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Disruption ahead – The challenge of German car manufacturers to sustain their leading market position in times of rapid industry change

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Abstract

In the context of this thesis, the challenge of German car manufacturers to sustain their leading market position in times of rapid industry change was examined by a combination of two strategy analysis frameworks – scenario planning and dynamic capabilities. The following hypothesis was examined with a qualitative research approach: *„German car manufacturers do not have the capability to maintain their leading position within the automotive industry"*. The findings of the study indicate that in many fundamental domains such as production techniques or supplier relationships, German car manufacturers are still the industry leaders. Thus, the results suggest that German car makers will be able to sustain their leading positions within the industry.

Keywords: Strategy, Automotive, Disruption, Industry change, Scenario Planning, Dynamic capabilities

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1. Introduction

Car enthusiasts might remember, the British car industry was once an integral part of the United Kingdom's economy. It produced the second most cars worldwide, employed five percent of the national workforce and successfully competed in the market with its luxurious brands like Bentley, Rolls Royce and Jaguar. Only a few decades later, two out of three brands belong to German car manufacturers, as the former managers of Britain's largest carmakers missed out the adaption within a changing market (Northedge 2009).

In 2021 the automotive industry is in the midst of the biggest transformation in its history. In particular, climate protection and digitalization are the factors that are about to determine the reconfiguration of the industry (Volkswagen 2021). This time, the German automotive industry finds itself at a tipping point and the leading market position of its manufacturers is endangered. As revenue pools are shifting towards new business models like shared mobility concepts and alternative powertrains, BMW, Mercedes Benz and Volkswagen must reassess their position within a disrupted environment. However, mismanagement in the change would affect the fate of many individuals. For over one million employees worldwide and hundreds of companies operating as suppliers, the future is irrevocably linked to the one of the manufacturers (Statista 2021). Given this high level of influence, the thesis examines the research question:

"Do German car manufacturers have the capability to maintain their leading position within the automotive industry?"

To analyse the answer to this research question, the paper applies a combination of two strategy analysis frameworks – scenario planning and dynamic capabilities. As a first step, both theoretical concepts are explained in chapter two in order to provide useful information for the general understanding of the paper. The third chapter gives a brief overview of the automotive industry, highlighting the position of the German market participants, the justification of their role as industry leaders and the reasons why it is endangered as well as the determination of the research question and its respective hypothesis. Chapter four, Methodology, describes the combination and execution of the two frameworks and how expert interviews as the qualitative research method are embedded in it. It is followed by chapter five, where the results and the answer to the hypothesis is presented. Before coming to the final conclusion in chapter seven, strategic options as well as limitations and directions for future research are presented in chapter six.

2. Literature Review

2.1 Scenario Planning

Ged Davis, former vice president of Shell once described scenario planning as several stories about the future, which have the purpose to make better decisions in the present. Thereby, scenarios are not seen as projections, prognoses, preferences or even utopia (Davis 2001, 1). Rather they are understood as a simplified illustration of a possible situation in the future which entails information about how circumstances are about to evolve from the current point in time into the upcoming situation (Schwarz 1996). As multiple perspectives are taken into account when creating the scenarios, they are seen as a powerful tool to build a more profound understanding of possible developments as well as strategic options. For instance, Shell has been a pioneer in scenario planning since the 1970s and it is consistently better in forecasting the demand for oil than any other competitor (Schoemaker 1995).

In comparison to other techniques, scenario planning differs as it aims to examine the full richness and range of possibilities. The sensitivity analysis for instance, follows a more narrative approach as it only examines the effect of a change in one variable. It also differs to contingency planning as it only assesses the impact of one uncertainty (Schoemaker 1995). Scenario planning has particularly proven its suitability in situations of uncertainty and discontinuity causing from multiple impact variables (Schwarz 1996). Hence, it is appropriate emphasizing the applicability of scenario planning to analyse the change in automotive industry and its multiple ambiguities.

Taking the aforementioned aspects into account, the three main goals of scenario planning can be stated as: broadening the view of the company about possible future outcomes; providing a basis for discussion to decision makers and preparing the entity for several future alternatives (Meinert 2014, 9).

In order to achieve these goals, the literature suggests following a number of tasks when creating the scenarios. However, several authors divide these tasks in between different numbers of four to ten steps. One type of framework is the so-called *intuitive approach* of scenario planning. Different versions were developed by Peter Schwarz, Kees Van der Heijden and Paul Schoemaker. The concept applied within this thesis mainly follows the one developed by Peter Schwarz but it incorporates elements of the other researchers in order to increase the robustness of the results.

The **first step** is defining the time horizon and the scope of the analysis. Scope is determined by assessing the products, markets, geographical areas and the technologies that are relevant for the projection of the company's uncertain future. When delineate the time horizon one should to raise questions about the duration of technological change, product life cycles within the industry, impact of political decisions and many other factors (Mietzner 2009, 141). The goal is to provide a clear understanding of what needs to be analysed, mainly to the researcher or analyst conducting the analysis, but also to any external individual that might get involved into the process (Schwarz 1996). Once these aspects have been determined, it is time to bring both factors into relation. Meaning, question how many issues affecting the scope can be expected within the defined time frame. In this sense, it can be helpful to think about the past and the former sources of uncertainty that occurred during that time (Schoemaker 1995).

After successfully setting up the frame of the analysis, the **second** – and most difficult – **step** concerns identifying the central influencing factors that shape the future state of the industry. The determined factors should be classified as important or unimportant as well as certain or uncertain factors. At a first glance, the number of factors that can be found seem countless but in practice it is much narrower as the ones relevant for the future have often already been relevant in the past. The influencing factors identified as certain provide structure and later it is important to embed them within any scenario (Meinert 2014, 14 f.). For instance, pollution of cars is an important influencing factor where the certainty is high that regulations will get stricter within the following years.

However, it is more crucial to screen for the most important influencing factors which are still very uncertain and hence hard to assess. For example, a new but unproven technology with the potential to fundamentally change the structure of relationships in the industry would be an important factor to consider within the scope of the scenario analysis. Once these factors are identified, the last task is about naming two factors/drivers that are both very important for the future development but still very uncertain from today's perspective. The two factors determined should here be characterized as being some overarching, extensive variables that can represent most of the uncertain factors raised (Mietzner 2009, 141). This limitation to two factors is seen as a necessity to create a more manageable number of scenarios as well as reducing complexity for the following tasks of the analysis (Meinert 2014, 15).

The **third step** is about defining opposing, independent endpoints the two drivers might develop to for the reason to assess consequences for any future development. This task also helps to illustrate interrelations and to achieve a more accurate reflection of reality. At this stage, literature also suggests starting to think about possible strategic reactions the company could announce for the different developments (Meinert 2014, 16).

Within **step four** the two factors and their corresponding endpoints are brought into relation in order to set the basis for the final creation of the different scenarios. Thereby, former analyses often used the approach of Kees Van der Heijden which suggests displaying the factors into a two-dimensional matrix. As illustrated in figure 1 (see appendix 1), the drivers are represented on the axes while each end is one of the opposing endpoints that have been developed in step three. In addition, the time horizon of the scenario analysis is represented by the outer limits of the matrix (which corresponds to the predefined future date). As a result of this step, the diagram frames four quadrants, each representing a scenario that is dependent on the specific development of the identified, most impactful and uncertain factors (Meinert 2014, 17).

Step five of the process is about the design of a scenario for each of the quadrants. This involves the creation of four distinguishable as well as comparable stories which stay in relation to the development of the two drivers (Meinert 2014, 17). In this process, each scenario is filled in with events, trends and patterns that were previously reflected (Mietzner 2009, 142). Hence, they represent the conclusions from the previous steps. A reason to build these narratives of the future is that portraying of complex and ambiguous interconnections as a concrete illustration makes the scenarios appear less abstract. Once created, all the scenarios should strive for a consistent and logical structure. Moreover, as a whole they should portray the full scope of the possible but yet uncertain future. Therefore, it is crucial to clarify aspects like the political, economic and social circumstances of the respective futures. Finally, as a rule of thumb, it should be possible to summarize the key aspects and basic logic of a scenario in about three sentences, while a meaningful title is showing the implication of the scenario from the very beginning (Schoemaker 1995).

In the **sixth** and final **step** the creator should reflect on the scenarios in a critical way. Here, it is crucial to continuously question the plausibility of the stories created in order to mitigate the risk of any mistakes taken within one of the previous five steps. Presenting the concept to other people who have knowledge about the respective firm/industry is considered a helpful measure to identify inconsistencies (Meinert 2014, 19).

Once the process of the scenario creation is completed it is time to get back to the initial question and conceptualize several possible answers. In this sense, strategic recommendations are created for each scenario and questioning for instance the current theory of the businesses, their strategies as well as their resilience and robustness (Chermack 2011, 169). The exact approach taken within this work project, will be explained in the methodology part in chapter four.

2.2 Dynamic Capabilities

Originally proposed by David J. Teece, Gary Pisano and Amy Shuen, the concept of dynamic capabilities works as a framework to analyse the root causes of superior performance of firms in uncertain and changing environments (Teece, Pisano and Shuen 1997, 509). Therefore, the concept sees dynamic capabilities as the reason why a firm can renew its sources of competitive advantage (i.e., superior value creation) and thereby adapt to disruptive industry changes while sustaining a superior performance. In this manner, disruptive changes are processes in which traditional business models, technologies, processes, products or services are radically challenged by new solutions for existing problems, and thus may be partially or fully displaced from the market (Christensen and Bower 1995).

Regarding other concepts, the dynamic capabilities framework argues that the sustainability of firms' competitive advantage has often believed to be solely reliant on a resource-based strategy where the accumulation of technology assets and their aggressive protection is key. However, since market analysts determined several companies that should have been successful according to the resource-based view but failed anyway, David J. Teece et al. point out, that being a leader within global marketplaces is more about demonstrating timely responsiveness and rapid/flexible innovation. For this to happen, Teece et al. emphasize it is crucial that a firm has the ability to coordinate and redeploy its internal and external competences in an efficient way (Teece, Pisano and Shuen 1997, 515). This statement goes in hand with the findings of

Eisenhardt and Martin, who argue that real competitive advantage can only be created through the reconfiguration of company resources, achieved by leveraging its dynamic capabilities (Eisenhardt and Martin 2000, 1106).

When it comes to the assessment of a firm's dynamic capabilities, the pillars upon unique and immutable advantages are developed and sustained, must be identified. To do so, Teece et al. designed their framework with three inter-related categories (Process, Position and Path) that entail a total of 13 factors (Teece, Pisano and Shuen 1997, 516).

Category one is about analysing the managerial and organizational "Processes" within firms, as they are the main origin of competences and capabilities of all business activities. In particular, processes are understood as the way things are executed within the company as well as routines or patterns of daily business and learning. The outcome of such processes as well as the opportunities they provide for developing competitive advantage are dependent on the asset position the firms holds and, on the path, it has chosen to execute its business. In this manner, those two factors are the subcategories two and three. The term "Position" is understood as the firm's technological capabilities, intellectual property as well as relationships to customer and external entities like suppliers. The subcategory "Path" questions aspects about strategic alternatives that are accessible to the firm, for instance short term adaptions in the product configuration when customer preferences are changing (Teece, Pisano and Shuen 1997, 518).

3. Status Quo of the automotive industry

The automotive industry is facing radical changes. After years of constant increases in production, the number of sold vehicles has fallen for the first time compared to the previous years and that even before the impact of the COVID-19 pandemic. In the year of 2019, sales numbers of German automakers declined by nine percent (VDA 2021). Moreover, new market participants like Tesla, BYD and NIO are on the rise, fighting for market share and showing huge growth in market capitalization within the last years (Gosh 2021). Some established companies are already trying to mitigate the economic change with significant staff cuts. For instance, Volkswagen recently announced a reduction in its headcount by more than one thousand employees, claiming a higher capital need for the investment into electric vehicles and other eco-friendlier technologies. The reasons are stricter emission regulations around the globe (Deutsche Welle 2021). Despite this, Volkswagen and its national competitors, BMW and Daimler, are still considered leading players within the automotive industry (Cornet, et al. 2019, 6). According to their EBIT margins, the German manufacturers rank among the most profitable companies within the industry (Statista 2021, 63). Furthermore, Daimler, Volkswagen and BMW currently hold the first, third and fourth place for the most valuable brands in the automotive industry (Statista 2021, 64). These achievements are likely to come from these manufacturers' leading positions within the following historical key drivers of value: Comfort, quality, and reliability in internal combustion engines. But while the mastery of competencies in these domains served for decades as an accelerator of an innovative economy, the German automotive industry finds itself now at a tipping point. As new technologies, changing customer needs and more eco-friendly powertrains seem to define the future of the industry, revenue pools tend to shift towards upcoming business models and the automakers are in need to reassess their position within a disruptive environment. Especially, because their leading position in technology is endangered by the new business models (Cornet, et al. 2019, 10). Detailed information about the manufactures' strategy can be found in a designated paragraph within appendix 2.

Recent analyses show that four topics have a particularly strong influence on the mobility of the future: Autonomous driving, connectivity, electrification and shared mobility (Cornet, et al. 2019, 15). The drivers of these developments are climate political goals, such as the reduction of greenhouse gases, nitrogen emission as well as noise pollution in (sub)urban environments. Apart from that, it is becoming increasingly difficult to meet customer expectations. As a younger, more technologically savvy generation is about to play the key role in tomorrow's mobility the expectations towards technological innovations are rising (Kuhnert, et al. 2018, 13). Furthermore, the priorities of the new generation are shifting. In contrast to a few years ago, where customers desired having an own car with a strong engine, are today's customers increasingly interested in holistic and ecologically friendly mobility concepts (Schuh, et al. 2019, 2). For instance, the number of cars sold for mobility on demand is expected to rise from 770 thousand units in 2020 to 4.85 million units in 2030 (Statista 2021, 33).

Due to these and several other aspects, the markets and profit pools are evolving to different business models and technologies, such as data-based services and alternative powertrains. However, the yet uncertain future should not only cause threats to the existing automakers but also new opportunities. To examine the future of German automakers, the work project raises the research question: *"Do German car manufacturers have the capability to maintain their leading position within the automotive industry?"* In order to answer it, the corresponding hypothesis: *„German car manufacturers do not have the capability to maintain their leading position within the automotive industry"* will be analysed in the following chapter.

The changes not only relate to the future of each automaker, but also to the future of the 832,400 employees working in the automotive industry in Germany (Statista 2020). Furthermore, the portion of the national GDP amounted to about 4.5% within each of the last years, emphasizing the importance of the industry (Destatis 2020). Thus, the thesis states its scientific added value on the one hand upon the overarching economic and social consequences of any future changes in performance of the national car manufacturers. And on the other hand, on the believe that only little research has been conducted about the adaption capability of the long-term market leaders in the novel situation of massive industry change.

4. Research Methodology

As mentioned before, the methodology of this thesis applies a combination of two strategy analysis frameworks – scenario planning and dynamic capabilities. At first, the scenario analysis was set up. The information needed to create the scenarios was gathered from resent industry reports of global consultancy firms like McKinsey, Bain and PwC. After the development, the illustrated futures were used to formulate specific questions to be posed to market experts in order to receive valuable insider information from primary sources. In this step, the questions were designed according to the dynamic capabilities framework. Due to this, the analysis enables an evaluation of the dynamic capabilities of the chosen industry players that identifies their chances of successful adaptation within the various future scenarios. Hence, the qualitative methodology is providing the information needed to evaluate the ability of the car manufacturers to sustain their leading positions within the automotive industry.

4.1 Building the scenarios

The scenario analysis executed in this work project follows the steps explained within chapter two. Thus, it starts with the scope and time horizon. The created scenarios aim to represent the disruptive environment within the automotive industry out of the perspective of a distinct set of companies. Namely, the leading German car manufacturers Volkswagen, BMW and Mercedes Benz. All of them are operating within the global automotive market, mainly selling high quality cars that are equipped with combustion engines. The time horizon of the analysis was defined until the year 2030 due to multiple reasons: First, several countries, such as France, Sweden, Spain and the United Kingdom declared that the sale of cars powered by fossil fuels will be prohibited the earliest by the year 2030 (Bundesregierung 2019). Second, cars are durable consumer goods, with a current life span of around 12 years (Budd 2018). Third, technological development within the industry and the corresponding impact on a company's market position takes time. On average, every six years a remodelling of the whole car, including its powertrains, is executed (Turpen 2012). Fourth, like explained in chapter two, going further in time bears the risk of losing the analysis in utopia. As a last task in step one, issues that are likely to appear within the defined time horizon were determined. For this task, the status quo in chapter three provides information about four technologies: Autonomous driving, connectivity, electrification and shared mobility that can be expected in the future and hence built the starting point for the identification of central influencing factors within the next step.

The determination of influencing factors was mainly done by screening recently published, forward looking, automotive reports of global consultancy firms as well as additional secondary resources. Here, the approach followed the suggestion of Paul Schoemaker to screen the factors by the categories: Social, technological, environmental, economic, political/legal and industry (Schoemaker 1995). As illustrated in appendix 3, a total of 33 influencing factors could be identified. In order to sort the factors by their influence, all of them were ranked from a level of one (low) to five (high) regarding their degree of uncertainty as well as relative importance. The determination of the respective level for these and the following measure is based upon relevant statements and comments in respect to each influencing factor. For instance, Dr. Klaus Stricker presents a detailed paragraph about the complexity and number of yet unsolved issues in the technology development of autonomous driving (Stricker, et al. 2020).

For the identification of two key uncertainties, a third measure – namely the relative familiarity – was introduced. The measure is about the evaluation of relationships in between influencing factors in order to determine overarching factors. In other words, the higher the level of relative familiarity of one factor, the more dependent are other influencing factors from it. In a final step, the most influential and uncertain factors were identified by adding up the result of the three respective measures. The graphic in appendix 4 shows that *"Technological development of hardware and software for autonomous driving"* and *"Prohibition for selling cars with combustion engines by 2030 to promote electrification",* were identified as the factors with the highest uncertainty, importance and influence. After simplifying the expressions, the two key uncertainties can be expressed as: *Degree of technological development of autonomous driving* and *Degree of electrification and de-petrolification*.

Following the procedure, opposing endpoints for the key uncertainties were identified. Regarding the automated driving, one endpoint is described as "very high" development. In that case, one can expect the achievement of fully autonomous driving, that is compliant with a legal framework. Furthermore, use cases such as mobility on demand or robotaxis would not be burdened by the capabilities of autonomous driving. The other endpoint is described as "stagnating" development, meaning the technological development of autonomous driving has not achieved any significant progress in comparison to 2021. For the degree of electrification, one opposing endpoint is the "full" electrification of vehicles, where every new car is powered by a 100% electric engine. The other extreme was identified as the "moderate development" of electrification, where the development barely differs to the situation in 2021.

Afterwards, the key uncertainties and its opposing endpoints were merged in the two-dimensional matrix presented in appendix 5, to form the four quadrants for the final scenario building. The horizontal axis goes from the stagnation to the very high development of autonomous driving, while the vertical axis goes from the moderate rise of new electric vehicles in the market to the full electrification and de-petrolification of all vehicles.

The resulting four future scenarios, each corresponding to one quadrant in Figure 3, will be presented next.

Starting clockwise, the **Automotive Revolution** is characterized by a high development of both key uncertainties, hence representing the most extreme future scenario. In this outcome, one can imagine new cars on the streets by 2030 as only 100% electric. Increasingly stricter emission regulations of international governments could not be met with combustion engines anymore. Furthermore, as the expansion of the charging station infrastructure was successfully executed, full usability for any type of customer was achieved and range anxiety is non-existent. Competition in terms of electrification is characterized by increasing battery range and price, while performance in terms of horsepower playing a minor role. Thus, either holding strong relationships to suppliers of state-of-the-art battery technology or investments in the own or joint development is the norm. In addition, shifts towards the new competencies and the unification of markets causes new software focused entrants. However, competition is also characterized by the improvement of autonomous driving technology. The development of level five (see appendix 6 for explanation) succeeded and complies to the regulation of most countries. Based upon the technological breakthroughs, several use cases such as robo taxis, mobility on demand were introduced. Causing a more diverse set of revenue streams and a progressive rise of mobility services as a substitute to car ownership.

The key uncertainties in the **Petrolified** scenario are characterized by a moderate development of the progress in vehicle electrification and a very high degree of development in autonomous driving. By 2030, most of the new cars are still using combustion engines as their means of propulsion. However, the pressure on car manufacturers to be compliant with increasing emission regulations is rising, but yet not enough to trigger an immediate and holistic innovation of the powertrain. As electric cars remain a niche market, private and public investment in charging infrastructure is held back. Hence, affecting the purchase decision of customers and the existence of range anxiety. Moreover, the threat of new entrants is low as most of the entrant's business models rely on a rising demand of electric vehicles. As the further development of combustion engines is at its technological and regulatory limit, the competition is primarily characterised by the technological achievements in autonomous driving. In this case, the degree of technological development is very high, and products were introduced in a regulatory compliant way. However, the degree of vehicles using the level five technology is limited as most cities require fleet cars to be zero emission (Bloomberg 2020). Hence, the breakthrough of autonomous driving and all its use cases is tied to the further development of electric vehicles.

In the **Classic Car** scenario, the development of both key uncertainties is low. As the change within the industry is retained by favourable regulatory frameworks, the manufacturers use the momentum to fully exploit the existing products. By 2030, most cars are plug in hybrids in order to comply with the slightly increasing emission restrictions. However, the rising criticism of batteries harmful impact on the environment and the lack of eco-friendly production methods causes problems (Rapier 2020): As further investments were postponed the technological development of autonomous driving and electric vehicles as well as complementary services is delayed. Hence, the differentiation and enhancement within the competition is mainly achieved through the development of better connectivity solutions. Furthermore, since the necessary technologies are not available, few opportunities are there to open up new mobility concepts and no legal framework for autonomous driving can be created.

Electrified is the fourth and final scenario, where the degree of electrification is high and technological development of autonomous driving is rather stagnating. In this case, the consumers choice when buying a car is limited to 100% electric vehicles as combustion engines are prohibited by law. In addition, the total cost of mobility for electric vehicles decreased massively since production units increased. Hence, its being a more cost-efficient generally accepted option anyway, which is not subject to any restrictions with regard to charging stations and battery efficiency. Even though the total electrification of vehicles is favourable for the development of autonomous driving, the technological progress is falling behind. At present, there is no final legal framework that allows the use of autonomous driving as there are still problems within the pilot projects. The competition in the market increased strongly since electric engines became the common powertrain and former niche companies – specified in electric powertrains – are now fighting for market share as they can fully leverage their competencies.

Once created, all scenarios were revisited to assess their plausibility and consistency. In that assessment, only minor reasons for adjustments could be identified and the analysis proceeded with the preparation of the expert interviews.

4.2 Interviews

In order to gather relevant data about the future of the automotive industry, interviews with industry insiders were chosen as the method of primary data collection, since the questions can be specifically addressed to them.

The acquisition of interview partners was carried out exclusively through my own network of contacts. Other requests by telephone and email to a wide range of industry experts were rejected entirely. Overall, the expert interviews were conducted with a total of eight people and an interview time of 31 to 39 minutes. None of the interviewees took the opportunity to end the discussion early or to skip specific questions. However, two participants asked me for the anonymisation of their identity to protect professional interests. Furthermore, all experts approved the initial draft of the transcript that was sent to them. Thus, no further adjustments that might had withhold information was done. The period during which the interviews were conducted was from the 27th of April 2021 until the 11th of May 2021 and all the interview transcripts can be found in the attachment of the thesis.

The interviewees of the study are characterised by extensive knowledge of the German automotive manufacturers. They gathered their expertise through several years of work in executive level positions and/or through multiple consulting projects within the automotive industry. At the time of the interview, all of them were directly involved in at least one project closely related to the current key aspects of the industry change.

All persons who agreed to take part in the interview received an information letter (see appendix 7), explaining the theme of the survey and the corresponding motives. The participants were also informed that the interview would be recorded, in case they decided to answer the questions orally. Furthermore, they had the right to end the interview at any time without giving reasons or to skip questions. If the interview participants requested, the results were treated anonymously. For the transcription a simplified method was used, disregarding dialects, sentence breaks, stuttering and word duplications. Finally, the lines of the transcripts were numbered so that the statements quoted can be assigned to its exact origin.

In order to maximise the effectiveness of the interviews, the decision was made to conduct most of it in the form of guideline-based expert interviews, as these contribute to the openness of the communication by imposing minimum requirements on the respondents' answers. Furthermore, having a guideline with previously formulated questions offers the advantage of limiting the interview thematically and thus focusing on the essential topics. It also prevents the conversation from getting lost in irrelevant details, which always represents an unnecessary additional expenditure of time for both parties to the interview (Creswell 2003). The guide prepared for the interviews contains a total of 15 questions, which can be divided into three categories. The order of the questions was carefully considered in order not to bias the interview participants.

In the first category the questions focus on the dynamic capabilities of the previously identified car manufacturers. All of them were created upon the framework of David J. Teece, Gary Pisano and Amy Shuen, which provides a total of 13 aspects for the identification of dynamic capabilities (Teece, Pisano and Shuen 1997). Four out of the 13 aspects were summarised in two questions, as repetitive answers from the respondents could otherwise be expected. The second category contains of questions regarding the created scenarios. On the one hand, once more this should test the robustness of the illustrated futures in order to enhance the overall plausibility of the analysis. At the same time, the opinion of the experts regarding the key uncertainties was sought, to grasp experts' view about the development of those uncertainties by the year 2030. In the third category, biographic information (background, connection to the automotive industry) is gathered to evaluate the competence of the different interview partners. Due to the expertise of its participants, the primary data collected in the interviews can be considered both relevant and reliable. For the presentation of the qualitative results of the interviews, the summary method according to Philipp Mayring is used (Mayring 2014).

5. Results

5.1 Interview

Within the first part of the interview, all participants followed the approach of answering each question by rating the respective ability of the manufacturers from one (very low) to five (very high). Additionally, all respondents gave a brief explanation for their decision. For the ten questions, an average of 3.6 and median of 3.8 was calculated, while the minimum is at 2.8 and the maximum at 4.3.

The first question dealt with the ability of the manufacturers to integrate new technologies. With an average of 4.0, all experts assess the companies' ability as high. This is explained for instance by the many years of experience in reconfiguring the production process and the knowledge of embedding new technological innovations into it (PLE 2021). Furthermore, the quick development of electric vehicles like the e-Golf or the ID4 of Volkswagen, are seen as examples for the ability of quick technological integration (VHA 2021). With 3.9, the learning ability is slightly above the average of 3.6. Even though, the justifications were generally positive – for instance, because of the competences within the research labs (FGO 2021) – minor concerns were raised about the bureaucracy within the companies causing a lengthy learning process (MSC 2021). In terms of the will to integrate new technologies, the expert opinions fluctuated. One argued, as the change is expensive none of the managers would decide to take this step if the regulations would not force them to do it (UBA 2021). However, another argued that the will to change themselves is generally high as they fear to miss out any opportunities when competing for revenue streams (DSA 2021). The greatest concerns were raised about the current and future value of the technological assets of the companies. As combustion engines are not seen as relevant in the future, a dilution of the production plants' value is expected by the experts (FGO 2021).

For some experts, another weak spot of the companies – compared to the other dynamic capabilities – is the financial situation. As the market capitalizations are beneath the one of Tesla or BYD, capital acquisition for the technological change is more difficult (MSC 2021). Anyway, others see the situation still as comfortable due to current stable revenue sources (FGO 2021). When asking for the reputation of the three manufacturers, the interviewees rated it with 3.8 as medium to high. Even though the diesel gate affair weakened it a bit, the companies brand value is still perceived as superb (DSA 2021). With a rating of 4.3, the relationship to the suppliers is seen as the biggest asset the companies entail. Both sides are incredibly reliant on the success of the other. Therefore, huge investments for technological adaption are also taken within the supplier companies, ensuring the manufacturers access to state-of-the-art components (VHA 2021). The experts believe that the benefits of Germany as a location is rather high to very high. Political stability, good education, conscious workforce but also high regulations were mentioned as reasons. With 3.3, issues causing from the past of the companies and affecting the adaptability is seen as rather high. As the size of the companies is very large, some experts see them as less agile (FGO 2021). Furthermore, the involvement of many stakeholders is believed to burden the management in quick decision-making processes (VHA 2021). Finally, the manufacturers' abilities to adopt new technologies is seen as high. For instance, it was mentioned that the companies reconfigured themselves many times as a response to changing demand and trends by adapting their product portfolio (DSA 2021).

In question one of part two, the experts were asked to name four uncertainties that will impact the future of the automotive industry in 2030. In total, eleven different aspects were mentioned. "Environmental legislation" was named five times, followed by "political impact" and "autonomous driving" with four mentions each. A complete listing of the aspects mentioned can be found in the appendix 8.

Concerning the two key factors selected through the scenario analysis – *Degree of technological development of autonomous driving* and *Degree of electrification and de-petrification* – most interviewees think that both will come to fruition by 2030. This is shown in appendix 9, where the majority of interviewees locate the interception of the key uncertainties within the top right quadrant by the year 2030. Thus, it is not surprising that seven out of eight experts named scenario one as the one most likely to occur. It is followed by scenario four as the second most likely.

In summary, it can be said that the experts did not evaluate any of the four scenarios as too unrealistic or even incorrect, as only the degree of development of the factors was questioned but not the conceptualization itself.

5.2 Answering the hypothesis

The results of the expert interviews strengthen the validity and the significance of the scenario analysis. This is shown, by the fact that the key uncertainties for the creation of the four scenarios match the uncertainties named by the experts. The results also do not indicate that errors were made in the conception of the questions on dynamic capabilities. With regard to the hypothesis, the average rating of 3.6 and the associated justifications indicate that the German car manufacturers BMW, Mercedes Benz and Volkswagen do not have low dynamic capabilities. Consequently, it suggests that the hypothesis: *„German car manufacturers do not have the capability to maintain their leading position within the automotive industry"* is not supported.

6. Discussion

6.1 Strategic recommendations

This section leverages the information gathered through the expert interviews to provide some actionable recommendations that are brought into relation with the current strategies of the German automotive manufacturers. A summary of these can be found in appendix 2. To provide a more detailed recommendation within the given constraints of the work project, a total of three strategic options are exclusively given to scenario one, as most experts choose it to be the most likely.

The first recommendation is to continue with the current strategy of the companies and push ahead electrification and autonomous driving. As most experts expect the ban of combustion engines to start the earliest by 2030, there is no need to further invest into a declining technology. Moreover, temporary solutions like plug in hybrids at Mercedes Benz and BMW should not be over investigated and internally promoted either as the experts expect them to fade quickly as well. Even though the majority of experts believe that autonomous driving remains a niche by 2030 – as a broad use is restricted by the authorities – the companies should be technologically ready in order to react quickly to changes in legislation. Accordingly, a strategic realignment with regard to shifting revenue streams to autonomous driving and new use cases of the vehicle is not necessary right now. As property, plant and equipment is expected to lose its value, the companies should consider selling off or outsource the machinery to foreign countries, where demand for internal combustion engines will persist beyond 2030. In this sense, one expert mentioned China, which has an increasing demand for vehicles with eco-friendly combustion engines in the countryside but does not have the knowledge to manufacture them.

In contrast to the plans of Volkswagen, the second recommendation is to not solely switch production towards electrification too quickly. Even though all experts expect the market to shift towards electrification, a rash change is not recommended. For now, many experts believe that the preconditions of electric driving will not be fulfilled too fast. On the one hand, the electric grid in many countries is not sufficiently developed yet. Therefore, high voltage charging stations cannot be built in a way that would provide a well-performing infrastructure. Furthermore, in many countries it is yet unclear how the additional demand for electricity is to be covered with renewable energies. Moreover, rapid change would cause the combustion engine as the main revenue source to collapse. As the market capitalization of German automotive manufacturers is low compared to the one of opponents like Tesla, financing of innovation is more dependent on internal than external capital gains. Therefore, from a financial point of view, it is important for German automakers to fully exploit the existing technology in order to finance a large part of the technological change as well as amortizing the investments taken as much as possible. Apart from these aspects, several experts indicated that renewable energy sources could also play a more direct role in the mobility of the future. Accordingly, other propulsion technologies such as hydrogen-powered fuel cells or synthetic fuels should also be kept under the radar.

The third and final recommendation is to maintain existing relationships with suppliers and form alliances with other market players. For now, the financial situation of the three companies can be considered comfortable. However, when the shift towards novel powertrains intensifies, some experts expect the current revenue to decline. Therefore, the financial pressure regarding the investment costs into novel powertrains is rising and strategic alliances for research and development could mitigate the burden. In addition, such alliances can lead to synergy effects and thus a better competitive positioning. Finally, as suppliers are seen as an essential factor for a successful transformation within the automotive industry, it is crucial to maintain the relationships to key suppliers.

6.2 Limitations

Within the constraints of this thesis, minor limitations were identified. Most of them can be explained by the imposed restrictions. In terms of the research approach, one could stress that three independent analysis of each manufacturer would allow us to have a clearer picture of the specific circumstances of each. However, conducting qualitative research for the three companies would increase the scope of the work project significantly. In addition, the already high requirements for interview partners would rise, as specialists would be needed for each of the respective companies. Hence, either a better access to industry insiders or a reconsideration of the establishment of contact would be needed. The other aspect that comes into play when talking about limitations is the accuracy of the interviewees' answers. Although this research relies on a diversity of opinions from multiple industry insiders, the interview answers are never free of biases coming from aspects like professional interests, pride or personal experiences. In addition, misinterpretation of questions may also lead to some inaccuracies.

6.3 Directions for future research

One approach to conduct further research based upon this thesis, is by reconfiguring the scenario building process. For instance, by implementing focus groups, researchers can change the process of ascertaining the influencing factors. Furthermore, through individual questionnaires, the rating of the respective factors – by their importance, uncertainty, and relative familiarity – can be examined by the study participants as well. Finally, once the two-dimensional matrix is created, the participants can get back together into their focus groups, where their creativity can be leveraged as a part of the scenario description process.

7. Conclusion

The empirical study conducted as part of this thesis presents evidence that the hypothesis: *„German car manufacturers do not have the capability to maintain their leading position within the automotive industry"* is not supported. Therefore, the research question: *"Do German car manufacturers have the capability to maintain their leading position within the automotive industry?"* can be answered with "yes".

As the answer to the research question is positive, the meaningfulness of the effort taken by the German car manufacturers to sustain their market position is justified. However, due to the transition, changes are about to occur in many respects.

From the suppliers' point of view, this means a significantly higher degree of electrification and autonomous driving, which will also cause a change in existing business models. For instance, owning a car versus pay per use of autonomous vehicles. These changes will also affect personnel organization but should not be seen as equivalent to a complete rationalization of jobs. Even though the way people use transportation on land is changing, the desire and need for mobility will continue and thus the need for carmakers will continue to exist as well. As a result, even long-standing market players can see the potential threat to their business models as an opportunity and use the change to their advantage. Companies will only sustain their market position in such a disruptive environment if they achieve an advanced understanding of the new technology at a relatively early stage. However, this is considered a complicated undertaking due to legal, educational and societal aspects, as there is still a lot of ambiguity. In this respect, the empirical investigation reveals that the legal aspect has a significantly higher influence on the future of automotive than previously assumed.

For multiple reasons, the government has a huge interest in the success of the car manufacturers. Therefore, more favorable circumstances for technological change should be created.

On the one hand, better infrastructure for the power supply must be achieved in various countries throughout Europe. This means, building high-voltage power lines and charging stations for the nationwide coverage of the increasing electricity demand. However, as the arguments in favor of electric vehicles often hinge on their benefits to the environment, policy-makers of all European countries should also see the provision of electricity from renewable and emission-free sources as a priority. If these aspects cannot be fulfilled by the time most new vehicles are electrified, promoting vehicles using other eco-friendly energy sources like synthetic fuels should be considered as well.

Finally, the government must create a legal framework in which the interested companies have the necessary freedom to realize the potential of autonomous driving to the fullest. This means, that the companies should have the chance to gather more data and insights about the technology via a higher number of permits for pilot projects – also in urban environments. Furthermore, it is important to define clear requirements for the individual stages of autonomous driving to enable companies a more target-oriented development. However, it must also be ensured that all individuals involved are sufficiently protected by legal requirements, as this is the only way to create and maintain the necessary acceptance.

In summary, key aspects like the electrification and autonomation of vehicles will not lose its relevance despite its current hurdles and the companies must continue to prove themselves in the disruptive environment. For now the results indicate that the German car manufacturers have the necessary means for a successful transition within the automotive industry. As a next step, the three manufacturers should start to think about how they can continue to exploit their advantageous market position and increase their legacy.

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Appendix

Appendix 1 – Current strategy of BMW, Mercedes Benz and Volkswagen

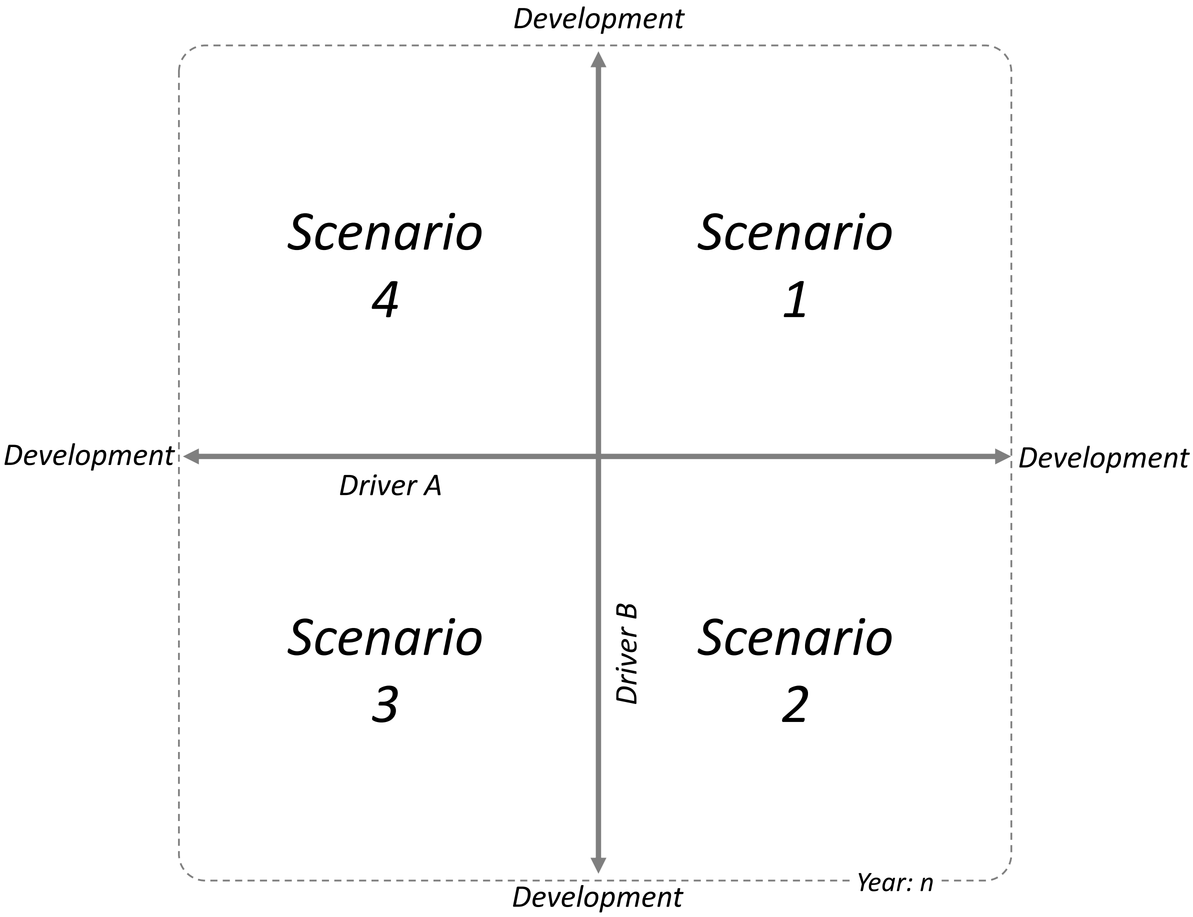


Figure 1 – two-dimensional matrix (own illustration)

Appendix 2 – Strategy of BMW, Mercedes Benz and Volkswagen

By 2030, VW wants to sell not 35 percent purely electrically powered cars in Europe, as previously planned, but around 70 percent. This would mean that more than two-thirds of the vehicles sold in Europe will be purely electric in ten years' time. In the USA and China, the figure is expected to be over 50 percent. Moreover, the figures communicated apply to the VW brand. For the premium brands Audi and Porsche – the direct competitors of BMW and Daimler – the Group is aiming for even faster electrification (Volkswagen 2021). In contrast, the latter plan to sell around 50 percent "electrified" cars, meaning pure e-cars and plug-in hybrids. Subtracting the hybrids, this results in an amount of perhaps 25 percent pure e-cars (Seinert 2021). From 2031 onwards, BMW wants to sell only electric models of the Mini. Accordingly, the last Mini model with a combustion engine is to be launched on the market as early as 2025 (BMW 2020). Daimler is also focusing on change and wants to reduce its combustion engines by 70% by 2030 (Daimler 2021). Due to electrification, Mercedes is relying on strong partners such as CaTl, Farasis and Sila nano in the field of battery development. The aim is to have the entire battery technology chain in their own hands and only focus on partnerships where they think it makes sense. Likewise, the next generation of e-motors is to be developed under their own responsibility, including advanced inverter and high-voltage technologies (Daimler 2021). Volkswagen and BMW have also already announced strategic alliances in this regard (Fasse 2021).

In addition to the successful transformation to electromobility, all three companies also see digitization as a crucial point for their future competitive position. The German manufacturers Volkswagen, BMW and Daimler are therefore working intensively to bring their operating systems up to smartphone level (Fasse 2021). All of them have recognized the importance of software and have set up their own units with thousands of developers. Despite great efforts, hardware and software are not yet clearly separated at any of the companies. Dozens of control units still have to be linked together in a cumbersome process. Compared to the central computers used by electric automakers like Tesla or Lucid, this approach is expensive, complex and error prone (Herrtwich 2021). That's why Daimler, for example, is increasing its team of coders, system architects and driving assistance experts to about 8,000 employees. This corresponds to an increase of 3,000 people (Daimler 2021). Volkswagen has even set up a new software subsidiary for this purpose, which currently employs around 3,000 people. By 2025, however, Volkswagen expects to have around 10,000 employees at Cariad, which will also be strengthened by bringing together all the developers from the subsidiaries. The goal is to enable better connectivity in the future (Volkswagen 2021). BMW, for example, wants to ensure a seamless transition of all smartphone applications in the car, and the software is to be kept permanently fresh over the air (BMW 2021).

In general, all manufacturers will increasingly rely on strategic alliances with selected partners instead of a network of thousands of individual suppliers in order to achieve their ambitious goals. Within the next ten years, Volkswagen Group CEO Herbert Diess intends to transform the traditional car manufacturer into a modern software provider, specializing in vehicle-related computer programs. To close the competitive gap with Tesla, Volkswagen is relying on its already mentioned subsidiary Cariad. Their software is intended to create a uniform operating system "VW.os" across all brands. Like Daimler's MBOS, the software is to be launched in 2024 and is expected to set new standards in the market (Volkswagen 2021).

Appendix 3 – Determination of influencing factors

Social

- Changing habits for mobility (Cornet, et al., 2019)
- Higher environmental sensitivity (Umweltbundesamt, 2020)
- Increase in shared mobility use (Kuhnert, et al., 2018)
- Desire for new payment methods (Cornet, et al., 2019)
- Tech savvy society (Kuhnert, et al., 2018)
- Decrease of range anxiety (Carrington, 2021)
- Delution of percieved value (status symbol) (Schuh, et al., 2019)

Technological

- Development of hardware and software for automated driving (Stricker, et al., 2020)
- Charging speed of electric vehicles (Carrington, 2021)
- Robo Taxis (Kuhnert, et al., 2018)
- Enhancement in battery production (Carrington, 2021)
- Integration of new technologies - e.g. augmented reality (Thiyagarajan, et al., 2020)

Economic

- Economic crisis (Stricker, et al., 2020)
- Increase in demand for personal mobility (Kuhnert, et al., 2018)
- Prolonged stagnation (World Economic Forum, 2021)
- Price instability (World Economic Forum, 2021)
- Increase of global wealth (Anna Zakrzewski, 2020)

Environmental

- Improvement of 5G and LTE accessability (Thiyagarajan, et al., 2020)
- Increase in price for raw materials (Cornet, et al., 2019)
- COVID-19 pandemic (Stricker, et al., 2020)
- Climate change (Stricker, et al., 2020)
- Infrastructure of charging stations (Cornet, et al., 2019)

Political

- Prohibition for selling cars with combustion engines by 2030 (Thiyagarajan, et al., 2020)
- Cities ban Diesel engines (Behrmann, 2019)
- Framework/Regulation for automated driving (Thiyagarajan, et al., 2020)
- Trade reforms due to interstate relation fractures (World Economic Forum, 2021)
- Geopolitical risk (war) (World Economic Forum, 2021)

Industry

- Insolvency of competitors (Stricker, et al., 2020)
- Changes in total customer base (Cornet, et al., 2019)
- Formation of conglomerats and alliances (Cornet, et al., 2019)
- Change in time of remodelling cyclus (Kuhnert, et al., 2018)
- New entrants (Cornet, et al., 2019)
- Mobility on demand (Statista, 2020)

Table 2 –STEEPI Analysis (own illustration)

#	Influencing factors	Uncertainty	Importance	Total
1	Technological development of hardware and software for autonomous driving	5	5	10
2	Prohibition for selling cars with combustion engines by 2030 to promote electrification	5	5	10
3	Legal framework/regulation for automated driving	5	5	10
4	Infrastructure of charging stations	2	5	7
5	Charging speed of electric vehicles	3	5	8
6	All cities ban Diesel engines	3	5	8
7	Robo Taxis	4	3	7
8	Delution of percieved value (status symbol)	3	4	7
9	Mobility on demand	4	3	7
10	Tech savvy society	2	4	6
11	Decrease of range anxiety	2	4	6
12	Enhancement in battery production	1	5	6
13	Improvement of 5G and LTE accessability	2	4	6
14	Increase in price for raw materials	3	3	6
15	New entrants	4	2	6
16	Formation of conglomerats and alliances	2	4	6
17	Changing habits for mobility	1	4	5
18	Higher environmental sensitivity	2	3	5
19	Increase in shared mobility use	1	4	5
20	Desire for new payment methods	3	2	5
21	Integration of new technologies - e.g. augmented reality	3	2	5
22	Economic crisis	1	4	5
23	Increase in demand for personal mobility	1	4	5
24	COVID-19 pandemic	5	3	8
25	Climate change	2	3	5
26	Trade reforms due to interstate relation fractures	2	3	5
27	Geopolitical risk (war)	2	3	5
28	Insolvency of market participants	3	2	5
29	Prolonged stagnation	1	3	4
30	Price instability	1	3	4
31	Increase of global wealth	1	3	4
32	Changes in total customer base	2	2	4
33	Change in time of remodelling cyclus	1	2	3

Table 2 –Influencing factors evaluation (own illustration)

#	Influencing factors	Uncertainty	Importance	Familiarity	Total
1	Technological development of hardware and software for autonomous driving	5	5	5	15
2	Prohibition for selling cars with combustion engines by 2030 to promote electrification	5	5	5	15
3	Legal framework/regulation for automated driving	5	5	4	14
4	Charging speed of electric vehicles	3	5	4	12
5	All cities ban Diesel engines	3	5	4	12
6	COVID-19 pandemic	5	3	4	12
7	Infrastructure of charging stations	2	5	3	10
8	Mobility on demand	4	3	3	10
9	Enhancement in battery production	1	5	4	10
10	Geopolitical risk (war)	2	3	5	10
11	Robo Taxis	4	3	2	9
12	Delution of percieved value (status symbol)	3	4	2	9
13	Tech savvy society	2	4	3	9
14	Decrease of range anxiety	2	4	3	9
15	Improvement of 5G and LTE accessability	2	4	3	9
16	Economic crisis	1	4	4	9
17	Increase in price for raw materials	3	3	2	8
18	New entrants	4	2	2	8
19	Formation of conglomerats and alliances	2	4	2	8
20	Changing habits for mobility	1	4	3	8
21	Climate change	2	3	3	8
22	Increase in shared mobility use	1	4	2	7
23	Integration of new technologies - e.g. augmented reality	3	2	2	7
24	Increase in demand for personal mobility	1	4	2	7
25	Trade reforms due to interstate relation fractures	2	3	2	7
26	Insolvency of market participants	3	2	2	7
27	Higher environmental sensitivity	2	3	1	6
28	Desire for new payment methods	3	2	1	6
29	Prolonged stagnation	1	3	2	6
30	Price instability	1	3	2	6
31	Increase of global wealth	1	3	2	6
32	Changes in total customer base	2	2	1	5
33	Change in time of remodelling cyclus	1	2	2	5

Table 3 –Influencing factors evaluation & familiarity (own illustration)

Appendix 4 – key uncertainty identification

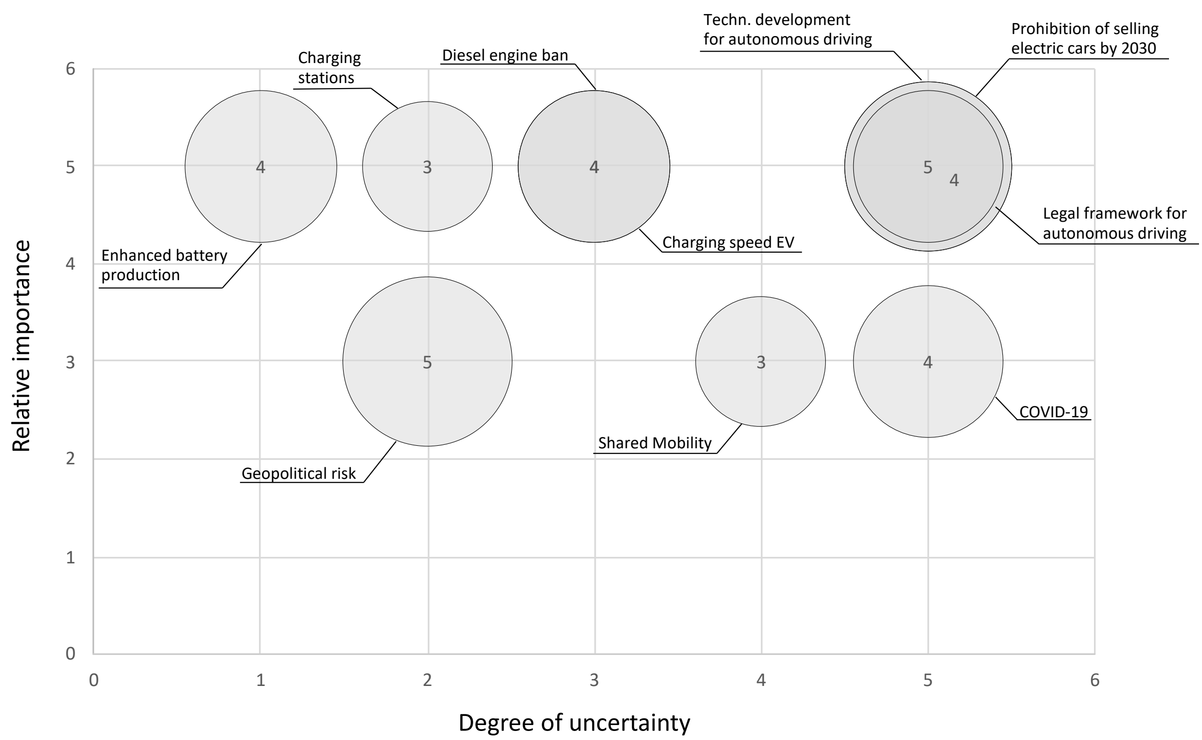


Figure 2 –Key uncertainties identification (own illustration); bubble size equals degree of familiarity

Appendix 5 – Scenario matrix

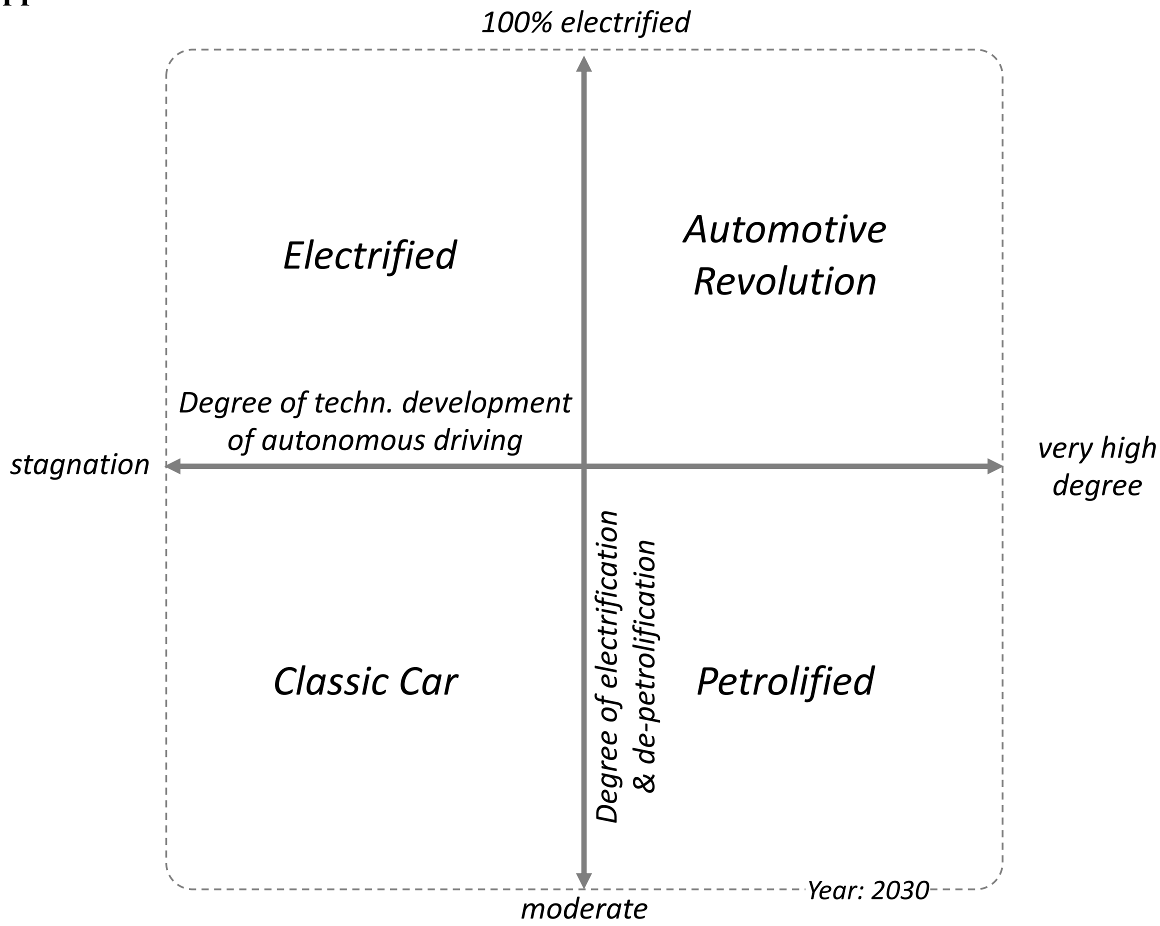


Figure 3 – Created scenario matrix (own illustration)

Appendix 6 – The levels of autonomous driving

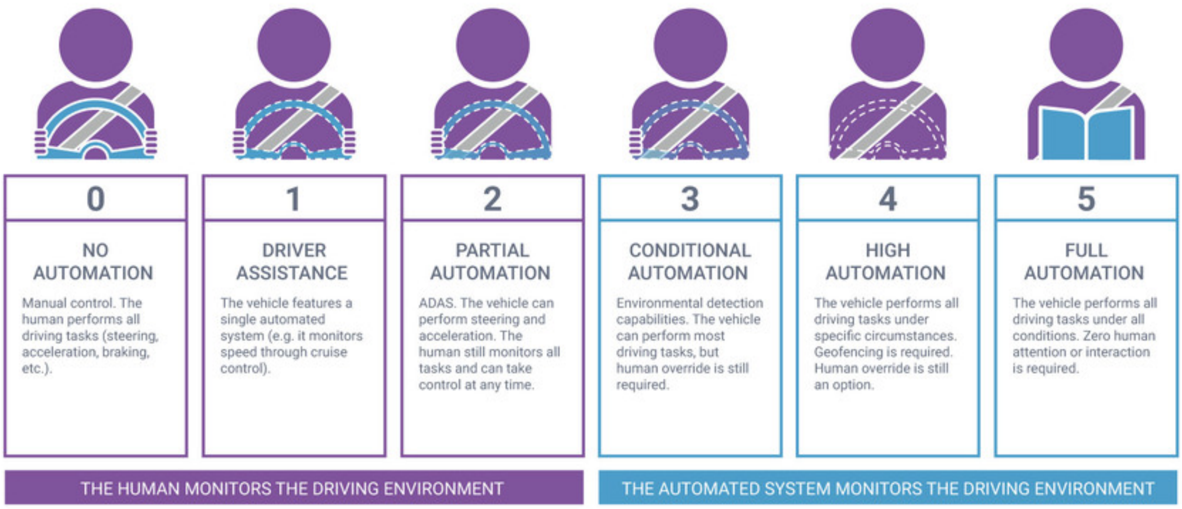


Figure 4 –The levels of autonomous driving (SYNOPSYS 2021)

Appendix 7 – Information letter for Expert interview

NOVA SCHOOL OF BUSINESS & ECONOMICS

Expert interview - preliminary remarks

The expert interviews will be conducted as part of the final thesis on the topic "The transformation of the automotive industry and its impact on market leadership" at the Nova School of Business & Economics Lisbon in the Master's in Management program, representing the main component of the empirical part of this thesis.

Depending on the participants' wishes, the interviews will be conducted either by telephone or in written form. If necessary, the entire interview will be recorded in order to enable an exact transcription afterwards. Each participant has the opportunity to receive a copy of the transcribed interview before submitting the work, to check it for accuracy and to approve it. All data collected here will be treated with the highest degree of confidentiality in the interest of the participants.

At all times, the participant is free to skip questions, without giving any reason, or even to stop the whole interview at any point during its execution. After successful participation in the interview, respondents hold the right to receive a final copy of the thesis.

In the following section you will receive the questions for the upcoming interview.

Thank you again for agreeing to participate in the expert interview!

Mit freundlichen Grüßen,

Jozanović

Luka Jozanovic

1

Expert Interview - Interview Questions

Part 1: Dynamic Capabilities

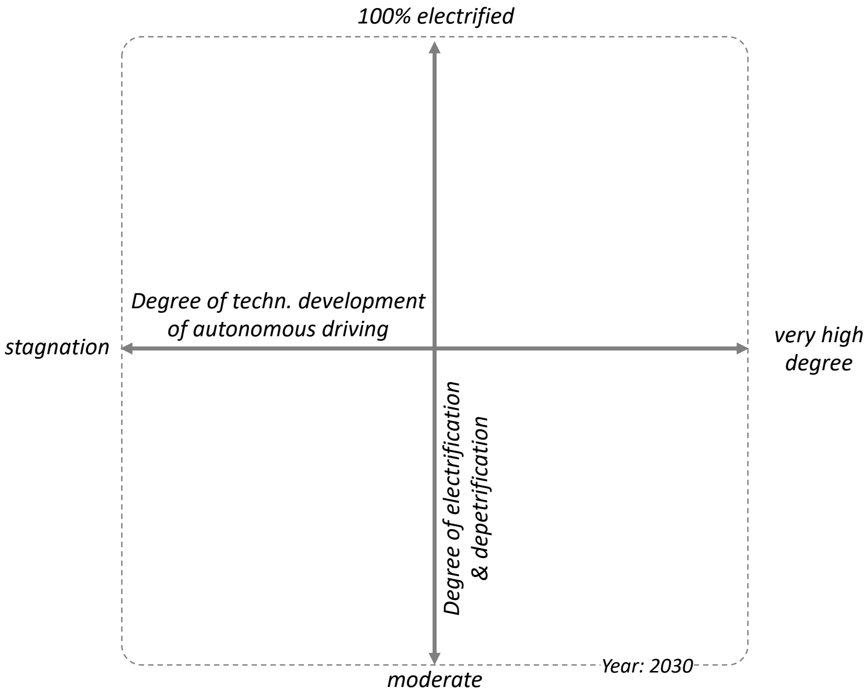
In the following, you will be presented questions relating to the development of the global automotive industry and its influence on the leading German manufacturers (BMW, Mercedes Benz and Volkswagen).

The procedure for answering the questions in Part 1 should always follow the pattern of first giving an estimate, for example from one (very low) to five (very high), on the expression of the respective question and then justify your decision with an explanation or using an example.

1. How would you rate the ability of manufacturers to integrate new activities into the company process? (e.g. activities to bring a new powertrain to the market)
2. How would you rate the learning ability of manufacturers?
3. How strong would you rate the manufacturers' will to integrate new technologies?
4. How would you assess the current and future value of the technological assets (e.g. plants & equipment, software, ...) of the manufacturers?
5. How would you assess the financial situation of the manufacturers?
6. How would you assess the reputation of the manufacturers in the market - especially with regard to the upcoming change?
7. How would you rate the structural assets (contacts and standing with suppliers and commercial customers) of the manufacturers?
8. How would you rate Germany as a location for the manufacturers?
9. How much does the past (investments made, company growth, ...) limit the technological change of manufacturers?
10. How would you rate the ability of manufacturers to adopt new technologies?

Part 2: Scenario Benchmarking

1. Please name four uncertainties that you believe will have a significant impact on the future of the automotive industry.
2. In the following chart you can see a matrix which represents on the x-axis the degree of technological progress of autonomation and on the y-axis the degree of electrification of automobiles. While the point of intersection of the two axes represents the current degree of both factors, all possible combinations within the quadrilateral represent the degrees in 2030. Please mark a point which, in your opinion, corresponds to the development of both factors in 2030.



3. In the following, four different future scenarios for the year 2030 are presented to you. Please read the respective description carefully and then briefly explain why you consider the respective scenario to be realistic/unrealistic.

Scenario 1 – Automotive Revolution:

In this outcome, by 2030 one can imagine new cars on the streets as only 100% electric. Hereby, increasingly stricter emission regulations of international governments could not be met with combustion engines anymore. Furthermore, as the expansion of the charging station infrastructure was successfully executed, full usability for any type of customer was achieved and range anxiety is non-existent. Competition in terms of electrification is characterized by increasing battery range and price, while performance playing a minor role. Thus, either holding strong relationships to suppliers of state-of-the-art battery technology or investments in the own or joint development is the norm. In addition, shifts towards the new competencies and the unification of markets causes new software focused entrants. However, competition is also characterized by the improvement of autonomous driving technology. The development of level five succeeded and complies to the regulation of most countries. Based upon the technological breakthroughs, several use cases such as robo taxis, mobility on demand were introduced. Causing a more diverse set of revenue streams and a progressive rise of mobility services as a substitute to car ownership.

Scenario 2 – Petrolfied:

By 2030, most of the cars are still using combustion engines as their means of propulsion. However, the pressure on car manufacturers to be compliant with increasing emission regulations is rising, but yet not enough to trigger an immediate and holistic innovation of the powertrain. As electric cars remain a niche market, private and public investment in charging infrastructure is held back. Hence, affecting the purchase decision of customers and the existence of range anxiety. Moreover, the threat of new entrants is low as most of the entrant's business models rely on a rising demand of electric vehicles. As the further development of combustion engines is at its technological and regulatory limit, the competition is primarily characterised by the technological achievements in autonomous driving. In this case, the degree of technological development is very high, and products were introduced in a regulatory compliant way. However, the degree of vehicles using the level five technology is limited as most cities require fleet cars to be zero emission (Bloomberg, 2020). Hence, the breakthrough of autonomous driving and all its use cases is tied to the further development of electric vehicles.

Scenario 3 – Classic Car:

As the change within the industry is retained by favourable regulatory frameworks, the manufacturers use the momentum to fully exploit the existing products. By 2030, most cars are plug in hybrids in order to comply with the slightly increasing emission restrictions. However, the rising criticism of batteries harmful impact on the environment and the lack of eco-friendly production methods causes problems (Rapier, 2020): As further investments were postponed the technological development of autonomous driving and electric vehicles as well as complementary services is delayed. Hence, the differentiation and enhancement within the competition is mainly achieved through the development of better connectivity solutions. Furthermore, since the necessary technologies are not available, few opportunities are there to open up new mobility concepts and no legal framework for autonomous driving can be created.

Scenario 4 – Electrified:

Hereby, the consumers choice when buying a car is limited to 100% electric vehicles as combustion engines are prohibited by law. In addition, the total cost of mobility for electric vehicles decreased massively since production units increased. Hence, its being a more cost-efficient generally accepted option anyway, which is not subject to any restrictions with regard to charging stations and battery efficiency. Even though the total electrification of vehicles is favourable for the development of autonomous driving, the technological progress is falling behind. At present, there is no final legal framework that allows the use of autonomous driving as there are still problems within the pilot projects. The competition in the market increased strongly since electric engines became the common powertrain and former niche companies – specified in electric powertrains – are now fighting for market share as they can fully leverage their competencies.

4. Now please rank the respective scenarios according to their probability of occurrence – Preferably from high to low.

Part 3: Personal questions

1. Please provide information about your:
   - Industry
   - professional position
   - field of activity
   - Name of employer

Appendix 8 – Interview results

Interview Partner	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
MSC	5	4	2	3	2	3	3	5	4	3	34
DAS	4	3	4	4	5	3	4	5	3	5	40
YKR	4	4	5	4	3	4	5	4	5	4	42
JST	4	4	3	2	3	4	5	4	3	3	35
UBA	3	3	1	3	3	4	4	3	2	5	31
VHA	4	4	4	2	2	3	5	3	3	3	33
FGO	3	4	4	2	4	4	4	3	4	5	37
PLE	5	5	3	2	4	5	4	3	2	3	36
Total	32	31	26	22	26	30	34	30	26	31	288
Awerage	4.0	3.9	3.3	2.8	3.3	3.8	4.3	3.8	3.3	3.9	3.6

Median	3.8
Max	4.3
Min	2.8

Table 4 –Interview results (own illustration)

Uncertainties named	Total
Mobility Concepts	3
Competition	1
Digitization	2
Supply Chain	1
Raw materials	3
Autonomous Driving	4
Environmental legislation	6
Political impact	4
Customer needs	2
Incentives	1
Digital sales	1
Batteries for EV	1
Energy supply for EV	1
Alternative powertrains	1

Table 5 –Interview results (own illustration)

Appendix 9 – Expert opinion on Scenario matrix

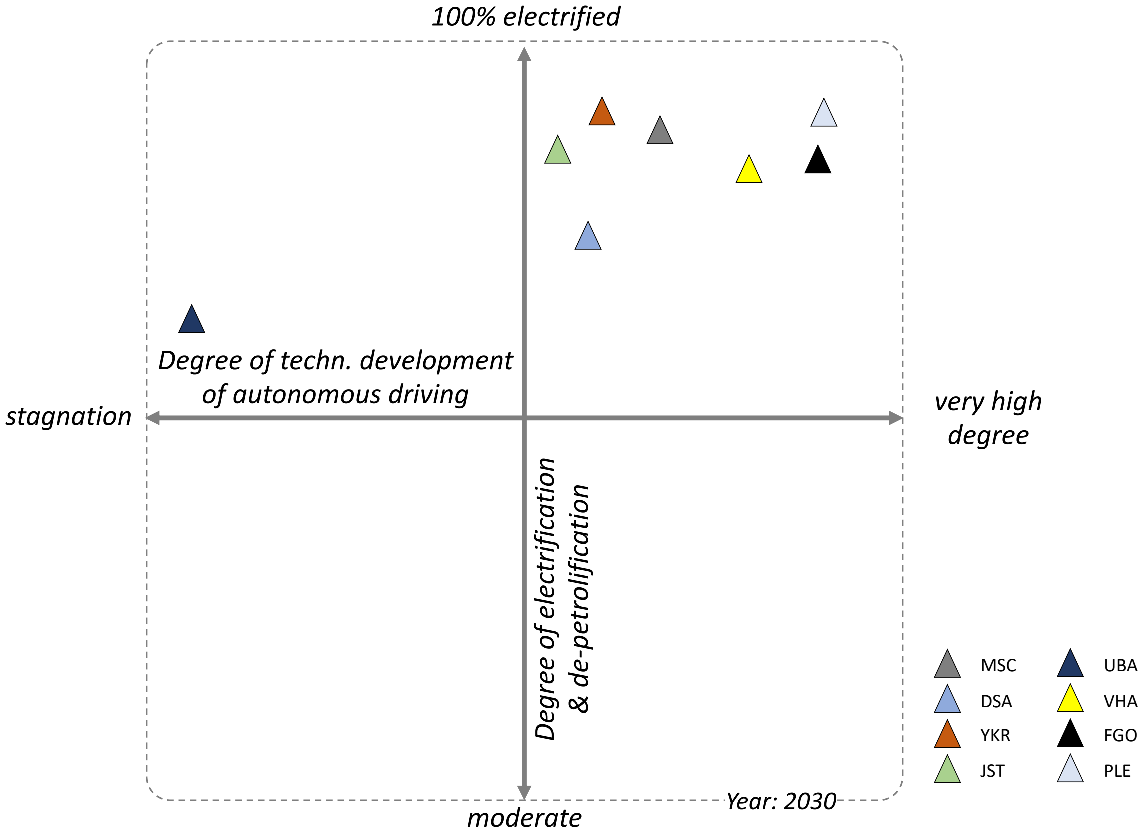


Figure 4 – Expert opinion on scenario matrix (own illustration)