Junior Management Science

journal homepage: www.jums.academy

Discussion of automotive trends and implications for German OEMs

Philip Christoph Häberle

Technische Universität München

Abstract

The rapid change in the automotive industry, largely triggered by four disruptive trends – autonomous driving, connectivity, electrification, and shared mobility (ACES) – poses major challenges for incumbent players. This thesis aims to provide a comprehensive literature review of these four trends and to discuss implications for German original equipment manufacturers (OEMs). To do so we use the structure of Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis and apply both qualitative and quantitative methods. Furthermore, we introduce new frameworks that shall support companies in make-or-buy decisions and competitor analyses. To this end, we present a new metric that provides information on the innovative capacity of OEMs – the ACES Index. We conclude the following: (1) German OEMs can use their financial power, brand popularity, and global presence to conquer new markets. (2) The organizational structures of German OEMs slow down their innovative power in identifying and developing disruptive trends, which is why they had to give up their leading position to new competitors. (3) The ACES Index has a decisive influence on the market capitalization of an automotive company, which is why German OEMs should integrate future-relevant technologies into their value chains by developing their own capabilities or establishing partnerships.

Keywords: Automotive trends; Autonomous driving; Electric vehicle; Shared mobility; German OEMs.

1. Introduction

The automotive industry is transforming at an immense pace due to disruptions from various fields. On the one hand, new technologies enable growing levels of automated driving and improved connectivity features, which increases safety (Fagnant & Kockelman, 2015), reduces emissions (Khondaker & Kattan, 2015; Zohdy & Rakha, 2016), and enables drivers and passengers to interact with their cars in entirely new ways (Bertoncello, Martens, Möller, & Schneiderbauer, 2021). On the other hand, the automotive industry plays a major role in the fight against climate change and must therefore drastically reduce its carbon dioxide (CO_2) emissions (European Parliament, 2019; Rogelj et al., 2016), leading to a shift from traditional internal combustion engine vehicles (ICEVs) to battery-powered electric vehicles (EVs) (Bernhart et al., 2019; Irle, 2021; Rietmann, Hügler, & Lieven, 2020). In addition, completely new mobility business models have emerged over the last decade, including on-demand ride services (Cramer & Krueger, 2016; Dudley, Banister, & Schwanen, 2017; Hensley, Padhi, & Salazar, 2017), carsharing (Münzel, Boon, Frenken, & Vaskelainen, 2018; Zhou et al., 2020), or subscription-based full-service ownership options (Brenner, Seyger, Dressler, & Huth, 2018).

Incumbent automotive companies have noticed that a successful deployment of these four trends – autonomous driving, connectivity, electrification, and shared mobility, frequently referred to by the acronym *ACES* (Holland-Letz, Kässer, Kloss, & Müller, 2019) – will require massive efforts. In addition, they have to respond to macroeconomic challenges such as the rise of e-commerce, saturated core markets, and ever-increasing competition. Being successful in the future, thus not only requires the development of new products or technologies but rather a complete enterprise-wide transformation to a “new mobility” company. A good example of this was provided by Volkswagen AG (Volkswagen), which announced its innovation roadmap for the next few years with an elaborate media event – the "Power Day" (Volkswagen AG, 2021b).

It is important to note that all trends are still at an early point in their product life cycles (Bertoncello et al., 2021; Bloomberg, 2020b; Irle, 2021). However, since last year, which was largely marked by the impact of the global COVID-

DOI: https://doi.org/10.5282/jums/v8i4pp955-992

19 pandemic, future trends have been gaining momentum. This manifests itself in a huge growth in EV sales (Irle, 2021), increasing levels of digitization in different business sectors (Sinha, 2020), and major innovations in the service sector (Heinonen & Strandvik, 2021). As a consequence, automotive companies, also referred to as original equipment manufacturers (OEMs), that fail to take advantage of the four ACES trends and the associated profit opportunities will find it difficult to stay competitive. Although it is hard to imagine that today's successful and established companies will disappear, past experience shows that especially these companies face serious problems when markets change abruptly due to disruptive innovations (Christensen, 2013).

This particularly threatens the economies of countries like Germany, which are heavily dependent on the automotive industry, as it contributes massively to the gross domestic product (GDP) and provides employment for 830,000 people (Bundesministerium für Wirtschaft, 2020). One important reason for this is that Germany is home to some of the world's best-known OEMs, including Volkswagen, Daimler AG (Daimler), and Bayerische Motoren Werke AG (BMW) and many of their subsidiaries.[1] Therefore, it is of great economic interest to secure the future viability of these companies.

The objective of this thesis is twofold. Firstly, it aims to broaden the reader's understanding of the four ACES trends and, secondly, to discuss how these trends will affect German OEMs. Since this discussion encompasses multiple aspects, we approach it by defining a series of questions, which are:

(1) What unique assets do German OEMs possess that put them in an advantageous position when it comes to implementing new trends?
(2) How do their organizational structures influence the way they respond to disruptive trends?
(3) Which emerging markets and profit pools offer attractive business potential given their capabilities?
(4) How can make-or-buy decisions about disruptive technologies be answered in the modern business world?
(5) How can competitors be clustered and who poses the greatest threat?
(6) How well have German OEMs implemented ACES trends compared to their competitors?
(7) To what extent do investors value the efforts made by OEMs to establish a pioneering role in the implementation of ACES trends?

We answer these questions using current data from annual reports, database extracts, newspaper articles, and market studies and substantiate the findings through detailed literature analysis.

This work starts with a comprehensive literature review of the four ACES trends (Chapter 2), as most studies consider them separately (Bertoncello et al., 2021; Cramer & Krueger, 2016; Fagnant & Kockelman, 2015; Rietmann et al., 2020) even though a joint analysis is critical to exploit their full potential (Lempert, Preston, Charan, Fraade-Blanar, & Blumenthal, 2021). The objective of the chapter is to familiarise the reader with later required definitions (e.g. the different levels of autonomous driving) and with technical basics of the different technologies (e.g. the difference between ICEVs and EVs). Furthermore, the advantages and disadvantages of the technologies are discussed, as the literature comes to inconsistent and contradictory conclusions regarding their added values, potential threats, and limitations.

The results are presented in Chapter 4, following the structure of the well-known strategic management tool Strengths-Weaknesses-Opportunity-Threats (SWOT) analysis, examining both internal and external factors (Pickton & Wright, 1998). The analysis of internal factors involves the identification of critical monetary as well as non-monetary assets. To do so, we will investigate their annual reports, value their brand equities, and measure their footprints in the largest automotive markets. Furthermore, we will assess how the corporate structures of German OEMs differ from those of newcomers. In the next step, opportunities and threats are derived from the interactions of the firms with external entities, including governments and competitors as well as changing market landscapes. This part of the paper also introduces new frameworks to help companies evaluate complex problems such as competitor analyses or make-or-buy decisions.

2. Literature review

This chapter aims to provide a literature overview of the most important trends that currently shape the automotive industry. It's important to note, that the trends must not be considered exclusively. Instead, their combination builds an entirely new understanding of mobility – a shared autonomous vehicle using an electric engine. The joint view on ACES trends is also critical, as Lempert et al. (2021) note that the most significant social benefits arise from the interplay of electrification, autonomous driving, and connectivity.[2]

2.1. Autonomous driving

2.1.1. Different levels of autonomous driving

The Society of Automotive Engineers International (2018) defines five levels of vehicle automation, with level 1 being the most basic (driver assistance) and level 5 being the ultimately advanced (full driving automation), as follows: In level 1 the vehicle performs either the lateral (steering wheel) or longitudinal (speed and brake) motion control and leaves all other tasks to the driver. In level 2 (partial automation of driving), the vehicle can perform both lateral and longitudinal movement control. In level 3 (conditional

[1] In the following the term *German OEMs* refers to Germany's largest automotive companies Volkswagen, Daimler and BMW.

[2] Other cross-industry trends such as the rapidly growing e-commerce business, complex global supply chains, saturated markets, or regulations are not part of the literature review but are addressed in the results section.

driving automation) all dynamic tasks of driving are performed by an automated driving system, including motion control and environment monitoring. The driver still needs to be available for occasional control. In level 4 (high driving automation) all dynamic actions are performed by an autonomous driving system and the driver is not required to respond or intervene. Within level 4 all features are only applicable for certain roads and conditions such as dry highways. Finally, in level 5 the vehicle can perform all actions during any conditions on its own and in some cases leaves no intervention possibilities to the driver.

2.1.2. Positive effects and value proposition of autonomous driving

The positive effects of autonomous vehicles (AVs) are manifold. One of the most obvious and impactful consequences is arguably the increased safety. Most fatal accidents are attributed to the driver and are caused by activities such as drunk driving, fatigue, and distraction. According to the Federal Statistical Office, human errors account for almost 90 % of accidents in Germany (Deutsches Statistisches Bundesamt, 2018b). As a consequence, 2,724 people died and 328,000 were injured on German roads in 2020 in total (Deutsches Statistisches Bundesamt, 2021). Furthermore, making roads safer is a worldwide goal. Within its Sustainable Development Goals, the World Health Organization (WHO) set the target of halving the number of road deaths by 2020 (Goal 3.6) (WHO, 2016). AVs could thus support the WHO to realize its ambitions.

To quantify potential benefits resulting from higher safety and fewer accidents Fagnant and Kockelman (2015) model three scenarios based on the American market, with AV adaption rates of 10%, 50%, and 90%. The authors find that at the lowest adoption rate AVs could save 1,100 lives and avoid 211,000 crashes. Taking economic consequences (damages) as well as costs reflecting pain into account, Fagnant and Kockelman (2015) derive potential annual savings of USD 1,470 per vehicle. With higher penetration rates this number grows exponentially, as according to the authors, communication between AVs further lowers crash rates. With a 90% AV market share, the saved amount per vehicle could be USD 5,460. AVs would thereby avoid 21,700 road deaths and 4,220,000 accidents annually. On a country level (United States), this would mean annual savings of over USD 400 billion which again highlights the enormous impact that AVs could contribute.

Whether comparably high adoption rates are likely to be achieved depends strongly on the technology price and people's willingness to pay (Bansal & Kockelman, 2017). Using survey results of 2,167 Americans, Bansal and Kockelman (2017) conclude that in the most likely scenario with a 5% annual technology price decline and constant willingness to pay, the level 4 AV penetration rate will be 24.8% by 2045. In their most optimistic scenario with a 10% annual price decline and 10% willingness to pay increase the share would reach 87.2% in 2045, thus being close to the 90% market share scenario analyzed by Fagnant and Kockelman (2015). Fagnant and Kockelman (2015) expect that once the added price for AVs falls below USD 10,000 the technology becomes competitive and the additional benefits compensate for the higher price.

In addition to safety improvements, AVs also have the potential to reduce freeway congestion, fuel consumption, and air pollution by reducing bottlenecks and smoothing traffic flow, mainly enabled by vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication (Fagnant & Kockelman, 2015). This enables more efficient braking, accelerations, and lane choice decisions. The authors estimate that with 10% AV penetration, congestion could be reduced by 15% and fuel consumption by 13%, saving USD 1,400 per vehicle. In their 90% adoption rate scenario, highway congestion is expected to be reduced by 60% and fuel consumption by 23%, resulting in savings of USD 970 per vehicle. Hoogendoorn, van Arem, and Hoogendoom (2014) assume that AVs could reduce congestion even stronger. They argue that even without V2V and V2I equipment, congestion could be halved. Additionally, Shladover, Su, and Lu (2012) note that lane capacity could almost double when AVs apply cooperative adaptive cruise control, which is the system responsible for longitudinal automated vehicle control. Khondaker and Kattan (2015) report that advanced algorithms, optimized for intelligent acceleration and deceleration maneuvers could save 16% of fuel. Zohdy and Rakha (2016) propose an advanced version of cooperative adaptive cruise control, that could efficiently handle intersections including traffic signals, all-way stops, and roundabouts. According to the authors, their version could reduce delays by 90% and fuel consumption by 45%. Other fuel-saving benefits could arise from lighter design (due to enhanced safety) or less powerful engines (due to efficient accelerations) (Milakis, van Arem, & van Wee, 2017).

2.1.3. Negative consequences and current limitations

However, these positive effects could be canceled out by a significantly higher number of vehicle miles traveled (VMT), as more underserved people, including elderly or people with medical restrictions, would gain access to AV transportation services (Harper, Hendrickson, Mangones, & Samaras, 2016). The authors find that AVs could provide great new opportunities to this group and enable them the same travel options as normal drivers. This could result in a 14% VMT increase (295 billion miles in the United States) for the entire population. On top of that, travel times could be used more efficiently and make cars an attractive alternative to rail or air travel (Yap, Correia, & van Arem, 2016). Taking all effects into account, (Fagnant & Kockelman, 2015) conclude that AVs could lead to a VMT increase of 26% (90% adoption rate scenario). Correia and van Arem (2016) conclude that AVs increase VMT by 17%, using the model of a European mid-sized city.

Additionally, several barriers to implementation still exist, which is why development remains below expectations and currently only level 2 technology is available on the market (Bloomberg, 2020b). One reason for this is that costs are considerably high so that AVs only appeal to a small proportion of potential buyers (Fagnant & Kockelman, 2015). On top of that AVs could become the target of cyberattacks (Petit & Shladover, 2015). Petit and Shladover (2015) warn that those threats with the highest probability of success (blinding the camera and GPS spoofing) can be achieved with little effort while having threatening consequences.

Cyberattacks, technical difficulties as well as mistrust among the population set high standards for the approval of AVs. Kalra and Paddock (2016) note that it could take billions of kilometers under normal road test conditions to prove the safety of AVs. They therefore call for innovative testing methods. Finally, the big questions about AV liability remain unresolved. Commissions need to clarify which parties bear ultimate responsibility and answer how algorithms should determine who is to be protected in the event of unavoidable accidents (amongst others Fleetwood, 2017).

2.2. Connectivity

2.2.1. Different levels of connectivity in connected cars (CVs) and scope

Similar to AVs, there are different degrees of connectivity within vehicles. Bertoncello et al. (2021) define a framework that distinguishes between five levels: Level 1 vehicles provide basic vehicle monitoring functions, while level 2 vehicles provide additional connectivity to the driver's digital ecosystem (Bertoncello et al., 2021). Level 3 technology additionally enables predictive and intelligent functions, including features such as personalized infotainment or advertising for all vehicle occupants. In level 4 vehicles, passengers have the option to engage in multimodal dialogues with the vehicle or proactively receive intelligent recommendations. Finally, in level 5, the vehicle acts as a virtual chauffeur and fulfills all passengers' needs with the help of Artificial Intelligence (Bertoncello et al., 2021). According to the authors, by 2030, the proportion of CVs will increase to 95% (560 million with level 1 or 2 capabilities, 120 million with level 3, and 160 million with level 4 or 5 capabilities). They also state that the massive expansion of the connectivity ecosystem will lead to further integration of players from other industries such as telecommunications, streaming services, and infrastructure providers.

To define the scope of vehicle connectivity, it additionally needs to be noted that there exist several overlaps with autonomous driving technology. Talebpour and Mahmassani (2016) for example state that connectivity features are the key enabler of autonomous driving. They argue that they enable AVs smoother and safer driving, as they do not only have to rely on sensor data but can rather use the information provided by other vehicles and infrastructure (V2V and V2I). These technologies, however, have already been discussed in Chapter 2.1 and will therefore not be part of this chapter.

2.2.2. Benefits and monetary potential from CVs

Lempert et al. (2021) report that the impact of CVs on increased social welfare including health, access, equity, and environmental benefits will depend not only on technological improvements but also on favorable policies. They conclude that only a combination of both will lead to improvements in all areas. In addition, Lempert et al. (2021) model two further scenarios, one with more optimistic policy assumptions but less optimistic technology assumptions and one vice versa. Both scenarios lead to environmental benefits, while only the former also offers health and access benefits (Lempert et al., 2021). In contrast, the latter will lead to a deterioration in health, access, and equity for most people which underscores the critical role of policy in ensuring a successful CV adoption (Lempert et al., 2021). Another positive impact on the environment could result from lower fuel consumption due to optimized route planning, taking into account both vehicle characteristics and traffic data (Miao, Liu, Zhu, & Chen, 2018). According to the authors, their new approach could reduce fuel consumption by up to 15%.

Besides social and environmental benefits, CVs have a huge monetary potential for OEMs, resulting from both additional revenue streams and reduced costs (Bertoncello et al., 2021). Bertoncello et al. (2021) identify nine use case clusters that could potentially deliver up to USD 400 billion of additional value. On the cost side, this includes topics such as research and development (R&D) optimization or vehicle health monitoring (Bertoncello et al., 2021). The authors state that depending on the connectivity level this could lead to savings of USD 100 (level 1 and 2) up to USD 210 (level 4 and 5) per vehicle. The revenue potential is even higher and includes use cases such as on-demand hardware/software, mobility insurance, and seamless in-car experience (Bertoncello et al., 2021). The additional revenue per vehicle is expected to be between USD 130 (level 1 and 2) and USD 610 (level 4 and 5) per vehicle according to the authors. Bertoncello et al. (2021) note that this potential will not monetize on its own. Instead, OEMs need to leverage customer feedback, build strong in-house expertise, and improve time-to-market. Athanasopoulou, de Reuver, Nikou, and Bouwman (2019) confirm that OEMs should use the increasing importance of vehicle connectivity to adapt their business models and successfully transform from product to service providers.

2.2.3. Technical base

To leverage the described potential, CVs must be able to collect, process, and transfer huge amounts of data accurately and within a very short time. For this purpose, the concept of the Internet of Things is well suited, as it encapsulates several essential functions, including the sensors, software, and internet connection. It additionally enables the interconnection between a vast number of physical objects (Rayes & Salam, 2017). The emergence of the fifth generation of broadband mobile networks will provide a further technology boost by offering enhanced capabilities such as increased bandwidth, best-in-class security, low latency, and very high reliability (Papathanassiou & Khoryaev, 2017). However, according to Ai, Peng, and Zhang (2018), conventional cloud computing is of limited suitability due to the high latency and high mobility of vehicles. They therefore propose the use of edge cloud computing, a technology where computation and data storage take place closer to the point of need (Ai et al., 2018).

2.3. Electrification

2.3.1. Background, technology, and current market

The impact of greenhouse gases on global warming has been widely discussed and there is a broad consensus that drastic reductions are needed to curb the effects (e.g. Schneider, 1989). As a result, the Paris Climate Agreement was agreed in December 2015, involving 195 nations, with the goal of keeping global warming well below two degrees above pre-industrial levels (Rogelj et al., 2016). To comply with this agreement, the European Parliament (2019) has committed to reducing CO_2 emissions from the transport sector by 60% until 2050 compared to 1990. Consequently, the automotive industry has a large and important role to play, as it accounts for 72% of transport emissions (European Parliament, 2019). An important step is to successfully drive the transformation from ICEVs to EVs, as the latter promise to produce less emissions, when using electricity from renewable resources (European Parliament, 2019). The need for EVs is further strengthened by the limited fossil energy resources (Shafiee & Topal, 2009). According to the authors, oil and gas reserves could run out as early as the 2040s.

In addition to pure EVs, there are also hybrid solutions that use both an internal combustion engine and an electric engine, supplied by a battery. They are called hybrid electric vehicles (Arslan, Yildiz, & Ekin Karaşan, 2014). A special variant of hybrid vehicles with extended ranges are plug-in hybrid electric vehicles (PHEVs), which can be recharged at the charging station in addition to pure recuperation (Arslan et al., 2014).[3] The components used in EVs are very different from those used in traditional ICEVs. One of the core technologies and differentiators in EVs are batteries. In recent years, the lithium-ion battery has emerged as a the technology leader due to its high specific power, high energy density, high specific energy, and low weight (Mahmoudzadeh Andwari, Pesiridis, Rajoo, Martinez-Botas, & Esfahanian, 2017; Tie & Tan, 2013). Another important component is the electric engine, which has the advantage of higher torque (especially at low speeds), more efficient conversion of electrical to mechanical energy, and the ability to recover energy during braking compared to an internal combustion engine (Mahmoudzadeh Andwari et al., 2017). Other components include the battery management system, which monitors and safely operates the battery, and the power electronics, which act as an intermediary between the battery and the engine (Mahmoudzadeh Andwari et al., 2017). To date, however, the technology has several disadvantages compared to ICEVs including costs, mileage, fueling/charging time, and service infrastructure (Kapustin & Grushevenko, 2020).

[3] In the scope of this thesis, PHEVs will be also considered as EVs, following Rietmann et al. (2020). They argue that pure EVs are steadily gaining PHEV's market shares and PHEV customers will switch to pure EVs.

Figure 1 depicts the global EV sales and market shares since 2011. It is evident that the growth in EV sales is significantly outpacing that of the total automotive market as shown by the increasing market penetration, which was over 4% of total sales in 2020. It is also clearly visible that the major share of EV sales comes from China and Europe. 2020 was the first year that Europe became the number one in EV sales, as many member countries doubled or even tripled their sales (Irle, 2021). As a consequence, one out of 10 cars sold in 2020 in Europe was equipped with a battery, according to the author. Other markets such as Japan that once were first movers in the e- mobility market have continuously declined within the last years and also the United States show only moderate growth (Irle, 2021).

2.3.2. EV emission reduction potential and influencing factors

The CO_2 saving potential of EVs is immense, as Teixeira and Sodré (2018) show that the emissions of an EV fleet can be 10 to 26 times lower than those of an ICEV fleet. Whether this potential can be realized on a global scale and whether EVs can thus contribute to lower CO_2 emissions worldwide depends on two main factors: The market share of EVs and the energy mix used for recharging (Rietmann et al., 2020). In order to predict the future market share, Rietmann et al. (2020) use a logistic growth model for 26 countries on five continents, which they base on actual sales data from 2010 to 2018. They conclude that the global market share of EVs will be 42.5% by 2035, albeit with strong differences between the examined countries. While countries such as Norway or Sweden are expected to reach a 50% market penetration in the 2020s, China or the United States will take longer than 2035 (Rietmann et al., 2020). The authors' second finding confirms the hypothesis of Canals Casals, Martinez-Laserna, Amante García, and Nieto (2016), who argue that the significant discrepancies in the energy mix between countries pose an additional challenge to a successful and sustainable EV implementation.

The results of Rietmann et al. (2020) underline that in all examined countries (except India and Hong Kong) EVs will lead to a significant CO_2 reduction. Rietmann et al. (2020) estimate that compared to an "ICEV only world" EVs will be able to reduce CO_2 emissions by 17.2% in 2035. However according to the authors emissions will still be 11.8% higher than in 2018, so further improvements are required. Gómez Vilchez and Jochem (2020) confirm these results and expect that total greenhouse gas emissions will be between 13% and 32% higher in 2030.

According to Rietmann et al. (2020) the biggest CO_2 saving contributions will come from countries like Sweden or Norway that combine a high EV market share with a renewable energy mix. They will consequently be able to reduce CO_2 emissions by over 60%. Other countries such as Germany or the United Kingdom will have to improve their energy mixes in order to benefit from the increase in EV sales (Rietmann et al., 2020). The authors see the greatest room for improvement in China and India. According to their sce-

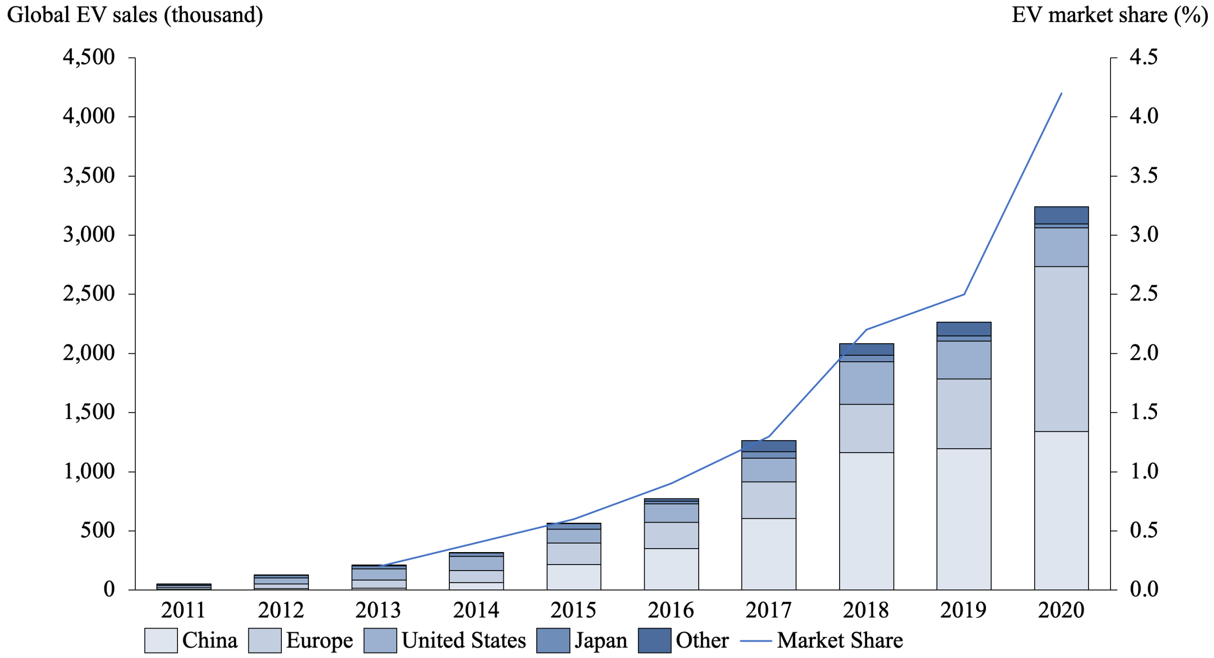

Figure 1: Worldwide EV market development 2011-2020.

Source: Adapted from Irle (2021)

nario, emissions will increase by 54% and 130% respectively compared to 2018, despite moderate increases in EV market shares due to the poor energy mix.

2.3.3. EV challenges – Manufacturing & scrapping, rare resources, and grid stability

As discussed before, EVs can make their contribution to emission reduction if they use renewable energy for operation. However, for comparison with ICEVs, both the manufacturing and the scrapping process (the vehicle cycle) need to be taken into account (Gómez Vilchez & Jochem, 2020). The authors conclude that these emissions will account for a significant share in 2030, representing one-third of an EV's lifetime emissions. As with the energy mix for operations, China and India occupy the last places in terms of manufacturing and scrapping emissions, which need to be improved in order to reduce greenhouse gas emissions (Gómez Vilchez & Jochem, 2020). Hao, Qiao, Liu, and Zhao (2017) therefore call to rethink the production and scrapping process, as they show that optimized recycling could reduce emissions by 34%.

Another criticism of EVs is their high consumption of scarce resources. Noori, Gardner, and Tatari (2015) note that one EV consumes over 3 million liters (>800,000 gallons) of water during its lifetime, which is almost six times higher than the consumption of an ICEV and is mainly due to upstream electricity generation and battery production. The latter also requires the use of rare earth elements, which yields several issues (Ali, 2014). Ali (2014) is especially concerned about the effects on the environment as well as on the safety, health, and society of workers.

According to Kapustin and Grushevenko (2020), the widespread adoption of EVs will lead to an 11% to 20% increase in global electricity consumption by 2040, even though the authors assume a significantly lower EV share (12% to 28%) than the studies discussed before. This and additional peak times, especially in the morning when people come to work and charge their cars and in the evening when people return home, create a major challenge for a stable energy grid (Kapustin & Grushevenko, 2020). Furthermore, Kapustin and Grushevenko (2020) argue that renewable energy sources are not suited to handle peak loads. Dharmakeerthi, Mithulananthan, and Saha (2014) come to a similar conclusion and urge the development of new load model predictions to accurately predict the energy demand changes from EVs. To counteract undesired grid instabilities and ensure a stable supply, one option could be to expand conventional fuel generation (Kapustin & Grushevenko, 2020). However, according to the authors, the more favorable solution would be to install energy storage combined with renewable energy feed.

2.4. Shared mobility

2.4.1. The concept of the sharing economy

Even though people have shared things for centuries, the concept of sharing has gained significant attention within the last decade driven by the emergence of digital platforms (Zervas, Proserpio, & Byers, 2017). Those platforms can reach a giant user base and facilitate transactions and thus enabled the creation of the "sharing economy". In academia there exist several definitions for this term. Sundararajan (2016,

p. 23) defines the sharing economy as "an economic system with the following five characteristics: largely market based, high impact capital, crowd-based networks, blurring lines between the personal and professional, and blurring lines between fully employed and casual labor." The different aspects included in this definition provide a comprehensive description of the ride-hailing business model discussed in Chapter 2.4.2. Lessig (2008, p. 143) characterizes the sharing economy as "collaborative consumption made by the activities of sharing, exchanging, and rental of resources without owning the goods", which neatly describes the concept of carsharing discussed in Chapter 2.4.3.

Like Airbnb, where owners can lend their homes to registered users, various forms of carsharing enable more efficient use of cars. There is a huge leverage for different business models to increase the efficiency of car usage, as Dudley et al. (2017) note that vehicles sit idle at least 90% of the time. This section aims to present the two most prominent sharing models in the mobility sector and to discuss their up and downsides.

2.4.2. Ride-hailing – Market development, value proposition, and limitations

One of the most prominent forms of sharing cars is ride-hailing (also called ride sourcing or ride sharing). It allows travelers to request a ride which is then matched to a nearby driver via a platform (Rayle, Dai, Chan, Cervero, & Shaheen, 2016). Typical providers are Uber Technologies, Inc. (Uber), Lyft, Inc. (Lyft) or Didi Chuxing Technology Co. (Didi). The largest ride-hailing markets, China (USD 24 billion) and the United States (USD 23 billion), are dominated by single players (Grosse-Ophoff, Hausler, Heineke, & Möller, 2017). The authors note that in contrast, the third-largest market Europe (<USD 6 billion) is more fragmented due to country and city-specific regulations. In combination with considerable VMT growth rates (150% until 2017) the ride-hailing market seems to be an attractive investment opportunity (Hensley et al., 2017). Holland-Letz et al. (2019) confirm this hypothesis. They report that between 2010 and 2019 over USD 56 billion were invested into ride-hailing companies, making it the largest new mobility investment category.

Cramer and Krueger (2016) who compare the usage of Uber and traditional taxis in five major American cities come to the result that Uber drivers have a 30% higher utilization rate measured by time and even a 50% higher utilization rate measured by miles. Similar to AVs this also helps to reduce congestion and emissions. Cramer and Krueger (2016) see a more efficient matching technology, a larger scale of Uber drivers, inefficient regulations for taxis, and finally Uber's more flexible working model as the main reasons for this advantage. Dudley et al. (2017) add that Uber rides are more transparent and convenient for travelers as the calculation of fares, the route planning, and the final payment are all done within the app. Hensley et al. (2017) expect that the occurrence of purpose-built vehicles (vehicles optimized for passenger experience and designed for different use cases) will provide a further push for ride-hailing companies. An even stronger impact could result if AVs find their position in the carsharing market. Shared AVs would significantly reduce costs for passengers and thus encourage more customers to switch to ride-hailing services. As a consequence private vehicle ownership could be reduced by 90% Boesch, Ciari, and Axhausen (2016); Fagnant and Kockelman (2014).

In addition to these positive aspects, there are some problems associated with ride-hailing that make further expansion difficult or even call into question the argument that ride-hailing makes travel more sustainable. For example, Hensley et al. (2017) note that ridesharing services are not applicable for people in rural areas. Furthermore, the authors argue that it is only cost-effective to forego a car and rely on ride-hailing for those people who travel 3,500 miles or less, which affects only 5% to 10% in America. As a consequence, only 1% to 3% of total VMT in major American cities are conducted with ride-hailing services (Bliss, 2019). Another aspect that complicates expansion for ride-hailing companies are conflicts with legislative systems as well as their drivers, who fight for better conditions and permanent employment (Dudley et al., 2017). This conflict endured for several years until in March 2021, the British Supreme Court decided that Uber drivers in Great Britain had to be considered as "workers" (Satariano, 2021). As a consequence, Uber must pay its 70,000 drivers the minimum wage as well as holiday allowance and provide access to a pension plan (Satariano, 2021). Moreover, Bliss (2019) notes that ride-hailing companies, namely Uber and Lyft increase VMT and traffic congestion. Henao and Marshall (2019) come to similar conclusions, finding that ride-hailing increases VMT by 83.5%.

A solution to the congestion problem could be achieved through on-demand ride pooling (Ke, Yang, & Zheng, 2020). With this model, not only one person but several people with a similar destination can be transported. On-demand ride pooling is also offered by Uber, Lyft or Didi and on top of that by Moia GmbH (Moia), a subsidiary of Volkswagen. Ke et al. (2020) demonstrate that if companies optimize the matching window (the time passengers are willing to wait for a vehicle), ride-pooling services are able to reduce congestion for both passengers and private car users.

2.4.3. Carsharing – Different models and their effects on vehicle ownership

Similar to ride-hailing, there has also been a clear development in carsharing in terms of availability and user numbers. Zhou et al. (2020) estimate that carsharing services are available in more than 30 countries and serve over five million users worldwide. Münzel et al. (2018) distinguish between four business models: cooperative, business-to-consumer (B2C) (roundtrip and one-way), and peer-to-peer (P2P) carsharing. According to Münzel et al. (2018) cooperative carsharing is mainly practiced in small towns and involves mainly small fleets. Its initial idea was to offer a more environmentally friendly and sustainable way of getting around (Münzel et al., 2018). Later, and with the help of advanced technology (as with other sharing economy business models), B2C carsharing providers such as Car2go

GmbH entered the market (Münzel et al., 2018). Within B2C carsharing the authors further differentiate between round-trip models (also called station-based carsharing), where users have to return the car at a certain point, and one-way models (free-floating carsharing), where users can park the car any-where within the grid. Illgen and Höck (2019) see the latter as the most promising, as it is the most suitable for most use cases. Finally, the P2P carsharing model allows users to share their cars with each other via a platform, which according to Münzel et al. (2018) is the best solution for very large cities. Münzel et al. (2018) find that fleet sizes in this model are the largest. As the presented models serve different purposes, Münzel et al. (2018) conclude that all different models can co-exist as they have only a few overlaps.

Similar to ride-hailing the desired effect of carsharing is a reduced vehicle ownership and less congestion (Zhou et al., 2020). In academia, controversial results are reported and discussed. While several early studies (e.g. Costain, Ardron, & Habib, 2012) confirm that the availability of carsharing services leads to less vehicle ownership, Zhou et al. (2020) neglect that effect, finding only a minor relationship between carsharing availability and reduced vehicle ownership. They argue that earlier studies mainly examined people who already used carsharing services and therefore contained a bias problem. Participants in these early studies were also found to be more environmentally conscious and therefore more willing to give up owning a car (Costain et al., 2012).

Instead of looking at the impact of car sharing as a single model, it is worth examining the impact of the different carsharing options. Using data from DriveNow GmbH & Co. KG (for free-floating) and Flinkster GmbH (for station-based carsharing), Giesel and Nobis (2016) show that only the latter leads to a significant reduction in car ownership (15% versus 7% reduction). A study by the German carsharing agency Bundesverband Carsharing (2020) comes to similar conclusions. They also confirm that only the less widespread station-based carsharing can significantly reduce car ownership.

3. Methodology

To broaden the understanding of how current trends in the automotive industry influence German OEMs and to evaluate possible strategies, we apply the mixed methods approach (Denscombe, 2008). This approach differs from purely quantitative or qualitative studies, as it combines the two and thus obtains benefits from both (Denscombe, 2008). On top of that Collins, Onwuegbuzie, and Sutton (2006) note that the mixed methods approach increases data accuracy and supports the creation of a more holistic view. This is of particular importance for the topic of this thesis, as the analysis includes several internal and external dimensions. Furthermore, the interactions of German OEMs with stakeholders as well as sudden industry changes further complicate the situation, which is why a holistic view is indispensable.

The general structure of Chapter 4 is based on a SWOT analysis, which is considered as one of the most respected and used tools in strategic management (Glaister & Falshaw, 1999; Panagiotou & Van Wijnen, 2005).[4] It includes both internal (a firm's strengths and weaknesses) as well as external factors (outside opportunities and threats) that are depicted in a basic 2x2 matrix (Pickton & Wright, 1998). The simplicity of the SWOT matrix, as well as its focus on core issues, is considered to be one of its major advantages (Pickton & Wright, 1998).

Pickton and Wright (1998) note that, as in other analyses, the assessment of strengths and weaknesses is only relative to the competition. The same applies to opportunities and threats – they result only from the actions and inactions of the analyzed parties and those of their competitors (Pickton & Wright, 1998). In the scope of this thesis, the analysis of the external factors will be complemented by concrete strategy recommendations. This is intended to counter one of the biggest criticisms of SWOT analyses, namely that they do not specify implementation strategies (Helms & Nixon, 2010).

It is important to note that both internal dimensions can be mapped to both external ones. This is described by Weihrich (1982) and counteracts the misleading perception that strengths always result in opportunities and weaknesses in threats. Instead, companies can also recognize their weaknesses and turn them into opportunities (Weaknesses x Opportunities) or vice versa (Strengths x Threats) (Weihrich, 1982).[5] Figure 2 visualizes a SWOT analysis for German OEMs with internal factors in the first and external factors in the second row. The shown dimensions are discussed in Chapter 4.

As intended in the mixed methods approach, the different subchapters will have different focuses and apply different methods, although they follow a similar structure. Each section aims to shed light on a current topic by formulating hypotheses based on current data and testing them with an extensive literature review. The latter will also be used to generate new frameworks that shall support German OEMs in their decision-making. For this purpose, various approaches from the literature are combined and adapted to current issues in the automotive industry.

To ensure that the data sets are as current and accurate as possible, we use the annual reports of the examined companies and additionally draw on market and business segment analyses by expert companies (Bloomberg, Reuters) or renowned external consulting firms (McKinsey & Company, Boston Consulting Group). Additionally, external databases and test results are used to enable industry-wide comparisons (EV Database, ADAC). On top of that, we employ newspaper articles to reflect current events (Die Zeit, Wirtschaftswoche).

This paper concludes with a quantitative assessment of the current implementation of ACES trends by German OEMs

[4] Although the origin of the SWOT analysis remains unknown it is likely to date back to the 1960s and 1970s (Helms & Nixon, 2010).

[5] Examples for the different combinations are discussed in Chapter 4.

Strengths	**Weaknesses**
1. Profitable business and large financial reserves 2. Localized R&D departments, local production, and global sales 3. Valuable brands 4. Long-established industry expertise and supplier relationships	1. Rigid organizational structures optimized for the "old automotive world" 2. Lacking investments into new technologies 3. Backlog in software technology 4. Missing e-mobility infrastructure 5. Outdated customer relationship
Opportunities	**Threats**
1. Increasing mobility requirements and emission-free vehicles 2. Emerging purpose-built vehicles market 3. Increased R&D expenditures, process improvements and partnerships 4. German government as stake holder 5. Increased upstream integration potential 6. Downstream integration, servitization, and direct-to-consumer sales	1. Regulations and missing intellectual property rights in China 2. Environmental regulations in Europe and Germany 3. Shrinking traditional profit pools 4. The competitive landscape of German OEMs 5. Indirect competitors (substitutors) and their business models 6. Direct/potential competitors and their technological advances

Figure 2: SWOT analysis for German OEMs.

Source: Own analysis

and a selected group of competitors. To the best of our knowledge, it is the first study to conduct a quantitative and holistic analysis of all trends. To do so, we divide each trend into several subcategories and rate the performance of the investigated OEMs in each subcategory using an ordinal scale from zero (0) to five (5), with 5 being the best score. Applying the arithmetic mean of the subcategories, we can assess how well an OEM has implemented each trend. In the next step, we define the ACES Index as the arithmetic mean of the scores of the four trends for each OEM. Finally, we use an ordinary least squares (OLS) regression to investigate whether a company's ACES index influences its market capitalization. If this is the case, it would support the objective of this paper, which is to highlight the importance of ACES trend implementation for German OEMs.

The three companies under consideration in this thesis are Volkswagen, Daimler, and BMW. Volkswagen is Germany's largest and the world's second largest OEM, delivering over 9.3 million units in 2020 (11 million in 2019) (Volkswagen AG, 2021a). The group consists of 12 brands ranging from the low to medium price segment (Skoda, Seat and Volkswagen) to the ultra-high price segment (Bentley, Lamborghini and Bugatti) (Volkswagen AG, 2021a). In between, the sporty and high-quality brands Audi and Porsche position themselves (Volkswagen AG, 2021a). Volkswagen is also active in the commercial vehicle segment (MAN and Scania), which is however not considered in this paper. Its size enables huge investments into new technologies. Consequently, Volkswagen increased the budget for its tech-transformation to EUR 73 billion until 2025 focusing particularly on electromobility (EUR 35 billion) and digitization (EUR 27 billion) (Volkswagen AG, 2020b).

Daimler is Germany's second largest OEM, delivering 2.8 million units in 2020 (3.3 million in 2019) (Daimler AG, 2021a). It consists of the three business units Mercedes-Benz Cars & Vans, Daimler Trucks & Buses, and Daimler Mobility (Daimler AG, 2021a). Again, the focus of this paper lies on the passenger vehicles, including the umbrella brand Mercedes-Benz which is complemented by Mercedes-EQ (electromobility), Mercedes-AMG (car tuning), Mercedes-Maybach (ultra-luxury) and Smart (urban mini cars) (Daimler AG, 2021a). Similar to Volkswagen, Daimler is planning to invest EUR 70 billion in electromobility and digitization in the next 5 years, especially in the car segment (Daimler AG, 2020b).

BMW delivered 2.3 million units in 2020 (2.5 million in 2019) (BMW AG, 2021). It is the only German OEM that consists only of premium brands (BMW, Mini and Rolls-Royce). It has been one of the pioneers in the area of EVs and carsharing services since it has introduced the i3 in 2013 (BMW

AG, 2021). Since then, however, their strategy has been less aggressive than that of the other OEMs. Instead of fully electrified model series, BMW plans to offer customers a choice between combustion, hybrid or electric engine for every series (BMW AG, 2021).

4. Results

4.1. Strengths

For decades, the German automotive industry has been the flagship for German engineering and quality, thrilling customers all over the world. There is no other country that has a comparable density of OEMs and where the automotive sector contributes more to GDP (Saberi, 2018). For a long time, this has helped them maintain their competitive position and become global leaders. In this chapter, several critical assets and their associated advantages are presented.

4.1.1. Profitable business and large financial reserves

One of the main strengths of German OEMs is their financial stability and their sustainable growth. Between 2010 and 2019 German OEMs managed to almost double their revenues.[6] Although their operating margins did not keep pace with this growth, they remained roughly constant. Even in the last three years, when the global markets became increasingly saturated (see Chapter 4.1.2) and as a consequence of the COVID-19 crisis began to shrink, German OEMs were able to achieve significantly positive operative earnings, mainly thanks to their successful ICEV business. Between 2018 and 2020, Daimler and BMW could achieve a total operating profit of EUR 20 billion each and Volkswagen of even EUR 40 billion (BMW AG, 2020, 2021; Daimler AG, 2020a, 2021a; Volkswagen AG, 2020a, 2021a).

Due to years of successful business activity, the three German OEMs have generated retained earnings of over EUR 200 billion by the end of 2019 (see Figure 3).[7] Since 2019 their retained earnings have increased at a compounded annual growth rate (CAGR) of around 10% and thus even exceeded the CAGR of revenues. Retained earnings are of great importance for companies as they not only provide a safety cushion but also have a significant positive impact on expected stock returns (Ball, Gerakos, Linnainmaa, & Nikolaev, 2020). This is due to the fact that they contain information on all past earnings which has a much greater influence in predicting future stock prices than current earnings (Ball et al., 2020). Therefore, investors pay a premium for shares in companies with high retained earnings (Ball et al., 2020). This suggests that German OEMs could cope with less profitable years without losing their attractiveness for investors. By reducing the focus on achieving high current earnings, German OEMs can invest massively in R&D for ACES trends and compensate for initial losses when entering new markets.

Figure 3 shows that R&D margins (the ratio of R&D spending to revenues) are at a high level and have increased to around 6% in 2019, which even exceeds Tesla, Inc.'s (Tesla) R&D margin (5.5%) (Macrotrends, 2021c). This suggests that German OEMs are increasingly investing in future trends, which is of great importance due to their enormous competitive importance (see discussion in Chapter 2). Increasing R&D activities also have a positive impact on a variety of metrics. This manifests itself in the positive influence of R&D expenses on subsequent sales (especially when they exceed the threshold of 3% of revenues) (Morbey, 1988), improvement in market share (Ettlie, 1998), and an increase in enterprise value (Ehie & Olibe, 2010).

A further balance sheet analysis in combination with literature research reveals another advantage of German OEMs. Van Binsbergen, Graham, and Yang (2010) outline that a company's balance sheet and asset composition affect the cost of debt. They state that firms with high asset collateral and high book-to-market values face lower costs of debt. Both apply to German OEMs (BMW AG, 2021; Daimler AG, 2021a; Volkswagen AG, 2021a) and, as they are highly leveraged (Damm, 2020), plays hugely in their favor, allowing them to borrow money on favorable terms. Compared to new ventures, German OEMs furthermore do not require expensive funding. In addition, the three companies have significant liquid assets, which they could use in case of financial distress. BMW leads this category with liquid assets of around EUR 19 billion, which earns them the second-best rating among investors worldwide (Schürman, 2020).

In addition to the sales of new vehicles, the aftermarket business is another important source of revenue for German OEMs. A strong position in this market is crucial for smoothing the cyclical vehicle sales, as maintenance and services are largely independent of the economic situation. On top of that, the margins within the aftermarket business are considerably high. Brandt and Springer (2015) report that the after-sales business accounts for around 50% of total profits at some car manufacturers.

4.1.2. Localized R&D departments, local production, and global sales

Another strength of German OEMs is their global presence on both supply and demand side. All three companies have local production plants, localized R&D departments, and a global supply chain network. Daimler reports of more than 30 production plants on four continents (Daimler AG, 2020a), BMW a similar number (BMW AG, 2020). For Volkswagen, this number is even higher with 124 production plants worldwide (Volkswagen AG, 2020a). BMW has R&D departments in twelve countries (BMW AG, 2020) and Daimler in 15 (Daimler AG, 2020a), a considerable amount of which in Asia.

Bhattacharya, Hemerling, and Waltermann (2009) find several advantages in localized R&D departments in rapidly developing economies. Firstly, companies are able to lower labor costs by up to 60% and on top of that gain access to

[6] Find detailed information on discussed Key-Performance-Indicators (KPIs) and sources in Appendix 1-3.

[7] Data for 2019 is used to avoid bias from the influences of the COVID-19 crisis. Information for 2020 can be found in Appendix 1-3.

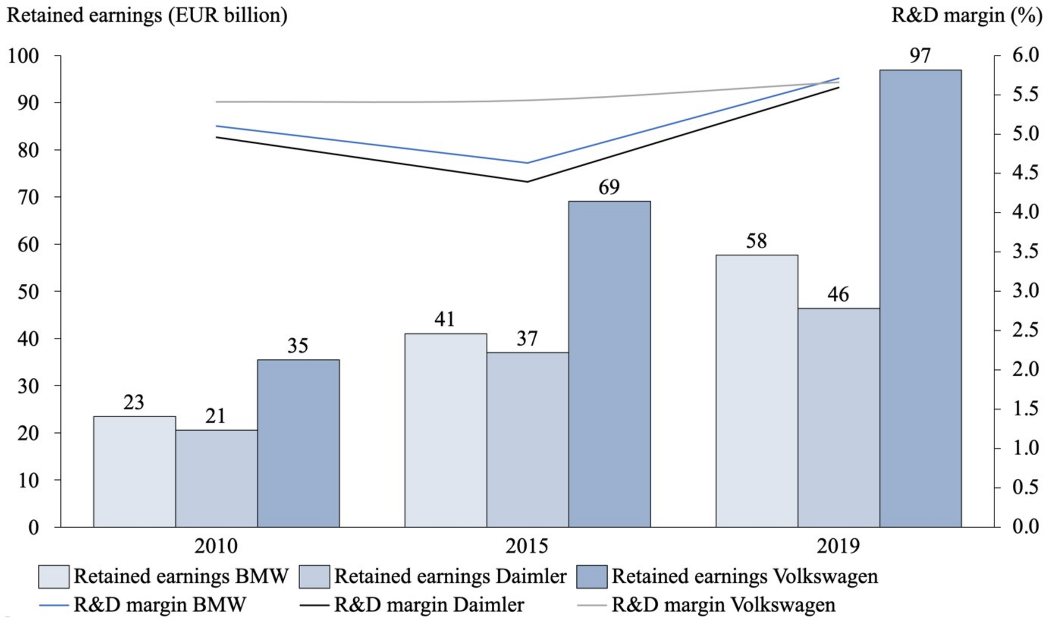

Figure 3: Retained earnings and R&D margins of German OEMs 2010-2019.

Source: See Appendix 1-3

a large pool of local talents (Bhattacharya et al., 2009). According to the authors, another aspect is that these markets become increasingly important due to their fast growth rates. The authors argue that the best way to enter these markets is to develop products or services that are specifically tailored to the needs of consumers in the respective regions. This can be better achieved when they are designed by locals (Bhattacharya et al., 2009). Finally, they argue that in established R&D clusters (places where firms co-locate with direct competitors) companies will benefit from partnerships and exchange of knowledge. Alcácer and Zhao (2012) confirm this hypothesis. They find evidence that in clusters innovations are quickly internalized and are more likely to involve cooperation across locations. Additionally, Alcácer and Zhao (2012) note state that strong networks help firms to keep control over local innovation and mitigate the risk of knowledge outflow.

An OEM's success in a market depends heavily on the economic conditions, as GDP development and passenger vehicle sales are highly correlated (European Automobile Manufacturers Association, 2018). For their advantage, downturns rarely hit economies with the same magnitude and at the same time, as the example of China shows. Even during the world financial crisis in 2008 and 2009 (GDP growth rate +9%) or during the COVID-19 crisis in 2020 (GDP growth rate +2%) (Macrotrends, 2021a) its economy was able to grow. Consequently, OEMs can stabilize their businesses, offering diversified product portfolios and being globally active, as the example of China shows.

German OEMs are active in almost all markets worldwide (BMW AG, 2021; Daimler AG, 2021a; Volkswagen AG, 2021a) with the highest volumes in Europe, China, and the United States, which are also the largest automotive markets measured in units sold (Verband der Automobilindustrie, 2020). The development of their three core markets in terms of passenger vehicles sold, market growth rates, and market shares of German OEMs between 2010 and 2019 are presented below (Figure 4 to Figure 6).[8]

Figure 4 shows how German OEMs developed and strengthened their positions in China. Daimler and BMW were able to almost triple their market shares, which is even more remarkable considering that the market itself grew by over 60% during this period. Volkswagen started from a higher level but also managed to grow its share by almost five percentage points. For Volkswagen, China has become the largest market (4.2 million units sold in 2019) (Volkswagen AG, 2021a). This was true even back in 2015 when they already sold around 15% more in China than in their home market Western Europe (Volkswagen AG, 2016).

An important decision that led to the strong growth in China was to develop models that are specifically tailored to the market's requirements, such as the Mercedes Benz GLA and GLC long version or the BMW 3 series long version. This hypothesis is supported by the literature. Calantone, Daekwan, Schmidt, and Cavusgil (2006) find evidence that active product adaption in foreign markets increases export performance. They further state that companies are more active with product adaptions when exports depend heavily on the target market and when the target market is very different

[8]Data for 2019 is used to avoid bias from the influences of the COVID-19 crisis. The detailed numbers as well as the sources can be found in Appendix 4-6.

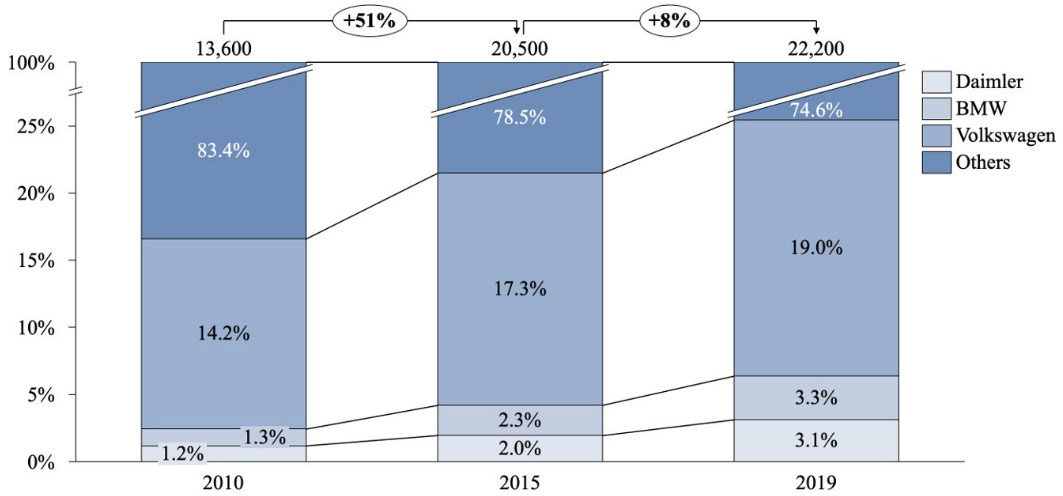

Figure 4: Market share development of German OEMs in China.

Source: See Appendix 4

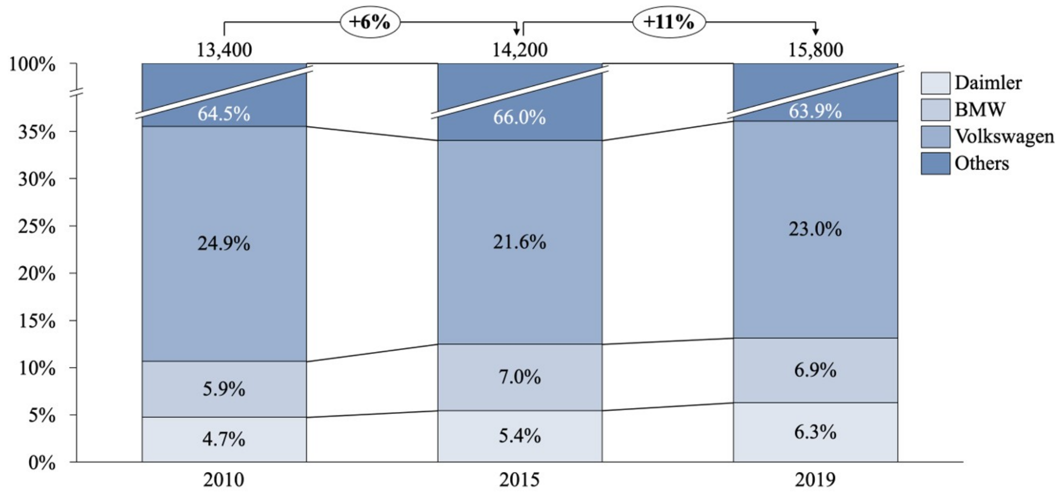

Figure 5: Market share development of German OEMs in Europe.

Source: See Appendix 5

from the home market. Both facts apply to China.

Compared to China, the European market showed only modest but nevertheless sustainable growth between (+6% between 2010 and 2015; +11% between 2015 and 2019). Again, Daimler as well as BMW could expand their market shares. For them Western Europe is the market with the highest volumes. In 2019 they sold almost 50% more units than in China (BMW AG, 2021; Daimler AG, 2021a). Volkswagen saw a slight decline of about 2 percentage points in Europe. This is not surprising, however, as this compensates for the massive growth in China.

In the United States all companies have a combined market share of less than 8% since the American market is dominated by American and Asian companies (Demandt, 2019). Nevertheless, German OEMs were able to benefit from the massive growth of over 50% between 2010 and 2015, as they were able to keep their market shares constant or, in the case of Volkswagen, even expand it.

4.1.3. Valuable brands

One of German car manufacturers' most critical assets are their brands. The marketing consultancy Interbrand (2019) found in its latest global report that two out of the three most valuable car brands are German - namely Mercedes Benz (USD 49.27 billion brand value) and BMW (USD 39,76 billion). Accordingly, the brand accounts for more than half of their group's market capitalization (Companies Market Cap, 2021; Interbrand, 2019). These high brand valuations even exceed that of the world's most valuable car manufacturer Tesla (USD 12,79 billion) by far (Companies Market Cap, 2021; Interbrand, 2019).

A strong brand is critical for several reasons. Firstly,

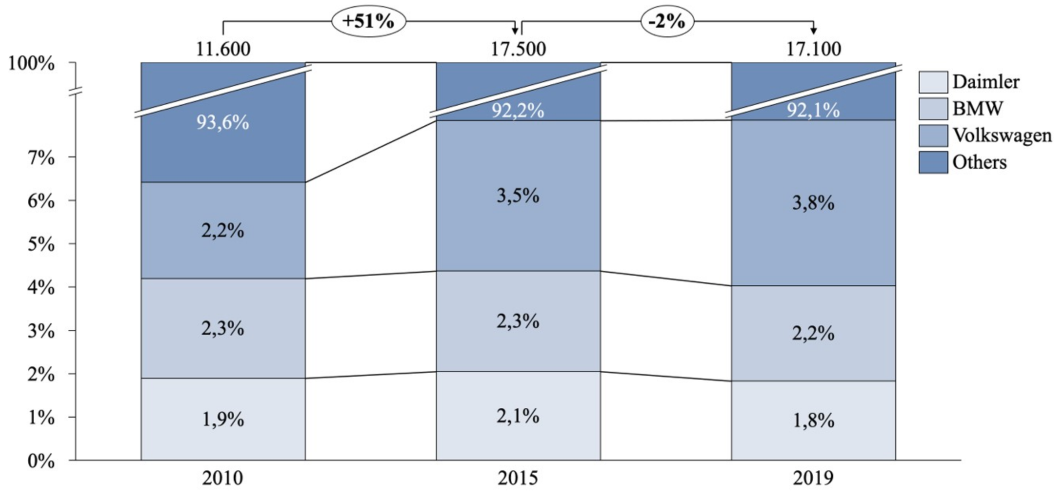

Figure 6: Market share development of German OEMs in the United States.

Source: See Appendix 6

Madden (2006) using the concept of the Fama-French model (Fama & French, 1992), by creating portfolios consisting only of high brand equity firms, finds that strong brands generate higher returns than their benchmarks and do so with lower variance. Other studies find significant relationships between brand values and market-to-book ratios (Kerin & Sethuraman, 1998) or profitability measures (e.g. return on investment) (Yeung & Ramasamy, 2008). Stahl, Heitmann, Lehmann, and Neslin (2012) study the influence of several components, associated to brand equity on the customer lifetime value. The customer lifetime value is defined as "the present value of the future cash flows attributed to the customer relationship" (Farris, Bendle, Pfeifer, & Rebstein, 2006, p. 143) and can be composed to customer acquisition, retention, and profit margin. Stahl et al. (2012) find that knowledge of a brand positively influences all three customer lifetime value components, whereas brand differentiation only positively influences profitability but negatively influences customer acquisition and retention.

Conforming results can be observed in the automotive sector, as retention rates for mass market cars tend to be higher than for more differentiated luxury market cars (J.D. Power, 2020). Still German OEMs achieve good results, with the brands BMW and Mercedes Benz ranking second and third within the luxury segment. The asset *brand* is also becoming increasingly important in China. The results of Guan, Gao, Wang, Zipser, and Shen (2019) show that the share of respondents that would buy the same brand again increased from 12% in 2017 to 31% in 2019. With 41% this share is particularly high for high-end cars, which is also the segment where German OEMs mainly compete.

Besides that, there is evidence that companies with strong brands are more attractive to young job seekers and therefore can acquire talents more easily (Myrden & Kelloway, 2015). Surveys concerning the attractiveness of employers among German graduates confirm this hypothesis: among students in both economic and engineering related fields, car companies rank at the very top (Arbeitgeber Ranking, 2020).

4.1.4. Long-established industry expertise and supplier relationships

German OEMs are globally known to deliver high quality including design, reliability, and safety. This is not only likely to positively influence brand perception as discussed before but is also a fundamental driver for several financial dimensions. For example, Phillips, Chang, and Buzzell (1983) find a positive effect of product quality on a firm's return on investment and Aaker and Jacobson (1994) a positive effect on stock return. Cho and Pucik (2005) also confirm a positive correlation between quality and the dimensions growth performance, profitability performance, and value performance.

Another positive effect of long-time industry expertise is a well-established supplier network. Volkswagen for example has 40,000 suppliers world-wide (Volkswagen AG, 2020a). BMW has around 12,000 and purchases two-thirds of its components from companies outside of Germany (BMW AG, 2020). The characteristics in car manufacturing – the assembly of thousands of small components (most of which are purchased from different suppliers) – allows their procurement departments an aggressive bargaining position and the ability to cut prices (Tyborski, 2020).

The literature also emphasizes non-financial advantages of established OEM-supplier relations. Kotabe, Martin, and Domoto (2003) find that higher-level technology transfers increase as relationships between OEMs and suppliers endure, for both the American and the Japanese market. As a consequence, the performance of suppliers increases, which is beneficial for the buyers as well. On top of that Dyer (1996) finds that co-specific investments (e.g. Daimler's investment in a strategic partnership with the Chinese battery cells manufacturer Farasis Energy (Ganzhou) Co., Ltd. (Farasis) (Daimler AG, 2020d)) have a positive effect on the return on assets for car manufacturers.

German OEMs also have a strong position in the field of future technologies. Bernhart et al. (2019) find that they are the technology leaders in the area of EVs, ranking before China and Korea. This is even more remarkable as Asian countries have significantly stronger expertise in battery cell production. Germany's technological advantage is also reflected in current sales figures. In 2020, Germany took second place in EV sales for the first time (398,000 units), overtaking the United States (328,000 units) and France (194,000 units) (Irle, 2021). Only the Chinese market was able to sell more EVs (1.34 million). As shown in Chapter 4.2.1 German OEMs can also benefit from this due to their strong position in China (Irle, 2021).

4.2. Weaknesses

The market capitalizations of German OEMs are low compared to most industry newcomers, suggesting that investors tend to believe in the long-term success of others companies (Companies Market Cap, 2021).[9] This is clearly illustrated by the valuation of Tesla, which is worth twice as much as the three German OEMs combined (Companies Market Cap, 2021). The situation is similar for Nio Inc. (Nio), whose market capitalization is almost equal to BMW's, although its sales volume in 2020 was only about 2% of BMW's (BMW AG, 2021) Companies Market Cap (2021); Nio Inc. (2021). Like Tesla, they benefit from a completely new way of thinking (replaceable battery, autopilot, and other connectivity features (see Chapter 4.4.6)). A comparable logic applies to competitors in the shared mobility sector. Uber's valuation reaches that of Daimler (Companies Market Cap, 2021; Macrotrends, 2021d) and Didi is catching up as they seek an initial public offering of around USD 60 billion (Bloomberg, 2021). This section will discuss which attributes of German OEMs make investors believe in other competitors.

4.2.1. Rigid organizational structure optimized for the "old mobility world"

The competitors mentioned above owe their high valuations mainly to their successful implementation of ACES trends (Tesla and Nio mainly in the area of electrification and connectivity, Uber and Didi mainly in shared mobility). Most likely, German OEMs were also aware of these trends but did not implement them, even though they had considerable cash reserves and large R&D departments that could have leveraged their innovative power (see Chapter 4.1.1). It is therefore logical to assume that fundamental problems lie in their organizational structures. In the following section, we will discuss three approaches.[10]

Henderson and Clark (1990) see one explanation in the difficulties of established actors to cope with architectural innovations, which they describe as the "reconfiguration of an established system to link together existing components in a new way" (Henderson & Clark, 1990, p.12). They argue that firms are optimized for component-level innovation and that their organizational divisions reflect the components of their products, which is advantageous as long as their underlying relationships do not change fundamentally. If they do, however, these changes are not as obvious as disruptive ones and therefore pose the threat of being detected too late (Henderson & Clark, 1990). This can lead organizations to wrongly assume to have a good understanding of the new technology. Even if companies recognize architectural innovations, they still need to build new knowledge and skills and find acceptance for them, which is again time and cost intensive (Henderson & Clark, 1990). On the opposite side, new players can start their businesses optimized for the new architecture (Henderson & Clark, 1990). An example of architectural innovation inside the automotive industry can be seen in the exponentially growing connectivity between components which lead to a new arrangement of the system, increased complexity, and reduced flexibility. Consequently, companies are forced to change the architectural design and adapt interdepartmental communication (Henderson & Clark, 1990).

Another approach is to analyze the effects of incremental and disruptive innovations on companies and link them to their organizational structures. There is strong evidence in the literature that the former tend to favor incumbent firms that have accumulated many years of experience in the field, whereas the latter tend to harm them and benefit new market entrants (Clark, 1985; Tushman & Anderson, 1986). Clark (1985) makes the connection to the organizational structure of a company by stating that once a company has chosen a certain path, subsequent decisions are based on it and chosen before alternatives. Consequently, companies build very specific knowledge that allows them to stay successful as long as disruptive technologies do not occur (Clark, 1985). If they do, however, most of their experience and knowledge become obsolete and established players run the risk of being replaced, the author argues. As the automotive industry is hit by several disruptive trends and German OEMs have spent decades incrementally improving established techniques such as the combustion engine, they failed to develop knowledge in battery technology or software that will be central for future mobility concepts.

An obvious solution could be to employ new talents, especially in IT-related areas. However, this is challenging, as due to their large sizes, cost-saving projects, and strict firing policies German OEMs have only limited employment capacities (Specht, 2019). Consequently, German OEMs barely hired additional staff (Appendix 1-3), whereas Tesla almost quadrupled their employees between 2015 and 2019 (Macrotrends, 2021b). Strack et al. (2019) note that competition for new digital talent has become increasingly international, with two-thirds of digital experts willing to move to another country for a job. This increases competition considerably so that German OEMs now must compete with companies like Amazon.com, Inc., Google LLC (Google), or Apple Inc. (Apple), which are known for attracting digital talent.

[9] All information is based on stock prices from April 15, 2021
[10] Discussion from Christensen (2013)

Christensen (2013) contributes a third theory by introducing the concept of value networks. A value network describes the position of a company in the value chain as well as the way it solves problems, reacts to customer demands, responds to competition, or maximizes profits (Christensen, 2013; Dosi, 1982). A firm's position in this value network is critical because it determines the markets in which the firm operates and how it evaluates new technologies. Based on these evaluations, managers decide how they allocate resources (Christensen & Rosenbloom, 1994, 1995). Christensen (2013) considers this as a decisive cause for the failure of incumbent companies since the allocation decisions are based on the economics of existing value networks and are therefore mainly in favor of incremental innovations. Disruptive technologies, however, create different value networks and require a different resource allocation.

Christensen (2013) argues that value networks have a strong influence on organizational structures and even on cultures within companies. On top of that, value networks determine how companies measure value (Christensen, 2013; Dosi, 1982). This becomes clear when comparing the unique selling propositions of German OEMs with those of new competitors such as Tesla or mobility providers like Uber. German OEMs have long prided themselves on their unique driver experience, strong performance, and high quality but failed to see that customers were demanding additional features. Tesla, on the other hand, has focused early on EV range extension, autonomous driving features, or over-the-air updates to improve the overall ownership experience. Mobility providers like Uber deliver convenient on-demand rides, make costs more controllable, and protect their customers from unwanted activities like maintenance.

Figures 7 and 8 compare two illustrative value networks for German OEMs. The first one shows the situation and markets that these companies used to address in the past. The latter shows a potential value network for a future mobility provider. It illustrates that companies are embedded in those networks, as their products are integrated into components within other products (Marples, 1961). The examples shown vary greatly as downstream market players force OEMs to deliver new products with very different characteristics, as shown here in the example of the powertrain. It also shows that purchasing decisions focus on other attributes (right side of boxes) and that components are delivered by other suppliers (left side of the box).

As demonstrated in this case, the new value network is completely changing the market landscape. Consequently, OEMs are forced to find their positions, develop new capabilities, and work together with new suppliers that can deliver the required parts and components.

Value networks not only specify the required product characteristics but are also responsible for the specific cost structures (Christensen, 2013). As a result, disruptive innovations can appear unprofitable when viewed through the lens of the old value network and therefore will not gain financial support from the management (Christensen, 2013). A comparison of the cost structure and resulting profitability between current ICEVs and EVs illustrates this. Baik, Hensley, Hertzke, and Knupfer (2019) show that the costs of the latter would currently be around 50% (EUR 12,000) higher if they had the same characteristics as ICEVs. As discussed earlier, however, future EVs will address different requirements. Therefore, manufacturers can simplify the design, optimize them for urban mobility, and reduce content. Combining these steps enables a cost reduction of EUR 5,700 to EUR 7,100 (Baik et al., 2019). The introduction of new business models such as battery leasing or fleet sales will further reduce costs so that their final costs will be only 20% higher (Baik et al., 2019). The authors further argue that, as the technology matures, costs will continue to decrease so that EVs will break even with ICEVs in 2025. This example shows that future mobility will form completely new value networks. This is another explanation why German OEMs have long left the field to new competitors. Based on the profit structures of the old value networks, managers apparently made the right decisions when they decided to continue ICEV production or to outsource software development. However, as disruptive technologies advanced, these decisions were doomed to fail.

Christensen (2013) finally argues that applying the economics of the technological S-curve will not help incumbent players when disruptive technologies occur. The technological S-curve represents the influence of time or engineering effort (horizontal axis) on the performance of certain product attributes (vertical axis) (Christensen, 2013). The theory holds that in the early stages of a new technology, progress is relatively slow, followed by a rapid development as it gains momentum until the technology finally matures (Sahal, 1981). Christensen (2013) argues that incumbent players are experts in identifying the point of inflection of S-curves and come up with successor technologies at the right time. However, as discussed before, disruptive technologies define new value networks which assess product attributes of performance (vertical axis) differently. Therefore, the new technological S-curve is placed in a different coordinate system (Christensen, 2013). As a consequence, all actions taken to sustain innovation by incumbent players (increased R&D investments, research consortia, technology scanning, etc.) will not address the new value network, as the new network demands fundamentally different attributes (Christensen, 2013). In the following subchapters, we examine a number of negative consequences that are most likely to result from organizational structures and related problems.

4.2.2. Lacking investments into new technologies

As depicted in Figure 8 future mobility concepts will serve other customer needs and therefore require other components and technologies. German OEMs cannot indefinitely benefit from their experience and advantages in the internal combustion engine technology, since stronger CO_2 regulations, consumer preferences of a clean technology and their own desire to build a sustainable company force them to shift their businesses. In addition, the development of various technologies needed to implement the four ACES

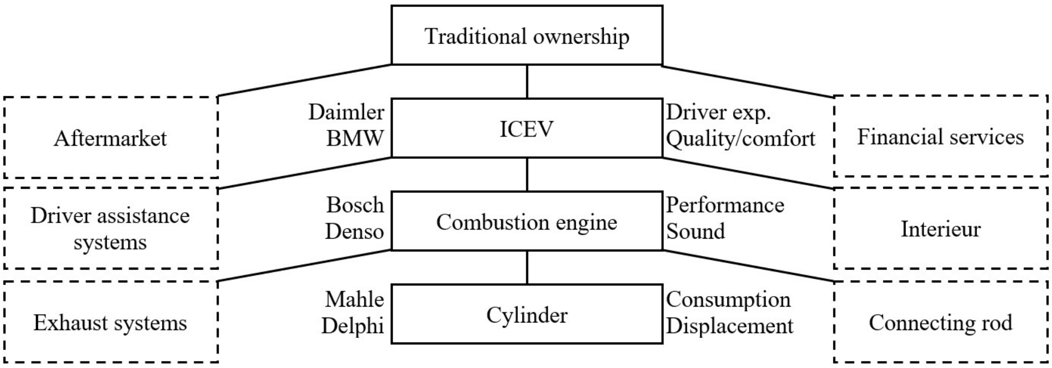

Figure 7: Value network for the "old automotive world".

Source: Own analysis adapted from Christensen (2013, p.35)

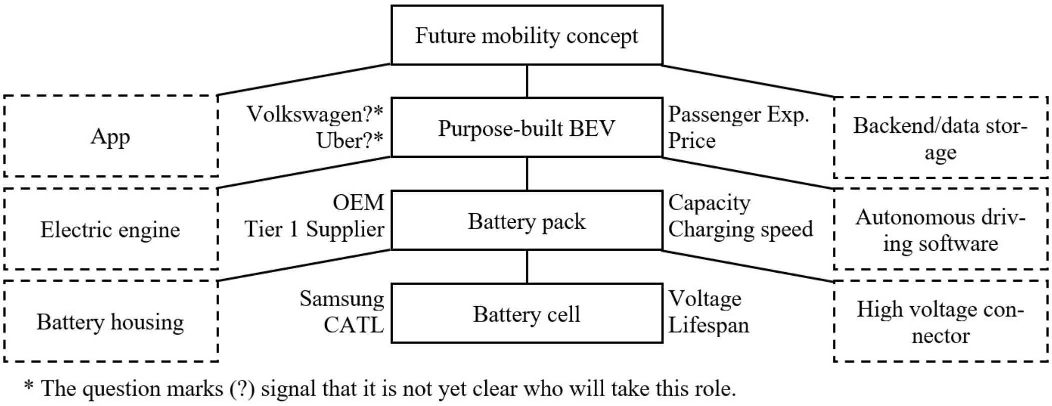

Figure 8: Value network for the “new mobility world”.

Source: Own analysis adapted from Christensen (2013, p.35)

trends is taking place in regions other than Germany or Europe. Holland-Letz et al. (2019) demonstrate that over a third (USD 84.5 billion) of overall investments into the mobility sector since 2010 has gone to companies in the United States. The European Union on the other side only accounts for USD 10.7 billion, ranking far behind China (USD 50.6 billion), United Kingdom (USD 34.1 billion) and Israel (USD 18.5 billion) (Holland-Letz et al., 2019). Holland-Letz et al. (2019) also find that investments have become larger, which indicates that the competition for ACES technologies is becoming more competitive and that technologies start to mature. Thus, it is becoming increasingly difficult for German OEMs to take a pioneering role in these trends, and they run the risk of having to purchase knowledge at a high price in the future. Another interesting finding is that 90% of the investments come from companies outside the automotive sector such as the Japanese SoftBank that invested USD 30 billion into new mobility trends (Holland-Letz et al., 2019). This data shows that the automotive market is becoming increasingly competitive with investments favoring technology players outside of Europe.

4.2.3. Backlog in software technology

Software, computing power, and advanced sensors will likely replace the engine as the technology core of future vehicles (Kaleta, 2021). According to this, the OEMs that best manage the transition from hardware to software will dominate the market in the future. However, German OEMs still struggle with this change and lag behind their competitors. This is also known at the management level, however, solutions are not in sight (Kaleta, 2021; Lambert, 2020). Volkswagen's Chief Executive Officer (CEO) Herbert Diess stated that Tesla's superior software competencies would give him “headache” and that it would be a “long way” to catch up (Krogh, 2020). Daimler's CEO Ola Källenius also embraced the crucial meaning of software which he calls “the brain” of a car (Kaleta, 2021). However, experts criticize that his efforts to regain control on that “brain” are not extensive enough. They argue that Daimler's innovations, such as subscription models or software updates, are not different from technologies that Tesla has already been offering for years (Kaleta, 2021).

As discussed in Chapter 2.1 one of the most prominent uses of software in future vehicles will be the function of the autopilot and later full autonomous driving. Bernhart, Hasenberg, Winterhoff, and Fazel (2016) assume that by 2030 shared AVs will gain around 40% of total global profits in the automotive market. To drive this development, German OEMs mainly rely on test fleet data, whereas Tesla uses the data generated by its entire customer fleet (Lambert, 2020). This means a serious disadvantage for German OEMs because, as the author argues, the Tesla fleet functions similarly to a neuronal network in this process. Like other neuronal networks it improves with the amount of data points collected. Tesla's customers already benefit from it, as Tesla provides its customers with a software update every two weeks (Lambert, 2020).

One reason for this backlog could be that German OEMs have long outsourced software development, possibly because they underestimated its competitive importance and value (see Chapter 4.2.1), as the example of Volkswagen demonstrates. Their current share of in-house software development is below 10% (Volkswagen AG, 2019a). They use 70 control units with operating systems from over 200 suppliers, some of them redundantly (Volkswagen AG, 2019a). This not only reduces their value creation share but also increases complexity drastically. As the lines of codes are often not separated from the hardware devices an update requires a complete replacement of the component in the worst case (Hohensee, Hajek, Reimann, & Seiwert, 2021). For many experts it was therefore no surprise that Volkswagen reported several problems during the final development phase of the ID.3 – the car they want to use to start the race to catch up with Tesla (Wimmelbücker, 2020). As a result, the first tranche of models shipped had several software shortcomings that needed to be fixed at a repair shop (Wimmelbücker, 2020).

4.2.4. Missing e-mobility infrastructure

Furthermore, the provision of charging stations has long been a problem in Germany (Thio, 2019). German OEMs have not found a competitive answer and have left the market to the utility companies, which today operate 80% of charging stations in Germany (Bundesverband der Energie- und Wasserwirtschaft, 2020). This has had two negative consequences. First, as Skippon and Garwood (2011) report, charging infrastructure is one of the main pain points for customers when deciding whether to buy an EV or an ICEV. As a result of a poor infrastructure, sales fell short of opportunities and the field for developing the EV market was left to competitors in other countries. Second, German OEMs missed out on a potential new revenue stream. As will be shown later, revenue streams in the automotive industry will change drastically, requiring OEMs to find new revenue opportunities. One possibility could be the charging station segment but as is apparent in the German market, other competitors are better positioned.

4.2.5. Outdated customer relationship

Another category that shows elementary disadvantages compared to new competitors is German OEMs' understanding of customer relationship. They (as most other incumbent players) mainly use the traditional sales via independent retailers (Ilg, 2019): potential customers go to a store, talk to salesmen, book a test drive and eventually buy a car. However, as in most other industries, there is an increasing trend towards online shopping, which is expected to grow from 0.5% today to as much as 17% in the United States by 2030, and to even higher figures in China and Europe (Lellouche, Grover, Blue, Walus, & Barrack, 2020). Moreover, Srivastava, Lellouche, Seners, and Vigani (2018) find that around 5% of customers would buy a car online without ever seeing or test-driving it. Although the number of online car purchases may still be low, online channels already play an important role in the purchase decision. Lellouche et al. (2020) report that 75% to 85% of the customers already base their buying decisions on internet research today. As a consequence, the average number of dealership visits per purchase have dropped from 4 to 1.4 (Srivastava et al., 2018).

As a further consequence of the current distribution model of established OEMs, there are few, if any, touch points with customers. Those that exist, however, are often painful. A Cox Automotive (2019) study shows that customers on average spend 50 hours with vehicle services during a vehicle's lifetime. This experience is particularly inconvenient compared to other products in the consumer-tech sector and poses a great risk of pushing young people towards alternative mobility concepts. In contrast, due to the business models of companies like Uber or Didi there is a continuous interaction with their customers, allowing them to collect user data on a regular basis.

4.3. Opportunities

4.3.1. Increasing mobility requirements and emission-free vehicles

From the strengths and weaknesses discussed above, several opportunities can be derived. One of the probably most important opportunities is that vehicle sales are expected to continue growing with an annual rate of 1.9% to 2.4% by 41 million units between 2015 and 2030 (Grosse-Ophoff et al., 2017). One reason for this growth is increasing urbanization. Studies estimate that the number of people living in cities will grow by 1 billion between 2018 and 2030 (Deutsches Statistisches Bundesamt, 2018a). Another reason are macroeconomic trends, such as a growing middle class (European Commission, 2017a). It is estimated that by 2030 the global middle class will reach 5.3 billion people, resulting in expenses of USD 64 trillion (European Commission, 2017b).

This growth is expected to mainly come from Asian countries (European Commission, 2017b) – markets where German OEMs are already well established. As discussed in Chapter 4.1.2 all three players were able to increase their footprint in China significantly within the last decade. Their joint share grew from below 17% in 2010 to over 25% in 2019, whilst the total market grew by over 60%. It can be assumed that this trend continues as increasing wealth is likely to have a positive impact on car sales that will further boost volumes in the Chinese automotive market. Weber, Krings, Seyfferth, Güthner, and Neuhausen (2019) estimate that the total number of cars in China will increase from 227 million to 339 million between 2020 and 2030, which corresponds to a CAGR of 4.1%.

Asian markets and the Chinese market, in particular, will furthermore provide a strong push to the aftermarket business, which is, as outlined in 4.1.1, a considerable income source for German OEMs. In China for example the growth of the aftermarket until 2030 is expected to be twice as high as that of traditional car sales (8% CAGR vs. 4% CAGR), which again underlines its importance (Kempf, Heid, & Hattrup-Silberberg, 2018).

To meet fleet emission standards German OEMs will need to increase their EV shares significantly. They thereby benefit from the combination of two of their vital strengths as well as governmental decisions. Firstly, German OEM are technology leaders within the development of EVs (Bernhart et al., 2019). Secondly, they have a strong footprint in the European as well as the Chinese market, which are the regions with the fastest-growing EV markets (Bernhart et al., 2019; Irle, 2021).

4.3.2. Emerging purpose-built vehicles market

As future mobility concepts like ridesharing gain importance, there will be a shift from driver to passenger ride experience. As a result, OEMs will have to put a higher focus on designing vehicles that maximize passenger ride experience (purpose-built vehicles) and consequently create this market (Bernhart, Hasenberg, Karlberg, & Winterhoff, 2018). This opportunity must be seized seriously, as this market will be of great importance. Bernhart et al. (2018) estimate that the market for purpose-built vehicles will reach a size of around 2.5 million sold units per annum in 2025 and that it will continue to grow to as many as 5 million annually sold units in 2030. This growth is again primarily driven by China, accounting for 60% of the volume (Bernhart et al., 2018). On top of the economic importance of this market, the authors consider it an important foundation for a successful position in the market for autonomous driving. They argue that the design and functionalities of a purpose-built vehicle will be very similar to those of a shared AV. They expect that once the technology for autonomous driving is sufficient, OEMs only need to replace the driver with software algorithms.

One way to get a foot in this market is demonstrated by Volkswagen, which signed a fleet management contract for 100,000 vehicles (two-thirds of which Volkswagen vehicles) with Didi (Shah & Shirouzu, 2018). In addition, the agreement provides for joint design and development and allows Volkswagen to access passenger data (Shah & Shirouzu, 2018). Daimler has taken a similar step, building a joint venture with the Chinese Geely Holding (Daimler AG, 2019). Together they plan to develop a purpose-built electric version of the smart.

Bernhart et al. (2018) propose three possible development scenarios for purpose-built vehicles. The first option is to design the new vehicles based on existing models. Grosse-Ophoff et al. (2017) highlight that reduced specifications like less powerful engines and simpler interiors will lower costs by 15%. Moreover, they find that distribution costs can be reduced by 80%, as purpose-built vehicles will be sold in larger bulks. In total, costs for purpose-built vehicles will be 25% less (Bernhart et al., 2018). According to Bernhart et al. (2018) this scenario would however not exploit the entire saving potential and thus would lead to a higher break-even point than the other options. They suggest that OEMs could alternatively start the design from scratch using traditional product development concepts. They consider this approach particularly favorable for non-traditional OEMs that can produce at lower costs. The third option is to come up with a new out-of-the-box design, investing a lot in research and design and build the vehicles in low-cost countries in Asia. This could lead to a 50% lower price compared to today's models.

Options 1 and 3 probably offer the greatest potential for German OEMs. In the former scenario, they would benefit from their strong design competence and market position in the quality segment. In the latter, they could use their strong financial situation and ability to make large R&D expenditures to develop new concepts (see Chapter 4.1.1). In addition, they could use their global production capacities, which enable low costs (compare Chapter 4.1.2 and 4.1.4). As the examples of Daimler and Volkswagen show, a promising approach to market entry can be the establishment of joint ventures with Chinese players.

Bernhart et al. (2018) stress that purpose-built vehicles will require a completely different design architecture. According to the authors, these vehicles will be optimized for certain use cases and passengers will have the opportunity to order transportation services according to their current needs. A vehicle ordered for leisure activities will therefore be very different from the one used for business rides. Figure 9 demonstrates three possible variants, including the categories “Productive”, “Relaxing”, and “Fun”. Bernhart et al. (2018) emphasize that all components need to be adaptive to serve the current desires of the customers. During the design phase, OEMs moreover can relieve pain points (lack of air conditioning control or avoidance of unwanted conversations with the driver) from current models. Due to changing customer concerns Bernhart et al. (2018) estimate that the product lifetime of purpose-built vehicles will be reduced to three to five years. OEMs can make use of that by using a modular architecture, that allows switching individual modules.

Finding the optimal point in time to enter a new market is a topic that has been widely discussed in academia. As a result, a shift from first mover advantage to first mover disadvantage research could be observed (Lieberman & Montgomery, 1998), with many scholars studying the effects of entry order (among others Lambkin, 1988). It is argued that while first movers enter a plain field with few competitors, the market lacks structure and therefore bears high risk to follow a wrong path (e.g. Aldrich & Fiol, 1994). However, firms should not hesitate too long, as that would increase the threat

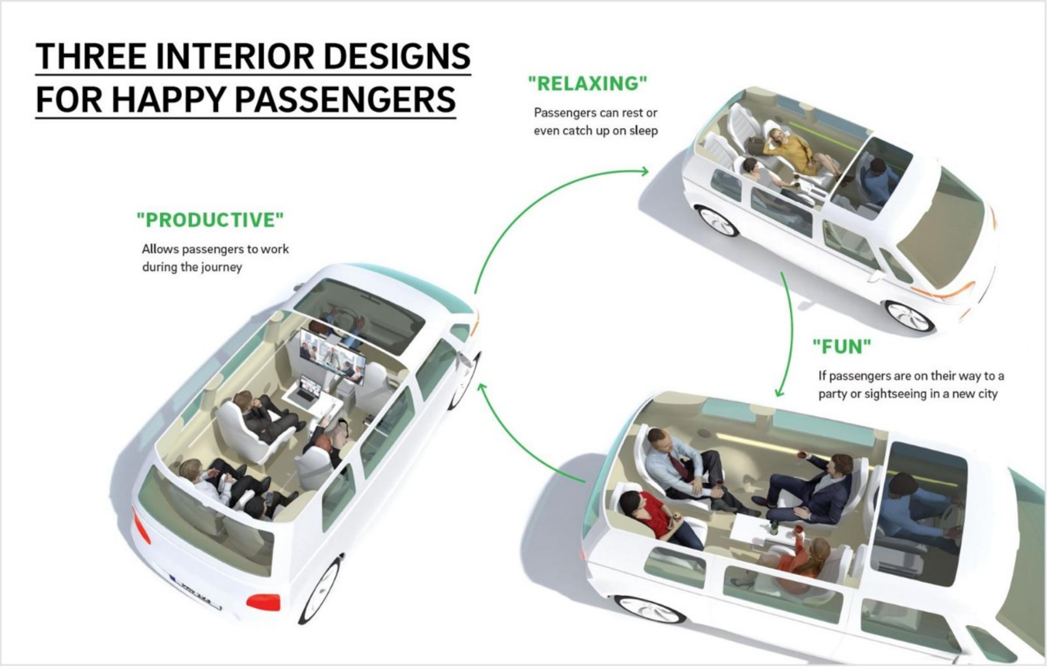

Figure 9: Three use case scenarios for purpose-built vehicles.

Source: Bernhart et al. (2018, p. 10)

to leave the market to their competition (Suarez & Utterback, 1995). The authors show that firms entering an industry before a dominant design emerges will have higher chances of being successful. Their explanation is that those firms will have more time to experiment with new products and that their competitors often fail to catch up. Suarez, Grodal, and Gotsopoulos (2015) combine these results and state that the optimal time to enter an industry is between the emergence of a dominant category and the emergence of a dominant design (see Figure 10). This is also the point in time where a dominant category has emerged, and an increasing number of players figures out a design.

There is evidence that the category of purpose-built vehicles is exactly in that window. As the data of expected growth presented above suggests, the market for purpose-built vehicles has emerged and is gaining momentum, however without an established design yet. Due to their strong financial resources, German OEMs have more time for "experiments" (Suarez & Utterback, 1995), which gives them a critical advantage in nascent markets (Rindova & Kotha, 2001). Rindova and Kotha (2001) also state that a strong identity is crucial for success in nascent markets and that in contrast to established players newcomers often lack it. With significant R&D expenses made by German OEMs (see Figure 3) they seem to be well prepared to play a dominant role in the market for purpose-built vehicles, which is still at an early stage.

4.3.3. Increased R&D expenditures, process improvements, and partnerships

To meet the challenges associated with ACES trends and become the mobility provider of the future, OEMs will need to invest heavily in these new trends. Holland-Letz et al. (2019) report that these investments must amount to at least USD 70 billion by the end of the decade in order to remain competitive. Although this sum represents a major challenge – even for wealthy German OEMs – recent reports show that they are actively addressing it: In addition to the already mentioned investments in e-mobility and digitization, Volkswagen announced at its first "Power Day" to build six gigafactories with a capacity of 240 gigawatt hours by 2030. They also want to expand the European fast-charging network by working with partners to quintuple the number of charging points (Volkswagen AG, 2021b). They have recognized their weaknesses and are now addressing them. Furthermore, Daimler announced investments of about EUR 70 billion (Daimler AG, 2020b), BMW followed with about EUR 30 billion of investments into future trends (Zwick, 2020).

Another area where established OEMs will profit from innovation is in process automation and outsourcing of white-collar jobs (Joas, Reiner, Deinlein, & Oertel, 2018). The authors conclude that these improvements will be higher than in previous decades and should lead to savings of up to 30%. Further cost reduction potential for OEMs beyond current limits can be achieved through the use of Artificial Intelligence throughout the value chain (Joas et al., 2018). The authors demonstrate that its use would enable a profitability potential increase of 15% to 20% per vehicle. Artificial

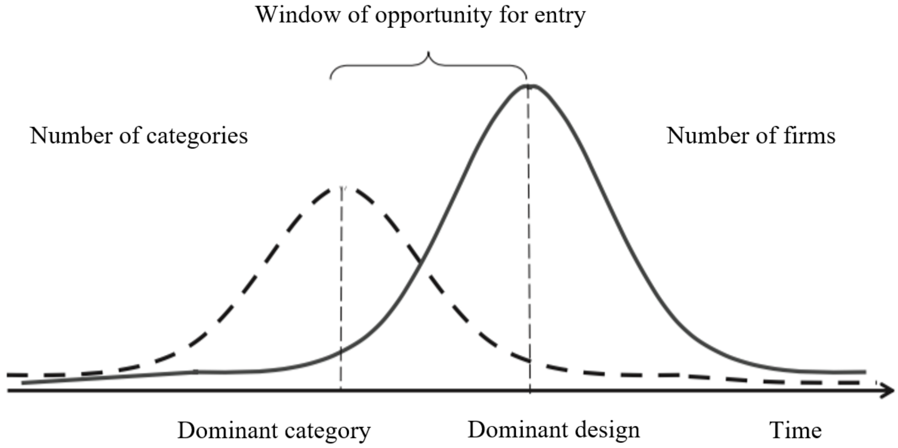

Figure 10: Dominant category and dominant design during the industry lifecycle.

Source: Suarez et al. (2015, p. 441)

Intelligence could for example improve purchase incentives by significantly reducing rebates and vehicle times on stock (Joas et al., 2018).

New technologies or business models are often accompanied by start-up problems or initial losses. This is also true for carsharing services or a comprehensive expansion of a charging station infrastructure (Fockenbrock, Fasse, & Hubik, 2019). However, through partnerships, it is possible to reduce these negative initial effects, use economies of scale and benefit from knowledge transfer and shared risks. One example is the joint-venture Ionity GmbH (Ionity) of Daimler, Volkswagen, BMW, and Ford Motor Company (Ford) (European Commission, 2017a). Under the project name EUROP-E Action, Ionity will build 340 Ultra-Charging stations (up to 350 kilowatt) in 13 EU member countries by the end of 2021 (European Commission, 2017a). They thereby mainly focus on highway locations. The average distance between the stations will be 120 kilometers (European Commission, 2017a). According to Jochem, Brendel, Reuter-Oppermann, Fichtner, and Nickel (2015), highways are the best location for charging stations for two reasons. Firstly, the volume of passing cars is high which increases demand and secondly, customers will be willing to pay more than for inner-city charging stations, making the business profitable by 2030 (Jochem et al., 2015).

4.3.4. German government as stake holder

The automotive industry is of great importance to Germany. In 2019, the industry generated revenues of EUR 436 billion (of which more than three-quarters came from OEMs), employed 830,000 people, and made Germany the world's export champion, as 75% of units were shipped abroad. (Bundesministerium für Wirtschaft, 2020). As a consequence, politics have a strong incentive in promoting and stabilizing the industry. They therefore work closely together with the German Association of the Automotive Industry (Verband Deutscher Autombilindustrie (VDA)). Past incidents illustrate how strong the influence of the VDA on German politics is. In 2015 VDA's president Matthias Wissmann was able to prevent stricter exhaust gas tests for diesel cars (S. Becker & Traufetter, 2017). In 2012 the VDA was heavily involved in the introduction of energy labels that assess CO_2 emissions, with the result that heavy German passenger cars with rather poor levels still achieved good rankings (Maisch, 2013).

Besides high involvement in political decisions, the automotive industry could also count on financial support during crises. To incentivize car purchases after the financial crisis in 2009, the government contributed EUR 2,500 for the exchange of an old car for a new one (Seiwert, 2010). As a consequence of the COVID-19 pandemic, the industry was supported with EUR 3 billion (Delhaes, 2020). The government is also strengthening Germany's position in the future mobility market and supporting OEMs in meeting the challenges associated with ACES trends. An example therefore is the EUR 382 million investment into R&D for e-mobility (Bernhart et al., 2019). These investments, measured as a share of GDP, exceed the investments of the Chinese or American governments in the automotive industry by a factor of 10 (Bernhart et al., 2019). On top of that the German government supports the purchase of EVs with up to EUR 9,000 (Delhaes, 2020). This measurement lead to a tripling of new registrations for EVs in Germany during 2020 (Irle, 2021). However, the advancement of EV technology is no exception in the field of innovation. According to the latest Bloomberg report on the innovation power of various nations, Germany is in first place (Jamrisko & Lu, 2020).

In addition to the German government, the European Commission also promotes innovation. One example is the funding of the charging station provider Ionity, which was supported with around EUR 40 million or 20% of the total project costs (European Commission, 2017a). Currently, however, significantly higher investment sums are in discussion. As Balser, Bauchmüller, and Meta (2020) report, the European Commission is currently considering subsidies in the area of mobility funding of up to EUR 100 billion, of which up to EUR 60 billion would be used for the development of future powertrain technologies. In addition, a double-digit billion amount is to be invested in the expansion of the charging infrastructure (Balser et al., 2020).

4.3.5. Increased upstream integration potential

Within a rapidly changing value network, new components gain importance. This chapter will discuss how German OEMs can benefit from these changes; threats will be discussed in 4.4.3.

Figure 11 demonstrates how profit pools will change over time according to Andersen et al. (2018). While the industry will be able to increase profits by 2.9% annually up to USD 380 billion in 2035, it becomes also clear that this profit will belong to the players that are able to successfully realize the income streams from emerging profit pools. Figure 11 underlines that. Traditional profits will only slightly increase until 2025 and then start to decline, while in the meantime emerging profit pools gain momentum.

The very right column shows how the profit pools will be composed in 2035. Around half of the emerging pools (USD 75 billion) will belong to companies that successfully improve their autonomous driving, electrification, and connectivity capabilities. This again highlights the major strategic importance of these trends and the compelling need to acquire the relevant skills. However, many OEMs still source the required components or software solutions from suppliers (e.g. Volkswagen AG, 2019). They should therefore reevaluate make-or-buy decisions and consequently build new capabilities or enter partnerships for critical technologies.

While early make-or-buy frameworks focused primarily on the cost or time-saving potential (Williamson, 1981), today's increasingly complex environments require a more holistic approach. To this end, it is worthwhile to start with a discussion of the factors that put companies in a (dis)advantageous competitive position. From this, a modern framework can be derived in a second step. One way to do this is to conduct an internal analysis of a company's capabilities, and to assess its resources, which is referred to as the resource-based view (e.g. Barney, 1991). Barney (1991) states that those firms with valuable, rare, inimitable, and not substitutable resources have a sustained competitive advantage over their competitors. However, Dyer and Singh (1998) note that this approach falls short, as many of a company's critical resources go beyond the company's boundaries and to a significant extent are sourced from suppliers. They argue that the success of a company therefore depends not only on the unique resources of a company but also on the relationships with companies that are integrated into the value chain.

As a consequence, Mudambi and Tallman (2010) recommend that companies should reformulate the problem from a make-or-buy to a make-or-ally decision. According to the authors, entering an alliance would allow companies to retain a certain degree of control over the production process without fully internalizing it. Companies could thus also protect and collect knowledge and benefit from the experience of the alliance partners (Mudambi & Tallman, 2010). Furthermore, this approach counters Dyer and Singh's (1998) criticism by considering the company's closer ties to suppliers (alliance partners).

Powell Mantel, Tatikonda, and Liao (2006) see dependence on suppliers (strategic vulnerability) as one of the most important determinants for make-or-buy decisions. They argue that when strategic vulnerability is high, which is the case when there are few suppliers in the market and costs are high, companies tend to produce in-house and vice versa. Additionally, Powell Mantel et al. (2006) note that companies prefer keeping production in-house when a product or technology is high in core competency. This is the case for products that help companies maintain a competitive advantage in the market (Powell Mantel et al., 2006).

Combining the different frameworks, it can be stated that the make-or-buy (make-or-ally) decisions depend on both the availability of resources (Barney, 1991) as well as their competitive relevance (Powell Mantel et al., 2006). Companies need to identify critical technologies (low availability and high competitive relevance) but also determine whether they are able to compete with suppliers. If they are not, however, which is especially the case with technologies that have already reached a certain level of maturity, they should use partnerships to benefit from the partner's experience and still participate in the value creation (Mudambi & Tallman, 2010). A comparison between autonomous driving and electromobility components illustrates this. As shown in Figure 11, both technologies should be integrated into the value chain due to their competitive relevance. However, implementation should differ, as the technologies are at different stages of maturity and thus the competitive opportunities of German OEMs vary (Bloomberg, 2020a; Eddy, Pfeiffer, & van de Staaij, 2019; Fleetwood, 2017).

Although autonomous driving algorithms and software are making steady progress, unresolved issues slow down their implementation (Fleetwood, 2017; Kalra & Paddock, 2016). As a result, OEMs are still far from offering level 5 vehicles and will not be able to do so on a broad basis within the next years (Bloomberg, 2020b). Consequently, the pressure to deliver a holistic solution is not as immediate. This gives OEMs time to build capabilities and develop the software internally, partner selectively, or acquire promising ventures. Holland-Letz et al. (2019) confirm that incumbent OEMs do most of the development of critical technologies in-house, being responsible for only 10% of the investments but 85% of the relevant patents. More importantly, 58% of all patents in the field of autonomous driving since 2010 have come from Germany, half of them from OEMs (German Department and Trade Mark Office, 2019b). In 2019, three of the four companies with the most patents were German, two of which were OEMs (German Department and Trade Mark Office, 2019a). As shown before Volkswagen has also recognized its shortcomings in the area of software and has therefore founded

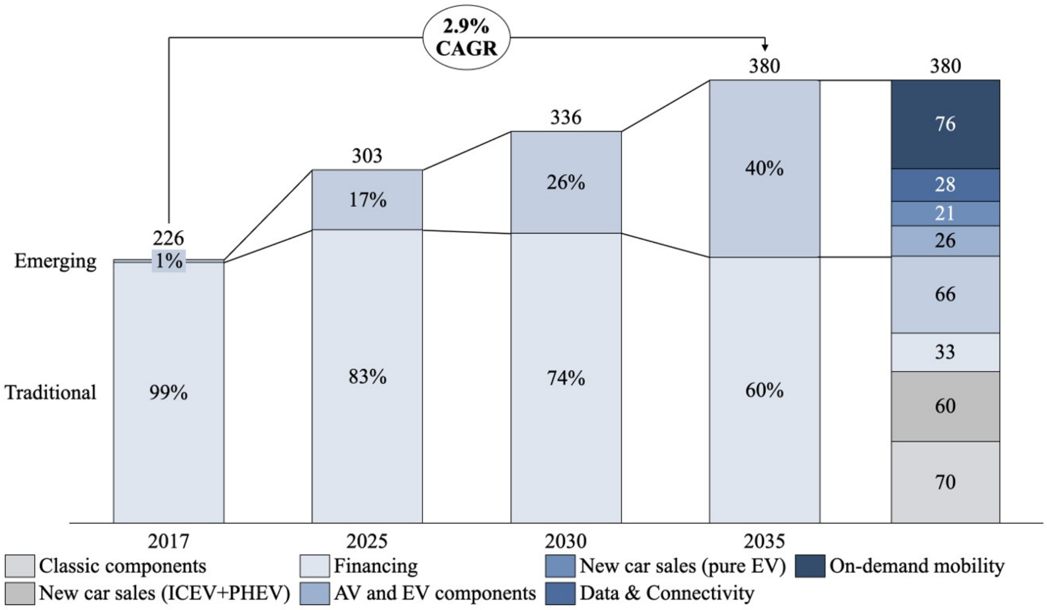

Figure 11: Traditional and emerging automotive profit pools 2017-2035.

Source: Adapted from Andersen et al. (2018)

the subsidiary Car.Software Organization, which will employ up to 5,000 people in the future (Volkswagen AG, 2019a). They aim to increase the company's share of software development from currently 10% to at least 60% (Volkswagen AG, 2019a).

As outlined above, German OEMs have also joined forces in autonomous driving technology development, as the cooperation between Daimler and BMW shows. They are jointly developing level 4 vehicles involving 1,200 employees (Bloomberg, 2020b). Daimler also cooperates with German Tier 1 supplier Robert Bosch GmbH (Bosch) on the development of level 5 vehicles (Bloomberg, 2020b). Another salient example of increased upstream integration is the joint acquisition of HERE, a provider of high-resolution maps, which was acquired by Audi, BMW and Mercedes (Bernhart et al., 2016).

In contrast to providers of comprehensive software solutions for autonomous driving, there is already a huge supplier base for battery cells with decades of experience (Eddy et al., 2019). Moreover, the knowledge required for successful battery cell production does not correspond to the core competencies of incumbent OEMs (Eddy et al., 2019). An example of this is Daimler's failed attempt to establish its own battery cell production under the name Li-Tec (Sorge, 2015). However, German OEMs must find a solution to participate in the profits, because the European battery cell market will have a volume of EUR 90 billion per year in 2040 and thus represents a major opportunity (Eddy et al., 2019).

One promising approach is to collaborate or set up joint ventures with battery cell experts such as Samsung SDI, Contemporary Amperex Technology Co. Limited (CATL), or LG Group. Eddy et al. (2019) emphasize the importance of this cooperation taking place close to the OEMs' locations. They see this as a fundamental building block for the long-term success of these companies. German OEMs have already implemented this: BMW has entered into a strategic partnership with CATL, which will produce battery cells in Erfurt (BMW AG, 2019), and Daimler with Farasis, which will produce in Bitterfeld-Wolfen and create 2,000 jobs (Daimler AG, 2020d). Another example is the joint venture between Volkswagen and Northvolt AB, which will provide 16 Gigawatt hours of capacity from 2024 on (Volkswagen AG, 2019b).

4.3.6. Downstream integration, servitization, and direct-to-consumer sales

Since the 1990s, there has been a clear trend of manufacturing companies moving downstream as they have realized that the service business is more lucrative (Wise & Baumgartner, 1999). The authors see the origin of this concept in the economic development in the second half of the last century: Firstly, due to the strong economic upswing since the 1960s and the increasing wealth of the population, more and more people could afford exclusive products. Secondly, after the growth slowed towards the end of the century, the high number of past purchases as well as the long product lifetimes had resulted in a huge base of products that required additional services (Wise & Baumgartner, 1999). Producing companies were thus able to compensate for lower sales figures with additional services such as maintenance, which increased the share of services in GDP from 16% to 40% (Wise & Baumgartner, 1999).

The trend described above is also known as *servitization* and was first described by Vandermerwe and Rada (1988) as the change of modern companies "offering more comprehensive market packages or bundles of customer-oriented combinations of goods, services, support, self-service, and knowledge" (Vandermerwe & Rada, 1988, p. 314). Servitization, however, not only offers companies an attractive additional source of revenue but also leads to some positive interactions with the product itself (Kastalli & Van Looy, 2013). Kastalli and Van Looy (2013) find that an increase in product sales leads to an increase in service sales, with EUR 1.00 generating an additional EUR 0.86 ($p<0.001$). Even more interestingly and less obviously, the authors confirm this effect vice versa, as they report that an additional EUR 1.00 in services sales leads to an increase in product sales of EUR 1.53 ($p<0.001$). Finally, Kastalli and Van Looy (2013) confirm that customer centricity, which is often only considered as an important component of the services business positively influences product sales ($p<0.05$).

E. Fang, Steenkamp, and Palmatier (2008) note, however, that positive effects from service sales do not monetize from the beginning but require a critical mass before the positive effect pays off. They determine that until service sales reach a share of 20% of total sales, the effect on the firm value is even negative but from that point reaches exponential growth. The dependance of the firm value on service ratio can thus be described as a U-curve (E. Fang et al., 2008). These findings suggest that companies should not only reap the low-hanging fruits but should see the service business as a major profit opportunity and invest heavily to scale it. German OEMs are in a good position to do so, given their strong financial background and their strong presence in the largest automotive/mobility markets. This, however, requires them to internalize these services. We will discuss some alternatives in the following.

A major opportunity for German OEMs lies in the Car-as-a-Service (CaaS) market, although it is currently mainly served by fleet management companies such as Sixt SE (Brenner et al., 2018). The CaaS model aims at a more flexible, subscription-based mobility solution with a full-service concept and therefore serves as a good example of servitization within the automotive sector. In order to enter the market, German OEMs could leverage their existing capabilities from their financial services subsidiaries and adapt them to more advanced customer requirements (Brenner et al., 2018). This could include extended warranty services, insurance, home delivery, and many more. In addition to the fact that German OEMs would be tapping into a previously unexploited market, this market is also developing attractively. Brenner et al. (2018) expect the CaaS market in Europe to grow at an annual rate of 5% to EUR 86 billion by 2025, when it will comprise 15 million units. Brenner et al. (2018) also do not see alternative mobility models such as carsharing or ride-hailing as a threat to the CaaS market. Instead, the authors assume that a changing perception of car ownership will further boost the CaaS model.

As shown in Figure 11, by 2035 on-demand mobility will be the biggest profit pool in the automotive/mobility sector (USD 76 billion). German OEMs positioned themselves in the car sharing sector early on and made their ambitions clear after the merger of BMW and Daimler under the brand Share Now, Europe's leading platform (Share Now, 2021). Volkswagen is also active in the ride pooling market under the brand Moia and plans to scale up significantly (Germis, 2019). In addition, it will be crucial for German OEMs to participate in the massive potential of the ride-hailing market through equal cooperation, as is currently being demonstrated by Volkswagen and Uber (Uber Technologies Inc., 2020).

Another important downstream profit pool is the European used car market, which has an annual turnover of EUR 600 billion (Busvine, 2021). A prominent example that illustrates the attractiveness of this market is the successful initial public offering of the German used car dealer Auto1.com GmbH (Auto1), which reached a valuation of around EUR 12 billion (Busvine, 2021). The company operates both an online B2B marketplace (AUTO1.com) and an online direct-to-consumer platform (Autohero) (Busvine, 2021). The latter achieved significant growth (+75%) in the last quarter of 2020 and exhibits high margins, which is why Auto1 will use the new capital to further develop the brand (Busvine, 2021). However, the number of sales is still small, especially compared to the new car sales of German OEMs. Consequently, German OEMs could tap into an enormous new profit pool if they managed to remarket a portion of their sold vehicles after their first life cycle.

The case of Auto1 and Autohero, in particular, demonstrates the power of the direct-to-consumer online distribution channel which is used by an increasing number of companies to boost their sales and increase their margins (Cao & Li, 2015; Duch-Brown, Grzybowski, & Romahn, 2017; Gao & Su, 2017). German OEMs could also take advantage of this and embark on a multi-channel sales strategy. By doing so, they would counteract one of their biggest weaknesses (missing customer relationship) and could create an end-to-end customer journey with multiple touchpoints. Online retail, however, offers several further advantages: Duch-Brown et al. (2017) state that direct online sales not only take significant shares from traditional channels but also significantly increase the overall turnover. Additionally, the authors argue that firms can transfer relevant product information to potential customers more efficiently and increase product differentiation using a superior website interface.

German OEMs could also use the buy online pick up in stores model proposed by Gao and Su (2017) and thus reach a new customer segment seeking information and convenience. This approach could also be a good fit for them, as delivering cars is costly and time-consuming for dealers, while picking them up is an experience for many buyers. An additional argument in favor of building an online retail channel is that Zhuang, Popkowski Leszcyc, and Lin (2018) report that, contrary to popular belief, the price dispersion of online products is higher, allowing for better price discrimination. The authors argue that this is particularly the case in e-marketplaces where customers have a high level of trust in the supplier, which can be assumed in this case, given the brand strength of German OEMs. Furthermore, Zhuang et al.

(2018) make clear that even without direct online sales, the online presence of manufacturers is crucial for obtaining information, which is also in line with the results of Lellouche et al. (2020), who report that 75% to 85% of customers base their purchase decision on internet research.

4.4. Threats

4.4.1. Regulations and missing intellectual property rights in China

As discussed in Chapter 4.1.2 German OEMs rely heavily on the Chinese market due to its strong growth and high margins. In strong contrast to these promising factors, however, the Chinese market also harbors many risks and dangers, especially due to the influence of the communist party and the associated low degree of freedom. China ranks only 103rd in the Economic Freedom Score, performing particularly poorly in the areas of intellectual property rights, government integrity, and investment/financial freedom (The Heritage Foundation, 2020). The first two pose a particular threat to German OEMs, as will be discussed in the following.

For foreign companies, such as German OEMs, weak intellectual property rights have two negative consequences: Firstly, foreign firms are often forced to establish partnerships or joint ventures with domestic players, which the latter use to absorb knowledge (Collinson & Liu, 2019). Weak intellectual property rights increase the difficulty for foreign firms to obtain the core of innovation in such partnerships. Therefore, according to Zhao and Anand (2009), they do not want to share critical information with their Chinese partners. This makes a trustworthy and successful collaboration almost impossible. Secondly, there is evidence that China's handling of intellectual property rights harms innovation (Brander, Cui, & Vertinski, 2017). As the main reason, the authors bring into play that weak intellectual property rights destroy the creation of incentives. They argue that innovation stalls if innovators are not rewarded for their achievements. L. Fang, Lerner, and Wu (2017) confirm this hypothesis. The results of their study show that companies in cities with higher intellectual property rights protection are more innovative.

On top of that, the Chinese government is often accused to favor local players, especially those in high-tech industries (Denyer, 2014; Sutherland, 2003). An example therefore is the rise of Nio which was financed with USD 1 billion by a municipal government in China (Bloomberg, 2020a). After this financing round Nio's stock price exploded (Bloomberg, 2020a). Now that the government owns shares, its interest in Nio's success has increased further, making the company a serious competitor to the established players (of which also Tesla is one). In the case of German OEMs, the strong influence of the government can be very dangerous because it not only supports local players but also makes lives difficult for foreign competitors, as the current example of Tesla shows. Tesla was accused of using spy software for military purposes (Zhai & Kubota, 2021). As a consequence, the government banned its vehicles for military or other state-owned companies (Zhai & Kubota, 2021).

4.4.2. Environmental regulations in Europe and Germany

To meet the European Union's CO_2 targets, German OEMs have adjusted their fleet mix and plan to increase the share of EVs significantly by up to 70% of total sales (Seiwert, 2019, 2021). For a long time, the European Green Deal regulation foresaw a CO_2 reduction of 40% until 2030 compared to 1990 (Götze, 2020). However, since a new legislative decision in December 2020, this target has increased to 55% (Götze, 2020). In addition, the author notes that there will be fewer penalty exceptions that OEMs currently benefit from. These additional requirements could hit German OEMs hard, as Volkswagen, for example, is responsible for 2% of worldwide CO_2 emissions (Seiwert, 2019). Experts such as the CEO of Bosch Volkmar Denner warn of the consequences of the new regulations, as he believes they will spell the end of ICEVs and the mass loss of jobs that will come with them (Seiwert, 2019).

Volkswagen, unlike BMW and Daimler, did not achieve the required fleet consumption in 2020 (Reuters, 2021). However, they benefited from the currently rather soft regulations and therefore had to pay a fine of just over EUR 100 million for exceeding the average fleet consumption by 0.5 grams per 100 kilometers (Reuters, 2021). Experts, however, assume that the fine could have been in the billions if the law was interpreted more strictly (Reuters, 2021). This illustrates the high penalties German OEMs could face in the next few years and underlines the disruptive power of regulations in the automotive sector. German OEMs are in a disadvantageous position compared to companies like Tesla or Nio, which have a pure EV portfolio or Volvo Car Corporation (Volvo) with significantly better fleet consumption (Freitag, 2020). These companies can sell their CO_2 credits to companies with worse fleet emissions and thereby achieve billions of euros in revenues as the example of Tesla and Fiat Chrysler demonstrates (Freitag, 2020).

Other regulations take place at the national level. One example is the current debate on the introduction of a speed limit on German motorways. Survey results show that the proportion of German citizens in favor of a speed limit has risen significantly since 2014 and in 2020 has overtaken the proportion of those against for the first time since 1993 (ADAC, 2020). Malorny (2020) sees a possible speed limit as a major threat for German OEMs. He argues that there is a strong correlation between a car's ability to reach speeds of 250 kilometers per hour and its perceived quality. In his opinion, consumers worldwide are convinced that German OEMs offer the highest quality cars due to the combination of an unrestricted speed limit and the fewest accidents per kilometer. He is concerned that a speed limit would damage the perceived premium quality of German OEMs and reduce their pricing power.

4.4.3. Shrinking traditional profit pools

The share of German OEMs' classic profit pools – vehicle sales and the aftermarket business –within the automotive/mobility market will shrink (Andersen et al., 2018). In this chapter, we look at the data shown in Figure 11 from

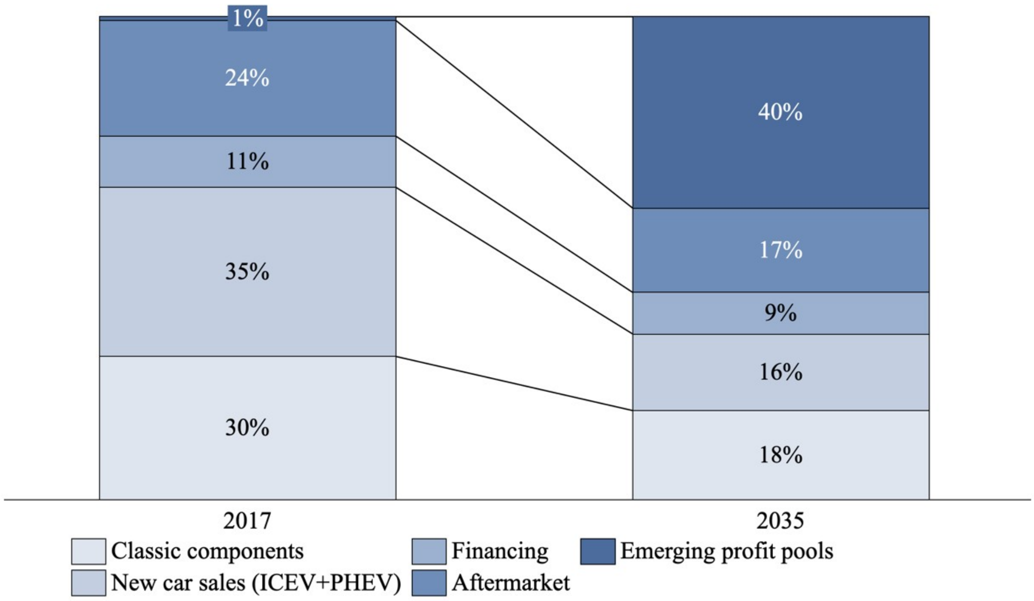

Figure 12: Automotive profit pools in 2017 and 2035.

Source: Adapted from Andersen et al. (2018)

a different perspective. Assuming that German OEMs will find it difficult to successfully exploit the new trends, their future appears uncertain, and they run the risk of losing importance and becoming low-margin hardware players. Figure 12 shows that by 2035, about 40% of traditional profit pools will be displaced by emerging ones. This hits sales of new cars with conventional combustion engines particularly hard and reduces their profit share by more than half to just 16%. The aftermarket and component business, which are also profitable for carmakers and dealers, will be similarly affected.

As discussed earlier, higher costs for the EV powertrain will change the economics in production. Weber et al. (2019) argue that premium OEMs should not compensate for this effect by lowering the cost of other components but instead raise prices. However, this risks shrinking sales in the competitive EV market (Weber et al., 2019). Furthermore, the authors discuss two scenarios based on an increase in the EV share. In their baseline scenario, they argue that the profit margins of incumbent OEMs will fall below 2% by 2030 due to increased costs and limited price increase opportunities as EV sales gain momentum after 2024/25. However, if OEMs manage to further reduce costs and increase customer perceived value and willingness to pay, they could break even at pre-COVID margins in 2025 (Weber et al., 2019).

Governmental decisions, especially those in Europe in China (Chapter 4.4.1 and 4.4.2) will further accelerate the decline in ICEV sales. In addition, the market growth caused by increasing urbanization (discussed in Chapter 4.3.1), is slowed down by shared mobility business models. Grosse-Ophoff et al. (2017) expect this effect to amount to 13 million fewer units sold per year and to be composed of two opposing forces: Due to sharing solutions, around 23 million fewer vehicles will be needed, however, since shared cars are used more frequently and thus wear and tear increases, 10 million more vehicles will be needed (Grosse-Ophoff et al., 2017).

In addition, ACES trends will seriously affect the aftermarket in several categories (Kempf et al., 2018). The authors expect that around 40% of profits (EUR 100 billion) will be redistributed as a result of disruptive trends. One reason for this is the technological progress in new vehicles. While an ICEV powertrain may have over 1,000 components, that of an EV contains only a few hundred (Küpper, Kuhlmann, Tominga, Arora, & Schlageter, 2020). This significantly reduces the susceptibility to faults and possible repair shop visits with the need for spare parts. In addition, networked components will be able to detect failures more quickly so that they can be replaced earlier and with less damage (Küpper et al., 2020). With the advent of automated driving technology, vehicles will be involved in significantly fewer accidents, which in turn will reduce the need for new components (Fagnant & Kockelman, 2015). In addition, further development of ACES trends will increase product complexity, which will require additional workforce qualification.

Another trend is the changing customer relationship. Kempf et al. (2018) predict that those who are able to best analyze the Big Data generated by their customers will succeed. Jäck and Sizov (2020) support this hypothesis. They conclude that future successful players in the automotive aftermarket business will use advanced analytics to better predict market baskets or calculate the probability of certain events. Another point Kempf et al. (2018) mention is that the increasing digitization of distribution channels reduces information asymmetry, making it even more difficult for market players to generate profits through traditional business.

Taking the discussed trends together, it is apparent that reduced ICEV sales volumes and falling profit margins are making it difficult for German OEMs to retain their leading position and thus to finance further significant R&D spending. Moreover, it seems rather unlikely that German OEMs have the necessary capabilities to establish their successful position in the aftermarket business. It seems more probable that newcomers who use Big Data effectively and those who take a better, customer-centric approach will shape the market. Even if German OEMs can survive in the aftermarket, its margins will most likely be lower and the positive smoothening effect will diminish.

4.4.4. The competitive landscape of German OEMs

German OEMs face increasing competition from different areas. The use of Bergen and Peteraf's (2002) framework allows for broader coverage of competition as besides direct competitors it also takes into account potential and indirect competitors (substitutors). This step is essential as Eisenhardt and Bourgeois (1989) warn that managers in high-speed environments like the automotive industry are tempted to focus too much on direct competition and risk overlooking competition from emerging sectors. They argue that competitor research in different sectors is significantly more complex, time consuming, and expensive and that managers dispose of a limited number of resources (time and budget), resulting in flawed allocations. An example of this is the struggle between incumbent OEMs who focused on beating the direct competition by developing better ICEVs but failed to recognize the entry of companies specializing in EVs, software, or advanced mobility solutions.

Figure 13 depicts the current situation of the automotive market from the perspective of a German OEMs, using Bergen and Peteraf's (2002) framework. The framework is based on the generally accepted simultaneous consideration of supply and demand side (e.g. Day, 1981). In order to build the framework, Bergen and Peteraf (2002) borrow from Chen (1996) using the dimensions market commodity (demand) and resource similarity (supply). According to Bergen and Peteraf (2002), market commodity is "the degree to which a given competitor overlaps with the focal firm in terms of customer needs served" (Bergen & Peteraf, 2002, p. 160) and resource similarity "the extent to which a given competitor possesses strategic endowments comparable, in terms of type, to those of the focal firm" (Bergen & Peteraf, 2002, p. 161). As the automotive market evolves at an ever-fast speed and clusters in the automotive market seem to be larger and more overlapping than in the traditional framework, arrows symbol the cluster's movements and extensions.

The application of this framework enables several observations. Firstly, it becomes apparent that established and large firms such as Toyota Motor Corporation (Toyota) or General Motors Corporation (General Motors), which can benefit massively from economies of scale due to their enormous sizes, represent direct competition for German OEMs. Their large sizes can be particularly beneficial in the group-wide standardization of operating systems, battery cell development, or the development of algorithms for autonomous driving, as the R&D costs can be allocated to a higher number of units. Secondly, the group of potential competitors and the group of direct competitors are converging, as the established OEMs have understood that they need to address other customer needs such as zero-emission travelling to remain competitive. Thus, they are addressing customer needs that previously only newcomers like Tesla could solve, which increases overlaps in market commodity. As a result, German OEMs will find themselves in a significantly larger direct competitor pool in the future. A similar, albeit less pronounced, convergence can be observed in the cluster of indirect competitors since OEMs are increasingly entering the service market (see Chapter 4.3.6). Additionally, growing interactions between mobility service providers and OEMs can be expected (see Chapter 4.4.5).

4.4.5. Indirect competitors (substitutors) and their business models

For decades there were hardly any penetrations into the automotive market due to high entry barriers and German OEMs have successfully defended their position within. According to Peteraf and Bergen (2003), indirect competitors or substitutors often pose the greatest threat as they are not recognized as such. Indirect competitors are those that serve similar customer needs but use different resources. In the case of an OEM, they can come from two different regions. First are mobility service providers such as Uber or Didi. Second are software companies such as Google or Nvidia Corporation (Nvidia). Both will be discussed in more detail.

Compared to OEMs mobility providers possess few assets, sell services instead of goods and often and employ their staff (drivers) on a self-employed basis. As discussed previously they however serve similar customer's needs – the need to get from A to B safely, fast, and cost efficiently. It can be argued that today the majority of people prefer owning cars but as the understanding of mobility and ownership further change, the boundaries continue to blur (Weber et al., 2019). The results of Weber et al. (2019) underline that. The authors report that around 74% of surveyed consumers opt for the most convenient mobility solution. Additionally, they note that over 40% of consumers in urban areas would give up their cars and that over 50% would pay up to USD 250 for unlimited free ride services. This seems reasonable as Andersen et al. (2018) report that by 2030 for 30% of Europe's population it will be less expensive to use shared mobility services compared to possessing a car. Bernhart et al. (2016) expect that mobility service providers will be at the "fat end" of the value chain, as they will make use of the direct customer interaction and maximize revenues and profits. On the other side, OEMs will lose influence and are threatened to be downgraded to pure device manufacturers that need to obey the specifications and requirements of mobility service providers.

Bernhart et al. (2016) portray three possible scenarios

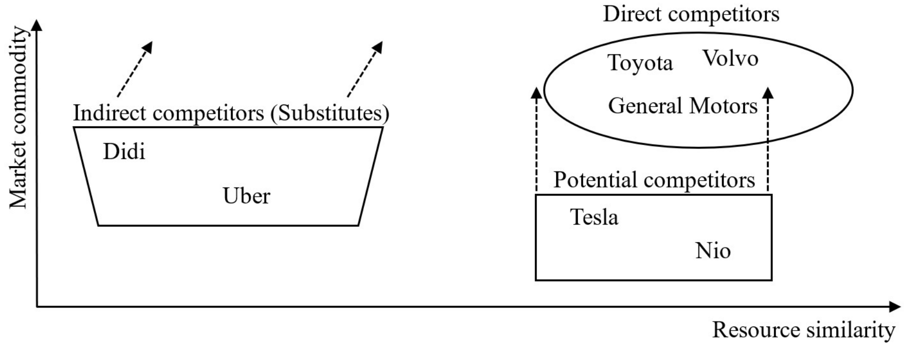

Figure 13: Competitive landscape of German OEMs.

Source: Adapted from Bergen and Peteraf (2002, p. 160)

for OEMs. There is only one, however, in which German OEMs can continue to profitably exploit their status position, based on the interplay of quality and brand. Alternatively, they could end up as contract manufacturers and would have to comply with the specifications of the mobility service providers (Bernhart et al., 2016). Even worse for them would be the third scenario, in which they would be white-label manufacturers and leave the complete branding to the mobility service providers (Bernhart et al., 2016). This is a crucial threat especially for German OEMs, as the brand is one of their most valuable assets (see Chapter 4.1.3).

As discussed in Chapter 4.3.6 German OEMs can also choose to enter the mobility services market. While this opens a new promising profit pool, Bernhart et al. (2016) note that OEMs face significantly higher internal costs. If they fail to adapt these and consequently will not reach the required profitability margins, they are in danger to lose the market to competitors.

In addition, the massive emergence of new competition from software specialists like Google, Nvidia, or in a broader sense Apple must be considered. Although they currently do not offer holistic mobility solutions, this could change quickly. According to recent rumors, Apple is looking for a hardware partner for its automotive business (Hohensee et al., 2021). Apple has also poached senior managers and engineers from Tesla and Ford for its car project called "Titan" (Hohensee et al., 2021). Furthermore, according to the authors, Apple's iPhone manufacturer Foxconn Technology Group has started to build a car factory in China. Another point that can be seen as evidence of the increasing influence of software companies in the automotive sector is the valuation of new competitors such as Tesla. According to Klebnikov (2020), Tesla is not priced as an automotive but rather as a fast-scaling software company. Entering the automotive market could pay off for Apple, as it could significantly expand its ecosystem and gather new customers and data. Experts believe that a third of Apple's worldwide customers would be interested in an Apple car (Hohensee et al., 2021). Given 1.5 billion Apple devices currently in use their market share would be enormous.

Besides the opportunity of providing holistic vehicle solutions, software specialists also focus on operating systems as the examples of Google and Nvidia demonstrate. Nvidia's CEO Jen-Hsun Huang expects that in the future OEMs will not earn money from vehicle sales but mainly from functionalities and services provided by software (Hohensee et al., 2021). Google Waymo's boss takes a similar position. Disguised as a "partnership", he wants to convince carmakers to produce cars while Waymo provides the "driver" (Hohensee et al., 2021). In return, this would mean the degradation of car manufacturers to pure hardware providers if they fail to produce the operating systems internally. Although this scenario sounds alarming, carmakers such as Volvo and Ford have decided to rely on Google's solution "Android Auto" in the future (Hohensee et al., 2021).

German OEMs, on the other hand, are focusing on independent development (Hohensee et al., 2021). However, this is associated with enormous costs and their comparatively low valuations make it difficult to raise additional money. In addition, the authors argue, it is more difficult for Daimler and BMW to allocate development costs due to their small sizes.

4.4.6. Direct/potential competitors and their technological advances

According to Bergen and Peteraf (2002) and Chen (1996), the greatest competitive threat comes from potential competitors, those that have high resource similarity and low market similarity. In the case of German OEMs, these are companies such as Tesla or Nio. Tesla has been relying on ACES technologies for some time and was therefore particularly attractive to tech-savvy and affluent consumers. However, established players have also recognized the importance of ACES trends, so that the clusters are consequently moving towards each other. In addition to new potential competitors, this section also analyses the established players, as the enormously fast development of the industry and the new applications of ACES technologies sometimes blur the boundaries between the two. Consequently, today's incumbent players have the potential to become tomorrow's innovators. This section is divided into three parts: First, we assess several OEMs in terms of their future capabilities to exploit the four ACES trends. To do so we introduce the ACES Index, which we define as the arithmetic mean of the scores that the considered OEMs achieve in the four dimensions *autonomous driving, connectivity, electrification,* and *shared mobility.* The score of each dimension results from several subcategories. Second, a prediction of future leadership is derived based on the three dimensions *size, ACES Index*, and *market capitalization*. Finally, we analyze whether the ACES Index is a good predictor for future success. Table 1 shows the results of the analysis of ACES capabilities for a selected group of OEMs. In addition to the German ones, Asia's and world's largest OEM Toyota, one of America's largest OEMs General Motors, and one of Europe's innovative players Volvo as well as the two newcomers Tesla and Nio are considered.

In each sub-category, a company can achieve scores from zero (0) to five (5), with 5 being the best score.[11] The scoring is based on an ordinal scale.[12]

The *autonomous driving* dimension consists of three subcategories (strategy/ambition, patents, and field testing). The results show that German OEMs are well positioned in the area of research due to partnerships or, as in the case of Volkswagen, hold strong stakes in autonomous driving technology companies. Daimler engages in research projects with Tier-1 supplier Bosch where they test vehicles with level 4 and 5 capabilities (Bloomberg, 2020b). BMW even plans the roll-out of the iNext in 2021, which will offer level 3 technology (Bloomberg, 2020b). German OEMs also hold several autonomous driving technology patents. Volkswagen leads this category with 1,101 patents, which is almost double that of second-placed General Motors and BMW ranks third (Bardt, 2019). However, compared to their competitors, with the exception of BMW, German OEMs conduct few field tests, which puts them in a position at the end of the line (Bloomberg, 2020b). Daimler for example only operates a test fleet consisting of twelve vehicles, Volkswagen collaborates with Argo AI LLC, using around 100 vehicles (Bloomberg, 2020b). Another problem for German OEMs could be their lack of sense of urgency. While Tesla is channeling almost all of its expenditures into the development of autonomous driving technology (Bloomberg, 2020b), BMW and Daimler have announced the end of their collaboration due to necessary cost savings (Daimler AG, 2020c). In this category, it is also noticeable that, in addition to the newcomers Tesla and Nio, the American OEM General Motors scores positively. Its good performance is largely based on the purchase of the American self-driving car company Cruise LLC in 2016 (Bloomberg, 2020b).

The *connectivity* dimension consists of three subcategories (connectivity/app services, infotainment, and user experience). As stated before a competitive position in this area is crucial, since many industry experts assume that future profits will mainly come from additional software services and functionalities (Hohensee et al., 2021). BMW and Daimler achieve very good results in this area (first and third place respectively) and can compete with Tesla and Nio. This is mainly due to their excellent app services (Mercedes me and BMW Connected), as well as due to large and high-resolution screens (Bender, Peuckert, & Waasen, 2020). Volkswagen, on the other hand, only takes sixth place. This is mainly due to less comprehensive app services and, in some cases, not fully intuitive usability (Bender et al., 2020). It needs to be noted here, however, that premium brands (BMW, Daimler, or Tesla) charge high fees for their services, which makes comparability difficult (Bender et al., 2020). As a result, Toyota's and General Motor's performances are at the bottom of the field. They offer only rudimentary app services and, in the case of Toyota, mediocre screen quality (Bender et al., 2020).

The *electrification* dimension consists of five subcategories (choice/availability, Center of Automotive Management (CAM) innovation power index, range, price per kWh, and charging speed). German OEMs perform in the midfield, leaving Toyota and General Motors far behind, as the latter currently do not offer pure EVs in significant numbers. Volkswagen even manages to win the subcategory "price per kWh" with their newly introduced ID.4. On top of that Volkswagen has a considerably high CAM innovation power index, which is almost as high as Tesla's and three times higher than that of third-placed General Motor's (Center of Automotive Management, 2021). In total, however, the backlog of German OEMs to Tesla and Nio is large. Apart from the Volkswagen example mentioned, the German OEMs must admit defeat to Tesla and Nio in every category. According to Eddy et al. (2019), the supply chain risk is another major threat for European players, as they currently possess little knowledge. With increasing demand, those that have integrated major parts of the value chain would further benefit.

Within the *shared mobilit*y dimension, the only subcategory "sharing services" assesses current and planned platforms for carsharing, ride sharing, and full-service leasing services. This is the only category where all German OEMs achieve good results, especially compared to new competitors who have announced sharing services but do not provide holistic solutions yet. All German OEMs have their own free-floating services and offer a solution for private carsharing ("Mercedes me") or ride-hailing services (Volkswagen Moia) (Daimler AG, 2021b; Germis, 2019). Whether internalized sharing services will give German OEMs a competitive advantage in the future however still remains unsure, as they still report negative figures (J. Becker, 2019). Similar is true for General Motor's service platform "Maven" which was shut down in 2020.

This section concludes with two analyses that shall test the influence of a company's ACES Index on its future success in a rapidly evolving market. In a first step, the examined companies are therefore clustered into one out four categories based on their ACES Indices as well as their current

[11] See Appendix 7-15 for the results and sources from subcategories.

[12] A score of 5 can only be accomplished when a company dominates all aspects from a category.

Table 1: ACES Indices for German OEMs and competitors.

	Autonomous driving	Connectivity	Electrification	Shared mobility	ACES Index	Rank
Daimler	2.0	3.8	2.4	3.5	2.9	6
BMW	3.2	4.0	2.4	3.0	3.2	5
Volkswagen	3.3	2.7	3.8	3.5	3.3	3
Tesla	4.5	4.0	4.6	1.5	3.7	1
Toyota	2.8	1.8	1.5	3.0	2.2	8
General Motors	3.7	2.3	2.2	2.0	2.5	7
Volvo	2.8	3.0	3.2	3.5	3.2	4
Nio	4.0	3.8	4.3	2.0	3.5	2

Source: Own analysis, see Appendix 7-15 for detailed results from subcategories and sources

market sizes (units sold in 2020).[13] For better comparability, we apply the logarithmic function of sales volumes, as sales numbers differ greatly (Nio. 43,000 units vs. Toyota 9.53 million units), following Fama and French (1992). The resulting four dimensions are *industry stars* (large size, high ACES Index), *aggressive innovators* (small size, high ACES Index) *incumbent players* (large size, low ACES Index) *and hardware niche players* (small size, low ACES Index). The emerging framework is reminiscent of the Boston Consulting Group's Matrix, which includes the dimensions of market growth and market share (Hambrick, MacMillan, & Day, 1982). Moreover, both frameworks include the market capitalization of the examined companies. Figure 14 depicts the resulting quadrants and the position that the examined companies take within. The areas of the circles represent the companies' market capitalizations.

As expected, the newcomers Tesla and Nio are placed within the "aggressive innovators" and the German OEMs as well as their large direct competitors within the "incumbent players" quadrant. Volvo is at the edge of being an "aggressive innovator" and a "hardware niche player". Probably the most noticeable result is that there is currently no company in the target quadrant "industry stars". Either they do not have the necessary size, or they do not have the necessary technological capabilities. The arising question is, which company will succeed in penetrating this quadrant. This could be answered by looking at the area of the bubbles, as these provide information about investors' expectations of future turnover/sales figures. The size of Tesla's bubble (market capitalization) is particularly noticeable, which leads to the assumption that Tesla will be able to significantly increase its sales figures and thus move along the horizontal axis towards the "industry star" quadrant. The same could be true for Nio, as its bubble is almost the same size as that of the established players, although it is much smaller in terms of sales volume. Investors expect significant growth here as well, so Nio could follow Tesla's movement and become an "industry star".

[13]Please find detailed information on sales volumes, market capitalizations, and sources in Appendix 16.

Given the results from Chapter 4.4.3, which showed that the automotive market growth is slowed down by the emergence of several trends, that would mean, by implication, that Tesla and Nio would be massively stealing market shares from incumbent companies. Consequently, incumbent OEMs could be pushed in the direction of "hardware niche players" if they fail to regain their technological leadership position. In the "hardware niche players" quadrant competition is particularly fierce. This is reflected in the current wave of consolidation that is affecting some of these competitors as the example of the Stellantis Group, which merged the Fiat Chrysler Group and the French PSA Group, shows (Piovaccari, 2021).

The purpose of the third analysis is to determine how well the ACES Index is suited to predict the future success of a company. A common indicator for the latter is the market capitalization, as it indicates expected future cash flows. Again, as company sizes differ significantly, we compensate for that by dividing the market capitalizations by the number of vehicle sales and thus obtain the valuation per vehicle. This is a similar metric to what Fisher (1984) introduced as the price-to-sales ratio. Without that adjustment, newcomers with low volumes would be underrated and incumbent players with high volumes overrated.

Table 2 depicts the results from a series of OLS regressions (n=8). First, it can be seen that the ACES Index serves as a good predictor of the market capitalization per vehicle (t-statistic = 2.341) and is able to explain around 48% of the model's variance. The high beta value of 950,328,98 again underlines the potential leverage of the ACES Index: If a company is able to increase its ACES Index by 0.1 points it could increase the valuation per vehicle by USD 95,328, according to the analysis. Second, controlling for all independent variables separately shows that only the variables *autonomous driving* and *electrification* have a significant positive impact on the market capitalization (t-statistic = 2.851 and 3.068 respectively). They are also able to explain a higher part of the variance compared to the ACES Index (R^2= 0.575 and 0.611 respectively). On top of that even their lower 95% confidence interval is significantly positive (88,574.12 and

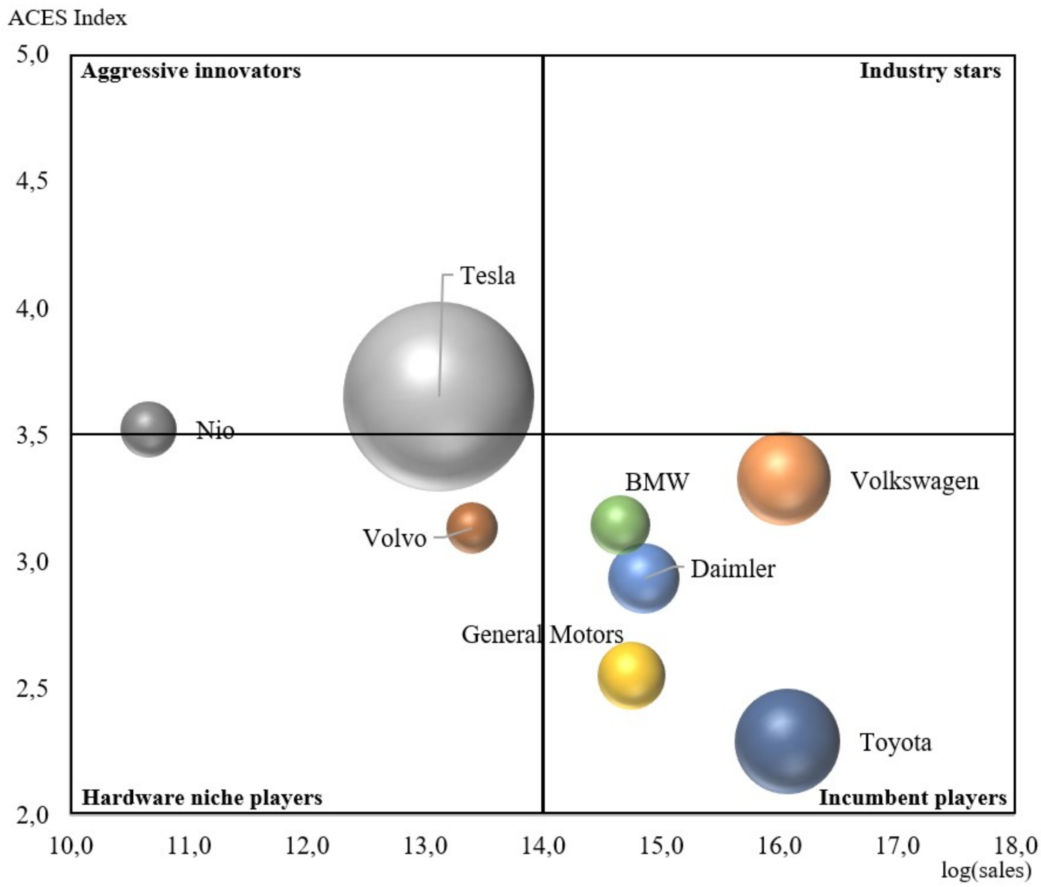

Figure 14: OEM clusters based on the ACES Index and size.

Source: Own analysis

Table 2: OLS regression analysis on ACES trends and market capitalization per vehicle.

Predictor	*Beta*	*t-statistic*	*p-value*	*Lower 95%*	*Upper 95%*	R^2
ACES Index	950,328.98	2.341	0.058	-42,787.78	1,943,445.75	0.477
Autonomous driving	624,616.68	2.851	0.029	88,574.12	1,160,659.25	0.575
Connectivity	402,792.90	1.549	0.172	-233,502.62	1,039,088.43	0.286
Electrification	455,548.88	3.068	0.022	92,189.45	818,908.30	0.611
Shared mobility	-609,492.44	-2.913	0.027	-1,121,458.54	-97,526.34	0.586

Source: Own analysis

Table 3: Correlation analysis of different trend indices.

	Autonomous driving	Connectivity	Electrification	Shared mobility
Autonomous driving	1.00			
Connectivity	0.19	1.00		
Electrification	0.67	0.54	1.00	
Shared mobility	-0.86	-0.22	-0.42	1.00

Source: Own analysis

92,189.45 respectively), which again illustrates that it is most likely that a high index positively influences the market capitalization per vehicle. Besides that, the two variables are highly correlated (r = 0.67) meaning that companies which perform well in one of the categories do so in the other as well (see Table 3).

The independent variable *connectivity* does not have a significant influence on the market capitalization per vehicle (*t*-statistic = 1.549). Its correlation to *autonomous driving* (r = 0.19) and *electrification* (r = 0.54) is again positive, however weaker than that of *autonomous driving* and *electrification.* Even more surprisingly *shared mobility* has a significant negative impact on the market capitalization per vehicle (*t*-statistic = -2.913). This effect is driven by the poor performance of the newcomer companies Tesla and Nio (those with the highest market capitalization per vehicle) and could also be a sign that investors do not value the offer of shared mobility services provided by OEMs. Controlling for correlation with the other variables confirms that hypothesis, as they show a strong negative correlation with *shared mobility* (see Table 3).

5. Conclusion

As initially targeted the present work contributes to providing a literature overview on the four trends that currently shape the automotive industry: Autonomous driving, connectivity, electrification, and shared mobility. While these trends often exist separately from each other today (carsharing models using ICEVs or privately used EVs), their interaction has the potential to introduce a new age of mobility – a carsharing concept with autonomous vehicles using electric engines and offering seamless connectivity features to their passengers. These vehicles not only generate attractive new profit pools for OEMs but also have the potential to increase social welfare by avoiding accidents, reducing emissions, and providing access to mobility for a wider population. On the other hand, there are still unresolved problems, such as the sustainable coverage of the electricity demand of EVs, the accountability of AVs, or the fair employment of staff in ride-hailing companies. Policymakers need to find answers to these questions in order to exploit the full potential that these vehicles could offer.

The discussion of the implications for German OEMs followed the structure of a SWOT analysis to answer the seven questions formulated in the introduction. To answer the first question, which related to the unique assets of German OEMs, we took a closer look at the companies' annual reports. We found evidence for profitable operations, significant retained earnings, and a strong presence in the largest automotive markets Europe, United States, and China. This allows them to invest heavily in new technologies, offset cyclical market downturns and benefit from local talent, which we were able to confirm through an analysis of R&D expenses and operating margins. In addition, German OEMs profit from their strong supplier relationships and powerful brands, which both have a positive impact on several KPIs. Secondly, we investigated how the corporate structures of German OEMs influence the implementation of disruptive trends. We therefore discussed three explanatory approaches from academia and finally compared the value networks of German OEMs to those of potential future mobility providers. We noticed that these networks differ significantly, as do the attributes that influence the perceived attractiveness of the components and technologies involved. As a consequence, incumbent companies have difficulties to classify the added values of disruptive technologies as they evaluate them with attributes that were exclusively applicable to predecessor technologies (Christensen, 2013). Therefore, incumbent players often fail to adopt disruptive technologies at an early stage, which has long been evident in the lack of EV development as well as outsourcing of software solutions. To answer the third question about attractive future business opportunities, we analyzed both emerging markets and untapped profit pools along the value chain. We found that an attractive opportunity for German OEMs lies in the market for purpose-built vehicles, which is still at an early stage of development and can thus be shaped in their favor. They could benefit from their R&D and design expertise, production locations in low-wage countries, and partnerships with ridesharing companies. In addition, downstream opportunities arise, including the CaaS market, the used car market as well as direct-to-consumer sales channels. We also noticed that new components are gaining importance due to the emergence of the four ACES trends, requiring German OEMs to carefully consider which ones to integrate into the value chain. To support decision-making, we propose a framework that encompasses the dimensions of resource availability, competitive relevance, and maturity of a technology. In short, the answer to the fourth question regarding make-or-buy decisions for disruptive technologies is, that those technologies with low availability and high competitive relevance should be integrated into the value chain. To answer the fifth and sixth questions, which relate to both competitor analysis and the implementation of ACES trends, a two-step approach was required. First, we distinguished between direct competitors (e.g. General Motors), indirect competitors (e.g. Uber), and potential competitors (e.g. Tesla). As the latter pose the greatest threat to German OEMs (Bergen & Peteraf, 2002; Chen, 1996) we conducted an analysis of the ACES capabilities of some major automotive players (including the three German OEMs). Therefore, we introduced a new metric, the ACES Index, which measures the capabilities of companies in the different trends. German OEMs achieved midfield positions in this ranking with Volkswagen in third (behind Tesla and Nio), BMW in fifth, and Daimler in sixth place. We then clustered the investigated companies into four segments according to their market sizes and ACES Indices. All German OEMs were identified as "incumbent players" and Tesla and Nio as "aggressive innovators". None of the companies was identified as "industry star" as this would require a high ACES Index in addition to a large size. The final analysis addressed the question of whether investors value a strong implementation of the

ACES trends (a high ACES Index). We therefore performed an OLS regression and confirmed a significant positive impact of the ACES Index on a company's market capitalization per vehicle. When we controlled for the different parameters separately, the strongest positive influence came from autonomous driving and electrification ($p<0.05$). In contrast, connectivity showed no significant and shared mobility even a negative significant influence on market capitalization per vehicle ($p<0.05$). Investors thus seem to value technology leadership in electrification and autonomous driving but prefer that OEMs leave the development of sharing services to specialized companies.

Finally, it should be noted that the managers of German OEMs, albeit not as first movers, have understood the importance of disruptive trends and are on the way to transforming their companies. Recent announcements clearly indicate that they genuinely aim to embrace the ACES trends and embark on further transformation paths. To achieve this, they can use their capital reserves, profitable operations, and brand popularity. In addition, they are backed by the German government, which, on the other hand, demands a clear commitment to sustainable mobility and thus supports the development of innovative solutions. They also need to create more agile corporate structures and develop the necessary capabilities to produce mission-critical technologies such as autonomous driving and electrification internally or in partnerships. For better competitive intelligence, we recommend the use of the ACES Index.

6. Limitations and outlook

In addition to the interesting insights provided by this work, we would like to point out potential limitations resulting from methodological weaknesses in the data sets and within the analyses. First, we based our research on secondary data and therefore had to accept the associated problems, such as uncertain quality, lack of personalization, and in some cases, incomplete data samples. In addition, we had to use some non-scientific sources, as this was the only way to ensure the timeliness of the data. However, we relied exclusively on sources from reputable institutes and publishers. Secondly, due to the limited scope of this thesis the competitor consideration set was small ($n=8$). Furthermore, the ACES Index framework presented is only an approximation for the innovative strength and implementation capabilities of OEMs, makes no claim to be exhaustive, and may be biased due to partly subjective assessments. Similarly, the make-or-buy framework presented is intended as a starting point for decision-making and should be considered as a qualitative assessment opportunity. Finally, it should be noted that we could not include all possible future automotive trends in the analysis, which is why we decided to exclude hydrogen fuel cell technology from the discussion. The reason for this was that most OEMs have committed themselves to battery cell technology.

As initially targeted, this thesis contributes to the existing literature as well as practice by discussing several implications that future automotive trends will have on German OEMs. It must be acknowledged, though, that the scope of the topic is too large to be discussed in this paper alone and that some limitations exist. However, future research could draw on our findings. Firstly, the structure and dimensions of the SWOT analysis could be transferred to other OEMs. Secondly, the ACES Index framework could be enriched by adding more competitors and dimensions within the different categories. Finally, our make-or-buy decision framework could be applied more broadly to other technologies. Furthermore, it could be extended to include a quantification method of added value. In this way, researchers could address some of the weaknesses identified and shed further light on this interesting area of research.

References

Aaker, D. A., & Jacobson, R. (1994). The Financial Information Content of Perceived Quality. *Journal of Marketing Research*, *31*(2), 191–201.

ADAC. (2020). *Tempolimit auf Autobahnen.* https://www.adac.de/verkehr/standpunkte-studien/positionen/tempolimit-autobahn-deutschland/. (Accessed: 2021/05/09)

Ai, Y., Peng, M., & Zhang, K. (2018). Edge computing technologies for Internet of Things: a primer. *Digital Communications and Networks*, *4*, 77–86.

Alcácer, J., & Zhao, M. (2012). Local R&D Strategies and Multilocation Firms: The Role of Internal Linkages. *Management Science*, *58*(4), 734–753.

Aldrich, H. E., & Fiol, M. (1994). Fools rush in? The institutional context of industry construction. *Academy of Management Review*, *19*, 645–670.

Ali, S. (2014). Social and Environmental Impact of the Rare Earth Industries. *Resources*, *3*(1), 123–134.

Andersen, M., Dauner, T., Di Domenico, D., Lang, N., Jentzsch, A., Palme, T., & Saded, P. (2018). *Where to Profit as Tech Transforms Mobility. Boston Consulting Group.* https://www.bcg.com/de-de/publications/2018/profit-tech-transforms-mobility. (Accessed: 2021/05/09)

Arbeitgeber Ranking. (2020). *Top-Arbeitgeber nach dem Studium.* https://www.arbeitgeber-ranking.de/magazin/berufseinstieg/top-arbeitgeber-studenten. (Accessed: 2021/05/09)

Arslan, O., Yildiz, B., & Ekin Karaşan, O. (2014). Impacts of battery characteristics, driver preferences and road network features on travel costs of a plug-in hybrid electric vehicle (PHEV) for long-distance trips. *Energy Policy*, *74*, 168–178.

Athanasopoulou, A., de Reuver, M., Nikou, S., & Bouwman, H. (2019). What technology enabled services impact business models in the automotive industry? An exploratory study. *Futures*, *109*, 73–83.

Baik, Y., Hensley, R., Hertzke, P., & Knupfer, S. (2019). *Making electric vehicles profitable. McKinsey & Company.* https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/making-electric-vehicles-profitable. (Accessed: 2021/05/09)

Ball, R., Gerakos, J., Linnainmaa, J. T., & Nikolaev, V. (2020). Earnings, retained earnings, and book-to-market in the cross section of expected returns. *Journal of Financial Economics*, *135*(1), 231–254.

Balser, M., Bauchmüller, M., & Meta, K. (2020). *EU-Kommission arbeitet an 100-Milliarden-Plan für Mobilität. Süddeutsche Zeitung.* https://www.sueddeutsche.de/politik/eu-konjunkturprogramm-corona-krise-automobilindustrie-1.4913344. (Accessed: 2021/05/09)

Bansal, P., & Kockelman, K. M. (2017). Forecasting Americans' long-term adoption of connected and autonomous vehicle technologies. *Transportation Research Part A: Policy and Practice*, *95*, 49–63.

Bardt, H. (2019). *Deutsche Industrie stark bei Autonomem Fahren - Wettbewerber holen auf. Institut der Deutschen Wirtschaft.* https://www.iwkoeln.de/fileadmin/user_upload/Studien/Kurzberichte/PDF/2019/IW-Kurzbericht_2019_Autonomes_Fahren.pdf. (Accessed: 2021/05/09)

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120.

Becker, J. (2019). *Carsharing rechnet sich in den meisten deutschen Städten nicht. Süddeutsche Zeitung.* https://www.sueddeutsche.de/auto/carsharing-studie-staedte-probleme-1.4554329. (Accessed: 2021/05/09)

Becker, S., & Traufetter, G. (2017). *Ex-Staatsminister beeinflusste Kanzleramt im Auftrag von Daimler. Spiegel.* https://www.spiegel.de/wirtschaft/soziales/daimler-cheflobbyist-eckart-von-klaeden-beeinflusste-kanzleramt-bei-regeln-fuer-abgastests-a-1161319.html. (Accessed: 2021/05/09)

Bender, M.-O., Peuckert, M., & Waasen, D. (2020). Connectivity in der Mittelklasse. *Connect*, 30–53.

Bergen, M., & Peteraf, M. A. (2002). Competitor identification and competitor analysis: a broad-based managerial approach. *Managerial and Decision Economics*, *23*, 157–169.

Bernhart, W., Hasenberg, J.-P., Karlberg, J., & Winterhoff, M. (2018). A new breed of cars. *Think:Act*, 1–19. (May)

Bernhart, W., Hasenberg, J.-P., Winterhoff, M., & Fazel, L. (2016). (R)evolution of the automotive ecosystem. *Think:Act*, 1–15. (March)

Bernhart, W., Olschewski, I., Busse, A., Riederle, S., Pieper, G., & Hotz, T. (2019). E-Mobility Index 2019: China pulls further ahead. *Roland Berger*.

Bertoncello, M., Martens, C., Möller, T., & Schneiderbauer, T. (2021). *Unlocking the full life-cycle value from connected-car data. McKinsey & Company.* https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/unlocking-the-full-life-cycle-value-from-connected-car-data. (Accessed: 2021/05/09)

Bhattacharya, A., Hemerling, J., & Waltermann, B. (2009). Taking R&D Global. Meeting the Challenge of Getting It Right. *Boston Consulting Group*.

Bliss, L. (2019). *How Much Traffic Do Uber and Lyft Cause? Bloomberg.* https://www.bloomberg.com/news/articles/2019-08-05/uber-and-lyft-admit-they-re-making-traffic-worse. (Accessed: 2021/05/09)

Bloomberg. (2020a). *NIO Gets $1 Billion Investment in China, Allaying Cash Concerns.* https://www.bnnbloomberg.ca/nio-gets-1-billion-investment-in-china-allaying-cash-concerns-1.1428594. (Accessed: 2021/05/09)

Bloomberg. (2020b). *The State of the Self-Driving Car Race 2020.* https://www.bloomberg.com/features/2020-self-driving-car-race/. (Accessed: 2021/05/09)

Bloomberg. (2021). *Didi Accelerates IPO Plans, Targeting Valuation Above $62 Billion.* https://www.bloomberg.com/news/articles/2021-03-19/didi-is-said-to-accelerate-ipo-plans-as-business-rebounds. (Accessed: 2021/05/09)

BMW AG. (2019). *BMW Group treibt Elektromobilität weiter voran und sichert sich den langfristigen Bedarf an Batteriezellen – Auftragsvolumina von insgesamt mehr als zehn Mrd. Euro vergeben.* https://www.press.bmwgroup.com/deutschland/article/detail/T0302864DE/bmw-group-treibt-elektromobilitaet-weiter-voran-und-sichert-sich-den-langfristigen-bedarf-an-batteriezellen---auftragsvolumina-von-insgesamt-mehr-als-zehn-mrd-euro-vergeben?language=de. (Accessed: 2021/05/09)

BMW AG. (2020). *Annual Report 2019.* https://www.bmwgroup.com/content/dam/grpw/websites/bmwgroup_com/ir/downloads/de/2020/hautversammlung/BMW-Group-Geschaeftsbericht-2019.pdf. (Accessed: 2021/05/09)

BMW AG. (2021). *Annual Report 2020.* https://www.bmwgroup.com/content/dam/grpw/websites/bmwgroup_com/ir/downloads/de/2021/bericht/BMW-Group-Bericht-2020-DE.pdf. (Accessed: 2021/05/09)

Boesch, P. M., Ciari, F., & Axhausen, K. W. (2016). Autonomous Vehicle Fleet Sizes Required to Serve Different Levels of Demand. *Transportation Research Record: Journal of the Transportation Research Board*, *2542*, 111–119.

Brander, J., Cui, V., & Vertinski, I. (2017). China and intellectual property rights: A challenge to the rule of law. *Journal of International Business Studies*, *48*, 908–921.

Brandt, F., & Springer, M. (2015). *The next horizon of automotive after-sales. Oliver Wyman.* https://www.oliverwyman.de/our-expertise/insights/2015/jul/automotive-manager-2015/r-d--sales-and-services/the-next-horizon-of-automotive-after-sales.html. (Accessed: 2021/05/09)

Brenner, A., Seyger, R., Dressler, N., & Huth, C. (2018). Car-as-a-Service: Medium-term opportunities for fleet management solution providers. *Roland Berger*, 1–24.

Bundesministerium für Wirtschaft. (2020). *Automobilindustrie.* https://www.bmwi.de/Redaktion/DE/Textsammlungen/Branchenfokus/Industrie/branchenfokus-automobilindustrie.html. (Accessed: 2021/05/09)

Bundesverband Carsharing. (2020). *CarSharing in Deutschland.* https://carsharing.de/sites/default/files/uploads/bsc_jahresbericht.pdf. (Accessed: 2021/05/09)

Bundesverband der Energie- und Wasserwirtschaft. (2020). *Ladesäulen: Energiewirtschaft baut Ladeinfrastruktur auf.* https://www.bdew.de/energie/elektromobilitaet-dossier/

energiewirtschaft-baut-ladeinfrastruktur-auf/. (Accessed: 2021/05/09)

Busvine, D. (2021). *UPDATE 2-AUTO1 shares go into top gear in Frankfurt debut. reuters.* https://www.reuters.com/article/auto1-ipo-idUSL8N2KA2LE. (Accessed: 2021/05/09)

Calantone, R. J., Daekwan, K., Schmidt, J. B., & Cavusgil, S. T. (2006). The influence of internal and external firm factors on international product adaptation strategy and export performance: A three-country comparison. *Journal of Business Research*, *59*, 176–185.

Canals Casals, L., Martinez-Laserna, E., Amante García, B., & Nieto, N. (2016). Sustainability analysis of the electric vehicle use in Europe for CO2 emissions reduction. *Journal of Cleaner Production*, *127*, 425–437.

Cao, L., & Li, L. (2015). The Impact of Cross-Channel Integration on Retailers' Sales Growth. *Journal of Retailing*, *91*(2), 198–216.

Center of Automotive Management. (2021). *Die innovationsstärksten Automobilhersteller von batterieelektrischen Fahrzeugen (BEV).* https://auto-institut.de/automotiveinnovations/emobility/die-innovationsstaerksten-automobilhersteller-von-batterieelektrischen-fahrzeugen-bev/. (Accessed: 2021/05/09)

Chen, M.-J. (1996). Competitor analysis and interfirm rivalry: toward a theoretical integration. *Academy of Management Review*, *21*, 100–134.

Cho, H.-J., & Pucik, V. (2005). Relationship between Innovativeness, Quality, Growth, Profitability, and Market Value. *Strategic Management Journal*, *26*, 555–575.

Christensen, C. M. (2013). *The Innovator's Dillema*. Harvard Business Review Press.

Christensen, C. M., & Rosenbloom, R. S. (1994). Technological Discontinuities, Organizational Capabilities, and Strategic Commitments. *Industrial and Corporate Change*, *3*, 655–685.

Christensen, C. M., & Rosenbloom, R. S. (1995). Explaining the Attacker's Advantage: The Technological Paradigms, Organizational Dynamics, and the Value Network. *Research Policy*, *24*, 233–257.

Clark, K. B. (1985). The interaction of design hierarchies and market concepts in technological evolution. *Research Policy*, *14*, 235–251.

Collins, K. M. T., Onwuegbuzie, A. J., & Sutton, I. L. (2006). A Model Incorporating the Rationale and Purpose for Conducting Mixed-Methods Research in Special Education and Beyond. *Learning Disabilities*, *4*(1), 67–100.

Collinson, S., & Liu, Y. (2019). Recombination for innovation: performance outcomes from international partnerships in China. *R&D Management*, *49*(1), 18.

Companies Market Cap. (2021). *Largest automakers by market capitalization.* https://companiesmarketcap.com/automakers/largest-automakers-by-market-cap/. (Accessed: 2021/05/09)

Correia, G., & van Arem, B. (2016). Solving the User Optimum Privately Owned Automated Vehicles Assign- ment Problem (UO-POAVAP): A model to explore the impacts of self-driving vehicles on urban mobility. *Transportation Research Part B: Methodological*, *87*, 64–88.

Costain, C., Ardron, C., & Habib, K. N. (2012). Synopsis of users' behaviour of a carsharing program: A case study in Toronto. *Transportation Research Part A: Policy and Practice*, *46*(3), 421–434.

Cox Automotive. (2019). *Cox Automotive Industry Update Report: January 2019.* https://www.coxautoinc.com/learning-center/cox-automotive-industry-update-report-january-2019/. (Accessed: 2021/05/09)

Cramer, J., & Krueger, A. B. (2016). Disruptive Change in the Taxi Business: The Case of Uber. *The American Economic Review*, *106*(5), 177–182.

Daimler AG. (2019). *Daimler and Geely Holding form global joint venture to develop smart.* https://media.daimler.com/marsMediaSite/en/instance/ko/Daimler-and-Geely-Holding-form-global-joint-venture-to-develop-smart.xhtml?oid=42917172. (Accessed: 2021/05/09)

Daimler AG. (2020a). *Annual Report 2019.* https://www.daimler.com/dokumente/investoren/berichte/geschaeftsberichte/daimler/daimler-ir-geschaeftsbericht-2019-inkl-zusammengefasster-lagebericht-daimler-ag.pdf. (Accessed: 2021/05/09)

Daimler AG. (2020b). *Aufsichtsrat bekräftigt Geschäftsplanung 2021-2025.* https://www.daimler.com/investoren/berichte-news/finanznachrichten/20201203-aufsichtsrat-unterstuetzt-neuen-investitionsplan.html. (Accessed: 2021/05/09)

Daimler AG. (2020c). *Partners reach joint decision: BMW Group and Mercedes-Benz AG put development cooperation in automated driving temporarily on hold – may be resumed later.* https://media.daimler.com/marsMediaSite/en/instance/ko/Partners-reach-joint-decision-BMW-Group-and-Mercedes-Benz-AG-put-development-cooperation-in-automated-driving-temporarily-on-hold--may-be-resumed-later.xhtml?oid=46637056. (Accessed: 2021/05/09)

Daimler AG. (2020d). *Strategic partnership with Farasis.* https://www.daimler.com/innovation/drive-systems/electric/mercedes-benz-and-farasis.html. (Accessed: 2021/05/09)

Daimler AG. (2021a). *Annual Report 2020.* https://www.daimler.com/dokumente/investoren/berichte/geschaeftsberichte/daimler/daimler-ir-geschaeftsbericht-2020-inkl-zusammengefasster-lagebericht-daimler-ag.pdf. (Accessed: 2021/05/09)

Daimler AG. (2021b). *Auf einen Blick: Neue und erweiterte Mercedes me connect Dienste.* https://media.daimler.com/marsMediaSite/de/instance/ko/Auf-einen-Blick-Neue-und-erweiterte-Mercedes-me-connect-Dienste.xhtml?oid=32705731. (Accessed: 2021/05/09)

Damm, C. (2020). *Deutsche Autobauer landen in den Top 10 der Firmen mit den höchsten Schulden weltweit – warum das trotzdem kein Grund zur Sorge ist. business Insider.* https://www.businessinsider.de/wirtschaft/vw-bmw-daimler-hohe-schulden-aber-kein-grund-zur-sorge/. (Accessed: 2021/05/09)

Day, G. S. (1981). Strategic market analysis and definition: an integrated approach. *Strategic Management Journal*, *2*, 281–299.

Delhaes, D. (2020). *Beschluss zum Autogipfel: Milliardenhilfen für Autohersteller und Zulieferer. handelsblatt.* https://www.handelsblatt.com/unternehmen/flottenmanagement/elektromobilitaet-beschluss-zum-autogipfel-milliardenhilfen-fuer-autohersteller-und-zulieferer/26633456.html. (Accessed: 2021/05/09)

Demandt, B. (2019). *US CAR SALES ANALYSIS 2019 – BRANDS. car Sales Base.* https://carsalesbase.com/us-car-sales-analysis-2019-brands/. (Accessed: 2021/05/09)

Denscombe, M. (2008). Communities of practice: A research paradigm for the mixed methods approach. *Journal of Mixed Methods Research*, *2*, 270–283.

Denyer, S. (2014). *U.S. companies feel a chill in China, even as many still rake in profits. The Washington Post.* https://www.washingtonpost.com/world/us-companies-feel-a-colder-wind-in-china-even-as-many-still-rake-in-profits/2014/07/03/dcbfa233-ee13-4e67-b791-3b3e38bca890_story.html. (Accessed: 2021/05/09)

Deutsches Statistisches Bundesamt. (2018a). *Stadtbevölkerung steigt bis 2030 weltweit um eine Milliarde.* https://www.destatis.de/DE/Themen/Laender-Regionen/Internationales/Thema/bevoelkerung-arbeit-soziales/bevoelkerung/Stadtbevoelkerung.html. (Accessed: 2021/05/09)

Deutsches Statistisches Bundesamt. (2018b). *Unfallentwicklung auf deutschen Straßen 2017.* https://www.destatis.de/DE/Presse/Pressekonferenzen/2018/Verkehrsunfaelle-2017/pressebroschuere-unfallentwicklung.pdf?__blob=publicationFile. (Accessed: 2021/05/09)

Deutsches Statistisches Bundesamt. (2021). *10,6 % weniger Verkehrstote im Jahr 2020.* https://www.destatis.de/DE/Presse/Pressemitteilungen/2021/02/PD21_084_46.html. (Accessed: 2021/05/09)

Dharmakeerthi, C. H., Mithulananthan, N., & Saha, T. K. (2014). Impact of electric vehicle fast charging on power system voltage stability. *International Journal of Electrical Power & Energy Systems*, *57*, 241–249.

Dosi, G. (1982). Technological Paradigms and Technological Trajectories. *Research Policy*, *11*, 127–162.

Duch-Brown, N., Grzybowski, L., & Romahn, A. (2017). The impact of online sales on consumers and firms. Evidence from consumer electronics.

International Journal of Industrial Organization, *52*, 30–62.

Dudley, G., Banister, D., & Schwanen, T. (2017). The Rise of Uber and Regulating the Disruptive Innovator. *The Political Quarterly*, *88*(3), 492–499.

Dyer, J. H. (1996). Specialized supplier networks as a source of competitive advantage: evidence from the automotive industry. *Strategic Management Journal*, *17*(4), 271–291.

Dyer, J. H., & Singh, H. (1998). The Relational View: Cooperative Strategy and Sources of Interorganizational Competetive Advantage. *The Academy of Management Review*, *23*(4), 660–679.

Eddy, J., Pfeiffer, A., & van de Staaij, J. (2019). *Recharging economies: The EV-battery manufacturing outlook for Europe. McKinsey & Company.* https://www.mckinsey.com/industries/oil-and-gas/our-insights/recharging-economies-the-ev-battery-manufacturing-outlook-for-europe. (Accessed: 2021/05/09)

Ehie, I. C., & Olibe, K. (2010). The effect of R&D investment on firm value: An examination of US manufacturing and service industries. *International Journal of Production Economics*, *128*(1), 127–135.

Eisenhardt, K., & Bourgeois, J. (1989). Politics of strategic decision making in high-velocity environments: Toward a midrange theory. *Academy of Management Journal*, *31*, 737–770.

Ettlie, J. E. (1998). R&D and Global Manufacturing Performance. *Management Science*, *44*(1), 1–11.

European Automobile Manufacturers Association. (2018). *Vehicle sales mirror economic growth (2006-2019 trend)*. https://www.acea.be/statistics/article/vehicle-sales-mirror-economic-growth-2006-2019-trend. (Accessed: 2021/05/09)

European Commission. (2017a). *EUROP-E: European Ultra-Charge Roll Out Project - Electric.* https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2017-de-tm-0064-w. (Accessed: 2021/05/09)

European Commission. (2017b). *Growing consumption.* https://knowledge4policy.ec.europa.eu/growing-consumerism_en. (Accessed: 2021/05/09)

European Parliament. (2019). *CO2 emissions from cars: facts and figures (infographics).* https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics. (Accessed: 2021/05/09)

Fagnant, D. J., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy and Practice*, *77*, 167–181.

Fagnant, D. J., & Kockelman, K. M. (2014). The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios. *Transportation Research Part C: Emerging Technologies*, *40*, 1–13.

Fama, E. F., & French, K. R. (1992). The Cross-Section of Expected Stock Returns. *The Journal of Finance*, *47*(2), 427–465.

Fang, E., Steenkamp, J.-B. E. M., & Palmatier, R. W. (2008). Effect of Service Transition Strategies on Firm Value. *Journal of Marketing*, *72*, 1–14.

Fang, L., Lerner, J., & Wu, J. (2017). Intellectual Property Rights Protection, Ownership, and Innovation: Evidence from China. *The Review of Financial Studies*, *30*(7), 2446–2477.

Farris, P. W., Bendle, N. T., Pfeifer, P. E., & Rebstein, D. E. (2006). *Marketing Metrics: 50+ Metrics Every Executive Should Master*. Wharton School Publishing.

Fisher, K. L. (1984). *Super Stocks*. Dow Jones-Irwin.

Fleetwood, J. (2017). Public Health, Ethics, and Autonomous Vehicles. *American Journal of Public Health*, *107*(4), 532–538.

Fockenbrock, D., Fasse, M., & Hubik, F. (2019). *Teure Flotte: Der Carsharing-Flop von Daimler und BMW. handelsblatt.* https://www.handelsblatt.com/unternehmen/industrie/mobilitaetsdienste-teure-flotte-der-carsharing-flop-von-daimler-und-bmw/25351186.html?ticket=ST-745403-zG4YHaBjFBnF073YjCEO-ap4. (Accessed: 2021/05/09)

Freitag, M. (2020). *Ford und Volvo vereinbaren CO2-Allianz. manager Magazin.* https://www.manager-magazin.de/lifestyle/auto/ford-und-volvo-vereinbaren-co2-allianz-a-04cfa50a-0da5-4574-b47f-54a733511b42. (Accessed: 2021/05/09)

Gao, F., & Su, X. (2017). Omnichannel Retail Operations with Buy-Online-and-Pick-up-in-Store. *Management Science*, *63*(8), 2478–2492.

German Department and Trade Mark Office. (2019a). *Autonomous driving, part 3: Facts and figures.* https://www.dpma.de/english/our_office/publications/background/autonomousdriving/autonomousdrivingpart3/index.html. (Accessed: 2021/05/09)

German Department and Trade Mark Office. (2019b). *Mobility of the future - Made in Germany.* https://www.dpma.de/english/our_office/publications/background/autonomousdriving/index.html. (Accessed: 2021/05/09)

Germis, C. (2019). *Volkswagen fährt jetzt mit Sammeltaxis durch Hamburg. Frankfurter Allgemeine Zeitung.* https://www.faz.net/aktuell/wirtschaft/auto-verkehr/volkswagen-faehrt-jetzt-mit-moia-sammeltaxis-durch-hamburg-16141988.html. (Accessed: 2021/05/09)

Giesel, F., & Nobis, C. (2016). The Impact of Carsharing on Car Ownership in German Cities. *Transportation Research Procedia*, *19*, 215–224.

Glaister, K. W., & Falshaw, J. R. (1999). Strategic planning still going strong. *Long Range Planning*, *32*(1), 107–116.

Gómez Vilchez, J. J., & Jochem, P. (2020). Powertrain technologies and their impact on greenhouse gas emissions in key car markets. *Transportation Research Part D: Transport and Environment*, *80*, 102214.

Götze, S. (2020). *Europas Kompromiss zur Rettung der Welt. spiegel.* https://www.spiegel.de/wissenschaft/mensch/green-deal-was-das-neue-eu-klimaziel-fuer-die-laender-bedeutet-a-b14b3b44-9b97-4c25-8640-adc5110f788e. (Accessed: 2021/05/09)

Grosse-Ophoff, A., Hausler, S., Heineke, K., & Möller, T. (2017). *How shared mobility will change the automotive industry. McKinsey & Company.* https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry. (Accessed: 2021/05/09)

Guan, M., Gao, P., Wang, A., Zipser, D., & Shen, P. (2019). *China auto consumer insights 2019. McKinsey & Company.* https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/china-auto-consumer-insights-2019. (Accessed: 2021/05/09)

Hambrick, D. C., MacMillan, I. C., & Day, D. L. (1982). Strategic attributes and performance of business in the four cells of the BCG matrix–A PIMS-based analysis of industrial-product business. *Academy of Management Journal*, *25*(3), 510–531.

Hao, H., Qiao, Q., Liu, Z., & Zhao, F. (2017). Impact of recycling on energy consumption and greenhouse gas emissions from electric vehicle production: The China 2025 case. *Resources, Conservation and Recycling*, *122*, 114–125.

Harper, C. D., Hendrickson, C. T., Mangones, S., & Samaras, C. (2016). Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions. *Transportation Research Part C*, *72*, 1–9.

Heinonen, K., & Strandvik, T. (2021). Reframing service innovation: COVID-19 as a catalyst for imposed service innovation. *Journal of Service Management*, *32*(1), 101–112.

Helms, M. M., & Nixon, J. (2010). Exploring SWOT analysis – where are we now? A review of academic research from the last decade. *Journal of Strategy and Management*, *3*(3), 215–251.

Henao, A., & Marshall, W. E. (2019). The impact of ride-hailing on vehicle miles traveled. *Transportation*, *46*, 2173–2194.

Henderson, R. M., & Clark, K. B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly*, *35*(1), 9–30.

Hensley, R., Padhi, A., & Salazar, J. (2017). *Cracks in the ridesharing market–and how to fill them. McKinsey & Company.* https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/cracks-in-the-ridesharing-market-and-how-to-fill-them. (Accessed: 2021/05/09)

Hohensee, M., Hajek, S., Reimann, A., & Seiwert, M. (2021). *It's the Software, stupid! wirtschaftswoche.* https://www.wiwo.de/my/unternehmen/auto/autobauer-its-the-software-stupid/26881104.html?ticket=ST-6766055-lJCehEwChaCjSDreCSAP-ap2. (Accessed: 2021/05/09)

Holland-Letz, D., Kässer, M., Kloss, B., & Müller, T. (2019). *Start me up: Where mobility investments are going. McKinsey & Company.* https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/start-me-up-where-mobility-investments-are-going. (Accessed: 2021/05/09)

Hoogendoorn, R., van Arem, B., & Hoogendoom, S. (2014). Automated driving, traffic flow efficiency and human factors: A literature review. *Transportation Research Record: Journal of the Transportation Research Board*, *2422*, 113–120.

Ilg, P. (2019). *Alles außer Autos. Zeit Online.* https://www.zeit.de/mobilitaet/2019-11/onlinekauf-autos-internet-automobilbranche-vertrieb-zukunft. (Accessed: 2021/05/09)

Illgen, S., & Höck, M. (2019). Literature review of the vehicle relocation problem in one-way car sharing networks. *Transportation Research Part B: Methodological*, *120*, 193–204.

Interbrand. (2019). *Best Global Brands.* https://www.interbrand.com/best-global-brands/?filter-brand-sector=automotive. (Accessed: 2021/05/09)

Irle, R. (2021). *Global Plug-in Vehicle Sales Reached over 3,2 Million in 2020. EV Volumes.* https://www.ev-volumes.com/news/86364/. (Accessed: 2021/05/09)

Jäck, D., & Sizov, G. (2020). *Boosting Automotive Aftermarket Revenues through Advanced Analytics. Bain & Company.* https://www.bain.com/insights/boosting-automotive-market-revenues-through-advanced-analytics/. (Accessed: 2021/05/09)

Jamrisko, M., & Lu, W. (2020). *Germany Breaks Korea's Six-Year Streak as Most Innovative Nation. bloomberg.* https://www.bloomberg.com/news/articles/2020-01-18/germany-breaks-korea-s-six-year-streak-as-most-innovative-nation. (Accessed: 2021/05/09)

J.D. Power. (2020). *Brand Loyalty Increasing among New-Vehicle Buyers, J.D. Power Finds.* https://www.jdpower.com/sites/default/files/file/2020-07/2020046%20U.S.%20Automotive%20Brand%20Loyalty.pdf. (Accessed: 2021/05/09)

Joas, A., Reiner, J., Deinlein, J., & Oertel, S. (2018). *AUTOMAKERS' CHOICE: DISRUPT OR BE DISRUPTED. Oliver Wyman.* https://www.oliverwyman.com/our-expertise/insights/2018/sep/automotive-manager-2018/cover-story/automakers-choice-disrupt-or-be-disrupted.html. (Accessed: 2021/05/09)

Jochem, P., Brendel, C., Reuter-Oppermann, M., Fichtner, W., & Nickel, S. (2015). Optimizing the allocation of fast charging infrastructure along the German autobahn. *Journal of Business Economics*, *86*, 513–535.

Kaleta, P. (2021). *„Die Luft wird dünn" – Daimlers Software-Rückstand auf Tesla und Apple wächst. Business Insider.* https://www.businessinsider.de/wirtschaft/mobility/daimler-software-rueckstand-auf-tesla-apple-waechst-sagt-autoexperte-a/. (Accessed: 2021/05/09)

Kalra, N., & Paddock, S. M. (2016). Driving to safety: How many miles of driving would it take to demonstrate autonomous vehicle reliability? *Transportation Research Part A: Policy and Practice*, *94*, 182–193.

Kapustin, N. O., & Grushevenko, D. A. (2020). Long-term electric vehicles outlook and their potential impact on electric grid. *Energy Policy*, *137*, 1–10.

Kastalli, I. V., & Van Looy, B. (2013). Servitization: Disentangling the impact of service business model innovation on manufacturing firm performance. *Journal of Operations Management*, *31*(4), 169–180.

Ke, J., Yang, H., & Zheng, Z. (2020). On ride-pooling and traffic congestion. *Transportation Research Part B. Methodological*, *142*, 213–231.

Kempf, S., Heid, B., & Hattrup-Silberberg, M. (2018). *Ready for Inspection – The Automotive Aftermarket in 2030. McKinsey & Company.* https://www.mckinsey.com/~/media/McKinsey/Industries/Automotive%20and%20Assembly/Our%20Insights/Ready%20for%20inspection%20The%20automotive%20aftermarket%20in%202030/Ready-for-inspection-The-automotive-aftermarket-in-2030-vF.ashx. (Accessed: 2021/05/09)

Kerin, R. A., & Sethuraman, R. (1998). Exploring the Brand Value-Shareholder Value Nexus for Consumer Goods Companies. *Journal of the Academy of Marketing Science*, *26*(4), 260–273.

Khondaker, B., & Kattan, L. (2015). Variable speed limit: A microscopic analysis in a connected vehicle environment. *Transportation Research Part C: Emerging Technologies*, *58*, 146–159.

Klebnikov, S. (2020). *Tesla Is Overvalued: Investors Are Treating It Too Much Like A Tech Company, Says Morgan Stanley. forbes.* https://www.forbes.com/sites/sergeiklebnikov/2020/06/23/tesla-is-overvalued-investors-are-treating-it-too-much-like-a-tech-company-says-morgan-stanley/?sh=28624d726c74. (Accessed: 2021/05/09)

Kotabe, M., Martin, X., & Domoto, H. (2003). Gaining from vertical partnerships: knowledge transfer, relationship duration, and supplier performance improvement in the U.S. and Japanese automotive industries. *Strategic Management Journal*, *24*(4), 293–316.

Krogh, H. (2020). *Volkswagen schmiedet Aufholplan zu Tesla. automobilwoche.* https://www.automobilwoche.de/article/20200425/BCONLINE/200429936/1334/exklusiv--herbert-diess-spricht-intern-klartext-volkswagen-schmiedet-aufholplan-zu-tesla. (Accessed: 2021/05/09)

Küpper, D., Kuhlmann, C., Tominga, K., Arora, A., & Schlageter, J. (2020). *Shifting Gears in Auto Manufacturing. Boston Consulting Group.* https://www.bcg.com/de-de/publications/2020/transformative-impact-of-electric-vehicles-on-auto-manufacturing. (Accessed: 2021/05/09)

Lambert, F. (2020). *VW admits Tesla's lead in software and self-driving in internal leak. electrek.* https://electrek.co/2020/04/27/vw-admits-tesla-lead-software-leak-internal/. (Accessed: 2021/05/09)

Lambkin, M. (1988). Order of entry and performance in new markets. *Strategic Management Journal*, *9*, 127–140.

Lellouche, K., Grover, P., Blue, M., Walus, S., & Barrack, T. (2020). *Will Consumers Finally Be Able to Buy New Cars Online? Boston Consulting Group.* https://www.bcg.com/de-de/publications/2020/impact-of-coronavirus-on-purchasing-new-cars-online. (Accessed: 2021/05/09)

Lempert, R. J., Preston, B., Charan, S. M., Fraade-Blanar, L., & Blumenthal, M. S. (2021). The societal benefits of vehicle connectivity. *Transportation Research Part D: Transport and Environment*, *93*.

Lessig, L. (2008). *Remix: Making Art and Commerce Thrive in the Hybrid Economy*. Penguin Press.

Lieberman, M. B., & Montgomery, D. B. (1998). First-mover (dis)advantages: Retrospective and link with the resource-based view. *Strategic Management Journal*, *19*, 1111–1125.

Macrotrends. (2021a). *China GDP Growth Rate 1961-2021.* https://www.macrotrends.net/countries/CHN/china/gdp-growth-rate. (Accessed: 2021/05/09)

Macrotrends. (2021b). *Tesla: Number of Employees 2009-2020 | TSLA.* https://www.macrotrends.net/stocks/charts/TSLA/tesla/number-of-employees. (Accessed: 2021/05/09)

Macrotrends. (2021c). *Tesla Research and Development Expenses 2009-2021 | TSLA.* https://www.macrotrends.net/stocks/charts/TSLA/tesla/research-development-expenses. (Accessed: 2021/05/09)

Macrotrends. (2021d). *Uber Technologies Market Cap 2017-2020 | UBER.* https://www.macrotrends.net/stocks/charts/UBER/uber-technologies/market-cap. (Accessed: 2021/05/09)

Madden, T. J. (2006). Brands Matter: An Empirical Demonstration of the Creation of Shareholder Value Through Branding. *Journal of the Academy of Marketing Science*, *34*(2), 224–235.

Mahmoudzadeh Andwari, A., Pesiridis, A., Rajoo, S., Martinez-Botas, R., & Esfahanian, V. (2017). A review of Battery Electric Vehicle technology and readiness levels. *Renewable and Sustainable Energy Reviews*, *78*, 414–430.

Maisch, A. (2013). *Automobilverband bestimmte über umstrittenes Ökolabel mit. Zeit Online.* https://www.zeit.de/mobilitaet/2013-10/autoindustrie-lobby-energielabel. (Accessed: 2021/05/09)

Malorny, C. (2020). *Deutschland braucht die Autobahn - ohne Tempolimit. manager Magazin.* https://www.manager-magazin.de/unternehmen/autoindustrie/deutsche-autoindustrie-deutschland-braucht-autobahn-ohne-tempolimit-a

-1305043.html. (Accessed: 2021/05/09)

Marples, D. L. (1961). The Decisions of Engineering Design. *IEEE Transactions of Engineering Management*, *EM.8*, 55–71.

Miao, C., Liu, H., Zhu, G. G., & Chen, H. (2018). Connectivity-based optimization of vehicle route and speed for improved fuel economy. *Transportation Research Part C: Emerging Technologies*, *91*, 353–368.

Milakis, D., van Arem, B., & van Wee, B. (2017). Policy and society related implications of automated driving: A review of literature and directions. *Journal of Intelligent Transportation Systems*, *21*(4), 324–348.

Morbey, G. K. (1988). R&D: Its Relationship to Company Performance. *Journal of Product Innovation Management*, *5*(3), 191–200.

Mudambi, S. M., & Tallman, S. (2010). Make, Buy or Ally? Theoretical Perspectives on Knowledge Process Outsourcing through Alliancesjoms_. *Journal of Management Studies*, *47*(8), 1434–1456.

Münzel, K., Boon, W., Frenken, K., & Vaskelainen, T. (2018). Carsharing business models in Germany: characteristics, success and future prospects. *Information Systems and e-Business Management*, *16*, 271–291.

Myrden, S. E., & Kelloway, K. (2015). Young workers' perception of brand image: main and moderating effects. *Journal of Organizational Effectiveness: People and Performance*, *2*(3), 267–281.

Nio Inc. (2021). *NIO Inc. Provides December, Fourth Quarter and Full Year 2020 Delivery Update.* https://ir.nio.com/news-events/news-releases/news-release-details/nio-inc-provides-december-fourth-quarter-and-full/. (Accessed: 2021/05/09)

Noori, M., Gardner, S., & Tatari, O. (2015). Electric vehicle cost, emissions, and water footprint in the United States: Development of a regional optimization model. *Energy*, *89*, 610–625.

Panagiotou, G., & Van Wijnen, R. (2005). The "telescopic observations" framework: an attainable strategic tool. *Marketing Intelligence & Planning*, *3*(2), 155–171.

Papathanassiou, A., & Khoryaev, A. (2017). Cellular V2X as the Essential Enabler of Superior Global Connected Transportation Services. *IEEE 5G Tech Focus*, *1*(2).

Peteraf, M. A., & Bergen, M. E. (2003). Scanning dynamic competitive landscapes: a market-based and resource-based framework. *Strategic Management Journal*, *24*, 1027–1041.

Petit, J., & Shladover, S. E. (2015). Potential Cyberattacks on Automated Vehicles. *IEEE Transactions on Intelligent Transportation Systems*, *16*(2), 546–556.

Phillips, L. W., Chang, D. R., & Buzzell, R. D. (1983). Product Quality, Cost Position and Business Performance: A Test of Some Key Hypotheses. *Journal of Marketing*, *47*(Spring), 26–43.

Pickton, D. W., & Wright, S. (1998). What's swot in strategic analysis? *Strategic Change*, *7*, 101–109.

Piovaccari, G. (2021). *After long journey, Fiat Chrysler and PSA seal merger to become Stellantis. reuters.* https://www.reuters.com/article/us-stellantis-deal-idUSKBN29L001. (Accessed: 2021/05/09)

Powell Mantel, S., Tatikonda, M. V., & Liao, Y. (2006). A behavioral study of supply manager decision-making: Factors influencing make versus buy evaluation. *Journal of Operations Management*, *24*, 822–838.

Rayes, A., & Salam, S. (2017). *Internet of Things From Hype to Reality - The Road to Digitization* (2nd ed.). Springer International Publishing.

Rayle, L., Dai, D., Chan, N., Cervero, R., & Shaheen, S. (2016). Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco. *Transport Policy*, *45*, 168–178.

Reuters. (2021). *Volkswagen verfehlt CO2-Ziele knapp - 100 Millionen Euro Strafe.* https://www.reuters.com/article/deutschland-volkswagen-idDEKBN29Q18W. (Accessed: 2021/05/09)

Rietmann, N., Hügler, B., & Lieven, T. (2020). Forecasting the trajectory of electric vehicle sales and the consequences for worldwide CO2 emissions. *Journal of Cleaner Production*, *261*, 1–16.

Rindova, V. P., & Kotha, S. (2001). Continuous "Morphing": Competing Through Dynamic Capabilities, Form, And Function. *Academy of Management Journal*, *44*(6), 1263–1280.

Rogelj, J., den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., ... Meinshausen, M. (2016). Paris Agreement climate proposals need a boost to keep warming well below 2 °C. *Nature*, *534*(7609), 631–639.

Saberi, B. (2018). The role of the automobile industry in the economy of developed countries. *International Robotics & Automation Journal*, *4*(3), 179–180.

Sahal, D. (1981). *Patterns of technological innovation*. Addison Wesley.

Satariano, A. (2021). *In a First, Uber Agrees to Classify British Drivers as 'Workers'. The New York Times.* https://www.nytimes.com/2021/03/16/technology/uber-uk-drivers-worker-status.html. (Accessed: 2021/05/09)

Schneider, S. H. (1989). The Greenhouse Effect: Science and Policy. *Science*(243), 771–781.

Schürman, C. (2020). *So viel Geld haben die Autobauer noch in der Kasse. wirtschaftswoche.* https://www.wiwo.de/finanzen/boerse/auto-kaufpraemien-so-viel-geld-haben-die-autobauer-noch-in-der-kasse/25802106.html. (Accessed: 2021/05/09)

Seiwert, M. (2010). *Erschreckende Bilanz der Autoverschrottung. wirtschaftswoche.* https://www.wiwo.de/unternehmen/abwrackpraemie-erschreckende-bilanz-der-autoverschrottung/5707118.html. (Accessed: 2021/05/09)

Seiwert, M. (2019). *Der „Green Deal" ist für Daimler der Horror. wirtschaftswoche.* https://www.wiwo.de/unternehmen/auto/klimaschutz-der-green-deal-ist-fuer-daimler-der-horror/25333692.html. (Accessed: 2021/05/09)

Seiwert, M. (2021). *VW lässt den Verbrenner fallen. wirtschaftswoche.* https://www.wiwo.de/unternehmen/auto/elektroautos-vw-laesst-den-verbrenner-fallen/26978300.html. (Accessed: 2021/05/09)

Shafiee, S., & Topal, E. (2009). When will fossil fuel reserves be diminished? *Energy Policy*, *37*(1), 181–189.

Shah, A., & Shirouzu, N. (2018). *Volkswagen in talks to manage Didi fleet, co-develop self-driving cars. reuters.* https://in.reuters.com/article/us-autoshow-beijing-vw-didi-exclusive-idINKBN1I10YP. (Accessed: 2021/05/09)

Share Now. (2021). *SHARE NOW trotzt der Pandemie mit gutem Geschäftsjahr 2020.* https://www.share-now.com/de/de/press-release-good-financial-year-2020/. (Accessed: 2021/05/09)

Shladover, S. E., Su, D., & Lu, X.-Y. (2012). Impacts of Cooperative Adaptive Cruise Control on Freeway Traffic Flow. *Transportation Research Record: Journal of the Transportation Research Board*, *2324*, 63–70.

Sinha, S. S. (2020). *How The Pandemic Has Served As A Catalyst For Innovation. forbes Magazine.* https://www.forbes.com/sites/forbestechcouncil/2021/12/28/how-the-pandemic-has-served-as-a-catalyst-for-innovation/?sh=5b0532e0812d. (Accessed: 2021/05/09)

Skippon, S., & Garwood, M. (2011). Responses to battery electric vehicles: UK consumer attitudes and attributions of symbolic meaning following direct experience to reduce psychological distance. *Transportation Research Part D Transport and Environment*, *16*, 525–531.

Society of Automotive Engineers International. (2018). *SAE International Releases Updated Visual Chart for Its "Levels of Driving Automation" Standard for Self-Driving Vehicles.* https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-‘‘levels-of-driving-automation’’-standard-for-self-driving-vehicles. (Accessed: 2021/05/09)

Sorge, N.-V. (2015). *Hier verscherbelt Daimler eine deutsche Industrie-Hoffnung. manager Magazin.* https://www.manager-magazin.de/unternehmen/autoindustrie/daimler-verscherbelt-li-tec-das-ende-einer-deutschen-industrie-hoffnung-a-1053709.html. (Accessed: 2021/05/09)

Specht, F. (2019). *Der deutsche Kündigungsschutz bremst den Wandel. handelsblatt.* https://www.handelsblatt.com/meinung/kommentare/kommentar-der-deutsche-kuendigungsschutz-bremst-den-wandel/24571694.html?ticket=ST-1347632-idfGPWjfFshqI1WofZPw-ap6. (Accessed: 2021/05/09)

Srivastava, R., Lellouche, K., Seners, R., & Vigani, F. (2018). *It's Time for a New Way to Sell Cars. Boston Consulting Group.* https://www.bcg.com/de-de/publications/2018/new-way-to-sell-cars. (Accessed: 2021/05/09)

Stahl, F., Heitmann, M., Lehmann, D. R., & Neslin, S. A. (2012). The Impact of Brand Equity on Customer Acquisition, Retention, and Profit Margin. *Journal of Marketing*, *76*(4), 44–63.

Strack, R., Antebi, P., Kateava, N., Kovács-Ondrejkovic, O., López Gobernado, A., & Welch, D. (2019). *Decoding Digital Talent. Boston Consulting Group.* https://www.bcg.com/de-de/publications/2019/decoding-digital-talent. (Accessed: 2021/05/09)

Suarez, F. F., Grodal, S., & Gotsopoulos, A. (2015). Perfect timing? Dominant category, dominant design, and the window of opportunity for firm entry: Perfect Timing? Dominant Category and Window of Entry. *Strategic Management Journal*, *36*, 437–448.

Suarez, F. F., & Utterback, J. M. (1995). Dominant Designs and the Survival of Firms. *Strategic Management Journal*, *16*, 415–430.

Sundararajan, A. (2016). *The Sharing Economy: The End of Employment and the Rise of Crowd-Based Capitalism*. Cambridge, MA: MIT Press.

Sutherland, D. (2003). *China's large enterprises and the challenge of late industrialisation*. New York: RoutledgeCurzon.

Talebpour, A., & Mahmassani, H. S. (2016). Influence of connected and autonomous vehicles on traffic flow stability and throughput. *Transportation Research Part C: Emerging Technologies*, *71*, 143–163.

Teixeira, A. C. R., & Sodré, J. R. (2018). Impacts of replacement of engine powered vehicles by electric vehicles on energy consumption and CO2 emissions. *Transportation Research Part D Transport and Environment*, *59*, 375–384.

The Heritage Foundation. (2020). *China.* https://www.heritage.org/index/pdf/2020/countries/china.pdf. (Accessed: 2021/05/09)

Thio, L. (2019). *Viel Frust beim Stromtanken. tagesschau.* https://www.tagesschau.de/inland/emobilitaet-ladestationen-101.html. (Accessed: 2021/05/09)

Tie, S. F., & Tan, C. W. (2013). A review of energy sources and energy management system in electric vehicles. *Renewable and Sustainable Energy Reviews*, *20*, 82–102.

Tushman, M. L., & Anderson, P. (1986). Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly*, *31*(3), 439–465.

Tyborski, R. (2020). *Zulieferer brauchen jetzt die Hilfe der Autohersteller. handelsblatt.* https://www.handelsblatt.com/meinung/kommentare/kommentar-zulieferer-brauchen-jetzt-die-hilfe-der-autohersteller/26175744.html?ticket=ST-16250867-91KLLgLY1V1C55cejlBT-ap6. (Accessed: 2021/05/09)

Uber Technologies Inc. (2020). *Volkswagen und Uber starten Pilotprojekt mit E-Fahrzeugen in Berlin.* https://www.uber.com/de/de/about/. (Accessed: 2021/05/09)

Van Binsbergen, J., Graham, J., & Yang, J. (2010). The cost of debt. *Journal of Finance*, *65*, 2089–2136.

Vandermerwe, S., & Rada, J. (1988). Servitization of Business: Adding Value by Adding Services. *European Management Journal*, *6*(4), 314–324.

Verband der Automobilindustrie. (2020). *European passenger car market shows modest growth in 2019.* https://www.vda.de/en/press/press-releases/20200116-european-passenger-car-market-shows-modest-growth-in-2019.html. (Accessed: 2021/05/09)

Volkswagen AG. (2016). *Annual Report 2015.* https://www.volkswagenag.com/presence/investorrelation/publications/annual-reports/2016/volkswagen/deutsch/Y_2015_d.pdf. (Accessed: 2021/05/09)

Volkswagen AG. (2019a). *Member of the Brand Board of Management Christian Senger explains the new Volkswagen software unit.* https://www.volkswagenag.com/en/news/stories/2019/06/volkswagen-is-developing-more-of-its-own-software.html. (Accessed: 2021/05/09)

Volkswagen AG. (2019b). *Volkswagen und Northvolt schließen Joint Venture für Batterieproduktion.* https://www.volkswagen-newsroom.com/de/pressemitteilungen/volkswagen-und-northvolt-schliessen-joint-venture-fuer-batterieproduktion-5316. (Accessed: 2021/05/09)

Volkswagen AG. (2020a). *Annual Report 2019.* https://www.volkswagenag.com/presence/investorrelation/publications/annual-reports/2020/volkswagen/Y_2019_d.pdf. (Accessed: 2021/05/09)

Volkswagen AG. (2020b). *Volkswagen Konzern erhöht Investitionen in Zukunftstechnologien auf 73 Milliarden Euro.* https://www.volkswagenag.com/de/news/2020/11/Volkswagen-Group-raises-investments-in-future-technologies-to-EUR-73-billion.html. (Accessed: 2021/05/09)

Volkswagen AG. (2021a). *Annual Report 2020.* https://www.volkswagenag.com/presence/investorrelation/publications/annual-reports/2021/volkswagen/Y_2020_d.pdf. (Accessed: 2021/05/09)

Volkswagen AG. (2021b). *Power Day: Volkswagen präsentiert Technology-Roadmap für Batterie und Laden bis 2030.* https://www.volkswagen-newsroom.com/de/pressemitteilungen/power-day-volkswagen-praesentiert-technology-roadmap-fuer-batterie-und-laden-bis-2030-6891. (Accessed: 2021/05/09)

Weber, H., Krings, J., Seyfferth, J., Güthner, H., & Neuhausen, J. (2019). *Time to get real: opportunities in a transforming market. strategy&.* https://www.strategyand.pwc.com/de/en/insights/2019/digital-auto-report/digital-auto-report-2019.pdf. (Accessed: 2021/05/09)

Weihrich, H. (1982). The TOWS Matrix – A Tool for Situational analysis. *Long Range Planning*, *15*(2), 54–66.

WHO. (2016). *Sustainable development goals (SDGs): Goal 3. Target 3.6: By 2020, halve the number of global deaths and injuries from road traffic accidents. World Health Organization.* https://www.who.int/health-topics/sustainable-development-goals#tab=tab_2. (Accessed: 2021/05/09)

Williamson, O. (1981). The economics of organization: the transaction cost approach. *American Journal of Sociology*, *87*(3), 548–577.

Wimmelbücker, S. (2020). *VW ID.3:Großes Software-Update steht zur Verfügung. automobilwoche.* https://www.automobilwoche.de/article/20201117/NACHRICHTEN/201119905/vw-id-grosses-software-update-steht-zur-verfuegung. (Accessed: 2021/05/09)

Wise, R., & Baumgartner, P. (1999). Go Downstream: The New Profit Imperative in Manufacturing. *Harvard Business Journal*, 133–141. (September-October)

Yap, M., Correia, G., & van Arem, B. (2016). Preferences of travellers for using automated vehicles as last mile public transport of multimodal train trips. *Transportation Research Part A: Policy and Practice*, *94*, 1–16.

Yeung, M., & Ramasamy, B. (2008). Brand value and firm performance nexus: Further empirical evidence. *Journal of Brand Management*, *15*, 322–335.

Zervas, G., Proserpio, D., & Byers, J. W. (2017). The Rise of the Sharing Economy: Estimating the Impact of Airbnb on the Hotel Industry. *Journal of Marketing Research*, *54*(5), 687–705.

Zhai, K., & Kubota, Y. (2021). *China to Restrict Tesla Use by Military and State Employees. The Wall Street Journal.* https://www.wsj.com/articles/china-to-restrict-tesla-usage-by-military-and-state-personnel-11616155643?mod=mhp. (Accessed: 2021/05/09)

Zhao, Z., & Anand, J. (2009). A multilevel perspective on knowledge transfer: evidence from the Chinese automotive industry. *Strategic Management Journal*, *30*, 959–983.

Zhou, F., Zheng, Z., Whitehead, J., Perrons, R. K., Washington, S., & Page, L. (2020). Examining the impact of car-sharing on private vehicle ownership. *Transportation Research Part A: Policy and Practice*, *138*, 322–341.

Zhuang, H., Popkowski Leszczyc, P. T., & Lin, Y. (2018). Why is Price Dispersion Higher Online than Offline? The Impact of Retailer Type and Shopping Risk on Price Dispersion. *Journal of Retailing*, *94*(2), 136–153.

Zohdy, I. H., & Rakha, H. A. (2016). Intersection management via vehicle connectivity: The intersection cooperative adaptive cruise control system concept. *Journal of Intelligent Transportation Systems*, *20*(1), 17–32.

Zwick, D. (2020). *Mit diesem Plan will BMW Tesla einholen. welt.* https://www.welt.de/wirtschaft/article216623544/BMW-Mit-30-Milliarden-Euro-fuer-Forschung-gegen-die-Autokrise.html. (Accessed: 2021/05/09)