensure similar results if the study would be conducted again. According to Bell et al., (2018) it is

impossible to achieve complete objectivity in research. However, to increase the **confirmability** of the conducted research, the literature review for example has been done with an extensive approach to reduce the risk of overlooking theoretical findings and to reduce biases (Lincoln/Guba, 1985).

4. Empirical Findings

The following chapter will present the main findings of the semi-structured interviews. In total four semi-structured interviews were conducted (see table three for more details).

Interview Partner	Position	Department
1	Lead Sustainability Employees	Corporate Strategy and Sustainability
2	Head of Marketing and Product Content Management (including Connected Services)	Brand Communication
3	Head of Business Intelligence & Data Analytics	Connected Car and Digital Products
4	Integration Lead	Dealer Domain (formally responsible for the visualization of the BMW Connected Services in the Connected Drive Store)

Table 3: The Interview Partner

The interviews and their main questions were created to contribute to answering the research questions and focused on the topics of currently offered connected services, their (potential) impact on sustainability, and their future development (also covering specific new services which may emerge). The interview script including all questions is attached to the dissertation (see appendix A).

4.1. Overall Impact of Connected Services

The first question of the interviews covered the overall impact of connected services on the automotive industry and BMW in particular. When it comes to the overall impact of connected services, all respondents state that connected services have a significant influence on the automotive industry in general. Respondent one argues, that in that regard the most important aspects of connected services are on the one side the customer expectations, that connected services are being also offered in a car to match their service usage in other dimensions of their everyday life ("They expect the car to have the same kind of services") and on the other side the car vehicle as a connected device which can communicate with its environment. She additionally emphasizes the need for OEMs to accelerate the development process of vehicles to be able to provide adequate hardware for required connected services as soon as possible. About BMW she indicates that strong innovation power and big process capabilities are an

advantage. Furthermore, she highlights that due to BMW´s early adoption of connected services, the current user base is already relatively large. Also respondent two shares the opinion that connected services offer the possibility to meet the customer at various touchpoints ("Connected Services allow us to much more meet the customer needs at various touchpoints") and continues to explain that with connected services OEMs can create ecosystems which ultimately increase customer loyalty. According to him, innovation can be the reason for competitive advantages in the industry. Also, when talking about innovation, he mentions that BMW is a leader in innovation (explicitly referring to sustainability too) and therefore already has been able to gain a competitive advantage. Respondent three starts his argumentation while emphasizing that connected services are "one of the main pillars" of the digitalization strategy of BMW and lead to new business models, which do enable direct customer contact at various touchpoints. Further, he indicates that connected services are very important for business revenues and they do enable re-occurring revenues. Thereby, the car itself becomes a selling point too, as features on-demand can be purchased directly from the car. Partner four especially emphasizes the increased ability of individualization due to connected services and explains, that on-demand connected services can satisfy short-term needs.

4.2. Development in Future

The potential future development of connected services overall was discussed next during the interviews. In that regard, respondent one claims that the increasing rollout of over-the-air updates and the growing number of services (especially on-demand features) will ultimately make connected services more available for the customer. She indicates further that new business models must be created/will establish to match that development and emphasizes that due to the increasing communication capabilities of vehicles (vehicle-to-x-communication), especially services with a focus on electric mobility, which ultimately are connected to the electric grid and the charging infrastructure will be most relevant in future. Respondent two puts the customer at the center of his considerations and argues that future development will mainly adapt to changing customer preferences (also regarding sustainability). Further, he indicates that big data is very relevant in identifying emerging trends and says that "Connected Services give the basis for getting more and more information about our customers". Partner three has the opinion, that digital and connected services are at the beginning of their lifecycles and therefore believes, that in the future a huge variety of new services will be offered. Further, he continues to argue, that the importance of subscription models as a selling strategy will grow similar, which offers more flexibility to the customer. That increased flexibility will also further

"boost" the acceptance of connected services. Also, partner four suggests that the number and variety of connected services will ultimately grow in the future.

4.2.1. New Connected Services

When it comes to new connected services, services that do enable charging (referring to electric mobility), services that do increase transparency, and services that enable holistic urban mobility (combining different forms of transportation) are at the forefront according to respondent one. The explanations of partner four go in the same kind of direction as he also indicates that the interconnectivity in the automotive ecosystem will grow and "become more open". That interconnectivity could then also be applied to other industries outside the automotive environment, such as e.g., smart homes.

4.3. Ecological Impact of Connected Services

From the point of view of respondent one, two different dimensions can positively influence sustainability as she states, "These are things where you help people reduce the emission further". First, she lists that due to increased transparency, which can be enabled by connected services, the carbon footprint of the car and the passenger are becoming more visible. Second, she reflects that connected services can reduce emissions directly as she says ("...get CO_2 Emissions down."). Compared to respondent one, which has been covering the topic of the sustainability impact of connected services from a broader perspective, respondent two explicitly mentions existing BMW connected services which according to him directly improve ecological sustainability. First, he talks about the Active Cruise Control with Stop and Go function and the Driving Assistant Plus which both reduce the amount of braking and accelerating, thus optimizing the driving behavior. He continues his argumentation while arguing that improved driving behavior will lead to reduced emissions of combustion engine cars and will reduce the energy usage of electric cars, so he also differentiates between the different forms of drivetrains. Moreover, respondent two goes on to talk about the Connection Navigation App and its updateability, which can lead to increased route efficiency (avoiding congestion) and therefore increases sustainability simultaneously. Finally, and likewise, to respondent one, he also addresses the aspect of the visualization of individual carbon footprints (with help of the driving statistics feature in the myBMW app) which he believes "may also trigger a change in the usage of your car and your personal drive behavior". Interview partner three also declares that connected services about navigation features are most important for ecological sustainability. For him, however, navigation features not only refer to ecological routing (emission-reduced navigation) but also includes the driving assistant plus autonomous

driving. Partner four agrees with the overall opinion that especially intelligent navigation can be most important regarding ecologic sustainability however he adds that a hybrid model (combining different forms of transportation) can be the best solution in that regard. In addition to that, he visualizes the importance of holistic sustainability along the whole supply chain.

4.4. Future Impact on Sustainability

When it comes to the future impact of connected services on sustainability, respondent two thinks that the combined impact of connected services on ecology will improve, as the usage of digital services will grow and can benefit from innovations in that field. He also states that Mobility as a Service (MaaS) can contribute to that future impact positively and gives the example of the digital BMW car key, which reduces the number of cars on the road (thus reducing emissions). When asked about the future ecological impact of connected services, respondent three explains that the current portfolio strategy tries to directly satisfy the customer needs plus is optimized in regard to profits for the company ("The driver is always to satisfy customer needs and to make money"). In the future, however, he believes that that may change and connected services, which explicitly try to increase ecological sustainability will be developed. He also states that in the future the overlap of customer needs and sustainability will increase so that connected services will be able to positively impact both dimensions at the same time. Respondent four suggests that in the future an eco-mode on demand could be a profound alternative to increase the future sustainable impact.

5. Discussion and Conclusion

The concluding section of this study summarizes the research process and main findings. In addition to that, the subsequent implications (academic and managerial dimensions) are also reflected. Further, future research directions and objectives are recommended and the potential limits of this thesis are discussed.

5.1. Answering the Research Questions

In the following sub-chapter, the research questions (introduced in chapter one) will be answered by taking into account the findings of the literature review and the results of the expert interviews.

5.1.1. Research Question 1

The first research question states: “What are the current approaches of leading industry OEMs (at the example of BMW) regarding connected services? What are current trends looking like?” and can be answered the following: Sustainability and digitalization built the core of BMWs corporate strategy. Connected services further contribute to that orientation and due to BMWs innovation power and early advance in that field, the company can offer customer-focused solutions. Furthermore, connected services are generating mass data and due to big data analytics, BMW can learn from its users, forecast trends in preferences, built ecosystems and increase loyalty. Currently the Connected Drive Store (marketplace, where the connected services are offered) consists of 14 services for the German market. Emerging trends are the further rollout of OTA capabilities as well as the emergence of more and more on-demand features, which can be activated in a flexible way as the required hardware is already built-into the car.

5.1.2. Research Question 2

The second research question goes by “How can connected services contribute to a more sustainable mobility? Which services can have the most important impact?” and the following considerations are important when it comes to answering it: Connected services can improve ecological sustainable mobility in several ways. First, they can lead to improved driving behavior (less braking and accelerating) which leads to reduced emissions for ICE-vehicles and to improved energy efficiency for EVs. Second, improved efficiency in terms of navigation helps to avoid congestions, which further reduces the number of carbon-dioxide emissions. Also, due to increased transparency of individual carbon-footprints their visualization through

connected services can lead to a more sustainable behavior overall. Most important connected services to increase sustainability are from the categories of Vehicle Features as a Service, Beyond Vehicle Services and Data Insight Services. Most important in BMWs current portfolio are the Active Cruise Control with Stop and Go function, the Driving Assistant Plus and in general all services that are related to navigation, such as the Map Update. Due to the combination of in-car connected services with the myBMW application and its services (for example the digital car key) sustainability can be improved even more. Also, the holistic supply chain needs to be analyzed when it comes to the sustainable impact, as the development process of connected services and especially the transfer of mass-data is causing for further emissions.

5.1.3. Research Question 3

The third research question is: "how will connected services appear in the future and how may they contribute to the future sustainability?" First and foremost, connected services which are interconnected between various forms of (urban) mobility will be most important when it comes to ecological sustainability as a mix of different forms of transportation will have the biggest impact when it comes to improving sustainability. V2X communication will be very important in that regard as it allos for the vehicle to interact with for example smart cities, the electric mobility grid or smart home applications. Moreover, due to overall rising figures of utilization (enabled by the further roll out of OTA-updates and the emergence of (new) features on demand) will increase the total impact connected services may contribute to sustainability. Last but not least the development process of new connected services, which will solely focus on improving ecological sustainability, will heavily contribute to the rising importance of connected services in that regard. An eco-mode on demand can be an example for such new services.

5.2. Implications

5.2.1. Academic Implications

Even though there is various literature that covers the interconnection of digitalization and sustainability in the automotive industry overall, the relation to connected services has not been recognized before. Consequently, this research builds a connection between the two dimensions and visualizes, how connected services as part of the digitalization of the automotive sector can impact ecological sustainability and thereby closes the identified research gap.

5.2.2. Managerial Implications

The study's findings have various implications for practice. One practical outcome of this research is that it might impact the thinking of readers by presenting new ideas. As presented during the research, connected services plus ecological sustainability grow in their importance for OEMs in the automotive environment. Furthermore, following a twin-transformation strategy can be economically beneficial. This research provides OEMs a road map, which ultimately can help to optimize existing connected service portfolios while taking the twin transformation into account. Further, due to the prognosis of future trends and developments, also long-term orientations can be adapted.

5.3. Limitations

First of all, due to the time frame of this dissertation, there was no room for broader research and the amount of conducted interviews had to be limited to four interviews. Conducting more interviews thereby could have made more insights possible by taking more different dimensions into account, thus increasing the quality of the research. Moreover, the interviews were limited to experts from the automotive sector. More specifically: only employees of the BMW Group, were interviewed which may limit the findings to the sector or case company at hand. Moreover, no physical meetings for conducting the interviews could be held because of the COVID-19 pandemic in combination with long distances. Still real face-to-face communication remains superior to digital communication as gestures and facial expressions as part of non-verbal communication can be very important. Overall, connected services and their ecological impact plus covering literature are continuously progressing and given the early stages of the current innovation cycle, the content of this research may not be significant for an extended period to come.

5.4. Future Research

This dissertation has given insights into the field of connected services and ecological sustainability. However, various topics for future investigation have been discovered. First, due to the changing competitive landscape and innovation in the automotive industry, a follow-up study in some period could be interesting to measure the impact of changing circumstances. Second, as identified by our research, connected services are still in the earlier stage of the innovation cycle so it is still unclear, how to maximize ecological impact in that regard. Future research should also focus on the interconnection between connected cars and for example smart home devices or smart cities and the potential to improve ecological sustainability here.

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Appendices

A - Interview Guideline

Expert-Interviews: Connected Services and Sustainability

Goals:

- Identify the impact connected services may have on ecological sustainability
- Identify the most important connected services of BMW for ecological sustainability
- Forecast of trends and future developments regarding connected services
    - How may they influence sustainability and revenues?
    - What kind of Connected Services could BMW add to its portfolio?

Script:

Introduction

- Welcome and thanks for the time
- A brief outline of the topic
    - Interconnection between ecological sustainability and digitalization in the automotive industry at the hand of connected services
- Brief description of the interview process and approximate duration
- Privacy agreement (Confirmation / Declining to be recorded)

Thank you for your participation in this study. The goal of our today's interview is to learn more about how managers/experts think of the ecological sustainability impacts of connected vehicles and we are interested in your thoughts and opinions on the environmental dimension of sustainability. Everything you say will remain confidential. I will be recording this session so that I can spend more time listening and talking with you rather than taking notes. The recording will only be available to our research team and will be destroyed after transcription. I'm not recording this right now, and I will only begin recording after you tell me it's ok for you to be recorded.

Does that sound alright to you? Do I have your permission to begin the interview?

- Yes/No
    - If the answer is going to be "yes" → start of recording

Introductory Question

- Could you please introduce yourself briefly? (Position and activity in the company, professional experience in the field of automotive industry / digital services/sustainability)

Connected Services – Key Questions

- What impact do connected services have on the transformation of the automotive industry and what impact do they have on your company in particular?
- How do you think the area of connected services will develop in the future?
  - Keeping that development in mind: How should BMW adapt/prepare? Which kind of Connected Services should be introduced?

Connected Services and Sustainability – Key Questions

- What kind of connected services are most important regarding ecological sustainability and how do they influence it? Can you mention examples of BMWs portfolio?
- How may that impact develop in the future? Can you think of new services, which can contribute to sustainability as well?

Finish:

First of all, thank you very much for your valuable answers. If you should not have anything to add right now, I will stop the recording.

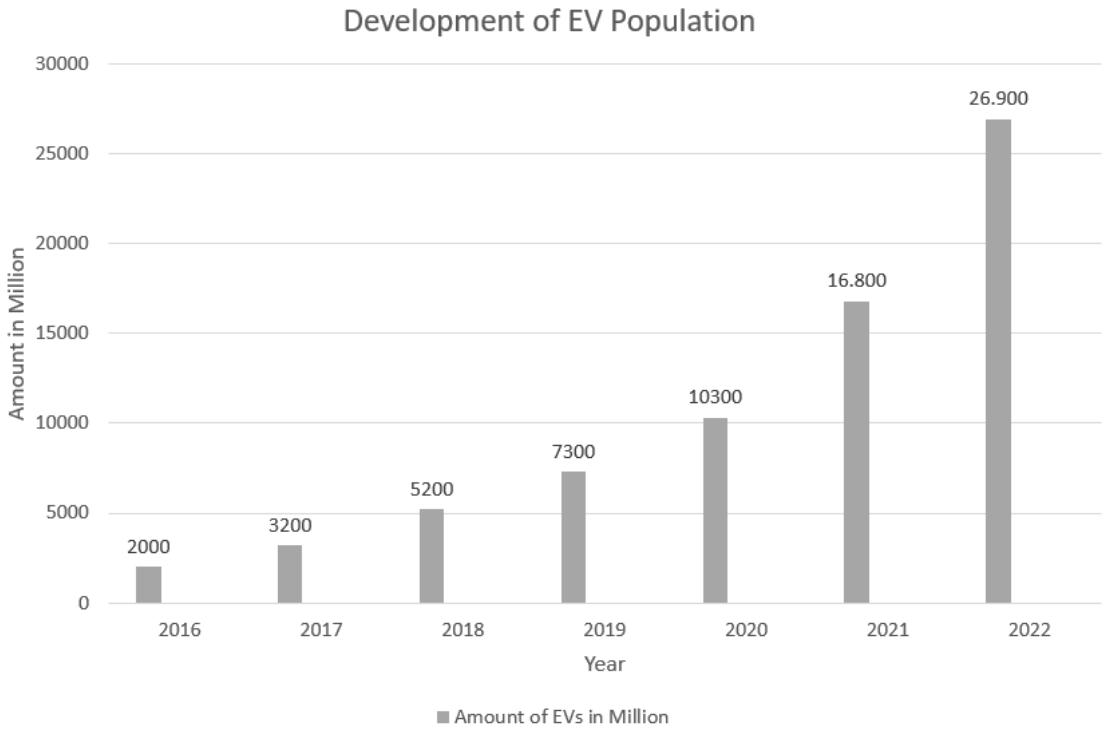
B - BMW Connected Service Portfolio

Currently, the BMW ConnectedDrive Store offers the following services for the German market (as of December 2022):

Active Cruise Control with Stop & Go function	Automatically keep a constant distance from other vehicles by using Active Cruise Control.
Adaptive M Suspension	The Adaptive M Suspension combines comfort and performance by adjusting to both - the driving style and the type of road the vehicle is on, giving the passenger the safest and finest driving experience possible.
Apple Car Play Preparation	An iPhone® can be used wirelessly, simply, and safely through the car's interface thanks to the Apple CarPlay® Preparation.
BMW Drive Recorder	Beautiful views as well as hazardous or crucial driving conditions in traffic can be captured on camera with the BMW Drive Recorder.
Driving Assistant Plus	Maintaining speed, lane, and distance to the preceding vehicle can be automatically assisted by the Driving Assistant Plus.
Seat Heating	Front Seat heating immediately raises the warmth of the front seats to a comfortable level that can be varied in intensity.
High Beam Assistant	When there is a car in front of or incoming traffic, High Beam Assistant automatically turns on and off the high beams.

IconicSounds Sport	The IconicSounds Sport feature brings the car's distinctive, dynamic BMW sound inside for a driving experience that awakens all of the customer's senses.
Map Update Package	By getting the most recent navigation map data either automatically over the air or via a USB update, the vehicle's Map can be kept up to date.
Online Entertainment Voucher	With BMW Online Entertainment, the customer has unlimited access to more than 30 million songs.
BMW Service Inclusive	With servicing costs that are fixed for the duration the customer chooses, BMW Service Inclusive provides the customer with peace of mind.
Parking Assistant Professional	A parking Assistant Professional takes care of parking and assists with maneuvering using numerous cameras and sensors.
Steering Wheel Heating	Driving in colder weather is more comfortable thanks to the steering wheel heater. With this feature, your steering wheel heats up to a comfortable temperature very quickly.
Real-Time Traffic Information	Real-time traffic information provides information on the current traffic situation, warns of traffic jams, and, if necessary, diverts traffic in a time-saving manner.

C – Electric Vehicle Development (Last six years)



Source: Seibt, 2021

D – The German Automotive Industry

To emphasize the dependence of German society on the OEMs in the automotive environment, the German automotive industry will be reflected further. The German automotive industry is considered the key industry of the German economy and is synonymous with the high quality of German work and their resulting products. For years, it has been able to shine with steadily rising sales and employment figures and has also made an enormous contribution to the export performance of Germany (Tagesspiegel, 2009). Considering its role as a customer of other industries, 9.8% of total German gross value added and more than and more than 7% of all jobs depend on the automotive industry (Puls and Fritsch, 2020). It also plays a major role in German society as measured by the number of employees, the automotive industry is one of the largest employers of all manufacturing sectors in Germany, directly employing around 786.000 people (Bundesministerium für Wirtschaft und Klimaschutz, n.d.). As the gross earnings per hour (on average 32,01€) stay way above the average gross earnings in Germany overall (19,88€ per hour), the industry contributes not only to the employment figures but also to the overall prosperity of German society (Statista, 2022).

Revenue of 410.9 billion euros was generated in total in the German automotive sector in 2021, representing an increase of almost 32.7 billion euros over the prior year. This was broken down into local sales of about 137 billion euros and international sales of about 274 billion euros (Statista, 2022). So especially foreign business remains to be the key revenue stream, as export sales, which accounted for a good two-thirds of total sales, developed extremely dynamically at +13 percent, whereas domestic sales only increased by one percent during the same period. In terms of export revenues, sales to both countries within and outside the eurozone increased simultaneously. Companies earned 77.2 billion euros within the eurozone (up 7% from 2020), and 196.8 billion euros with nations outside the eurozone (up 15% from 2020). However, the core business of leading OEMs is negatively impacted by production constraints due to material bottlenecks (Verband der Automobilindustrie, n.d.).