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The interaction between industrial policy and business in the automotive battery industry

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Before all, let me express my gratitude to my thesis supervisor, Professor Jean-Christophe Defraigne, who has also taught me a lot during 6 weeks about European Public Affairs. His advice, knowledge, guidance and availability did not only contribute to the realization of this thesis, but it gave me also the opportunity to debate and to learn more about the topic.

In addition, I would thank every person who helped me to realize this research paper, especially my colleagues at MINI (BMW Group Belux) for their professional knowledge et help during my five-month internship.

Finally, I'm deeply grateful to my family and friends for their permanent support since the beginning of my academic journey. They helped me to overcome a lot of obstacles not only during the realization of my thesis, but also during my whole academic career.

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ABBREVIATIONS

BEV	Battery Electric Vehicle
CATL	Contemporary Amperex Technology Co. Limited
CN	China
EU	Europe(an)
EV	Electric Vehicle
FCV	Fuel Cell Vehicle (hydrogen)
GM	General Motors
HEV	Hybrid Electric Vehicle
ICV	Internal Combustion Vehicle
IEA	International Energy Agency
JP	Japan
KR	South-Korea or Republic of Korea
PHEV	Plug-In Electric Vehicle
R&D	Research & Development
VW	Volkswagen
ZEV	Zero Emission Vehicle

INTRODUCTION AND STRUCTURE

The transition to electrified mobility has become a very intense subject since several years, especially since some car manufacturers have announced to produce only electric vehicles from 2025 at the earliest. This consolidates the real desire to disturb the supremacy of internal combustion vehicles by switching completely to cars using green fuel and electricity.

From that point, we can think about who will benefit from the electrification of the automotive industry. Indeed, we know from several technical sources that 40% of the EV's value is made up of the battery which gives significant power to the battery producers, potentially disrupting the automotive landscape. However, the technology is not that advanced when we notice the poor level of infrastructure which is already implemented in the world regarding charging points for electric vehicles. Moreover, we can also ask ourselves if the production capacity of EV batteries will meet the future demand and achieve the environmental and economic goals set by the (intra)national governments and car manufacturers.

The reason why this subject interests me so much, is because I have worked during my academic career as business consultant for several car manufacturers like Opel, Mercedes-Benz, and Porsche. Lately, I also completed a five-month internship in the product and marketing department of MINI at the BMW Group Belux in Bornem. During these professional experiences, I witnessed the importance that these brands gave towards the launch of their electric models. After numerous discussions with senior employees[1] from Porsche and MINI, they confirmed me that the expectations are high regarding the electrification of the automotive landscape and that electric vehicles will surpass the share of internal combustion vehicles in the following decades. However, the most of them had also the opinion that hydrogen will also play an important role in the automotive industry.

At the beginning of my master's degree at the Louvain School of Management, I had to choose a major with specific courses. After having strongly considered Finance and Marketing, I chose

[1] Thierry Van Dalen - Managing Director at Kronos Porsche Center; Didier Van Dalen – Business and Marketing Manager at Kronos Porsche Center; Bart Verhoef – Head of MINI Belux; Joachim Sas – Sales Manager at MINI Belux; Alexandre Cuvelier – Product Manager at MINI Belux

the major in European Business because my curiosity for companies across all industries and continents was high. Besides, the European institutions and EU policy in general was something I loved to read. As a European citizen, I believe that it is also our duty to follow the actuality regarding the implications and influence of European decision-making. In addition, the strategies of different countries on how they crave to gain economic power and influence worldwide, as well as for its companies, was also a key argument to deepen my knowledge in this matter. Add to this my natural fascination for the car industry and you have the following research question:

"Which automotive manufacturers and EV battery producers are going to benefit the most economically from the radical change into electrified mobility and which countries will, thanks to its national policy, have a greater influence in the automotive industry?"

The aim of this research question is to identify who will benefit or suffer from the electrification of the automotive landscape. To do so, we will have to define criteria for the identification of the companies and countries that will be considered in this analysis. Afterwards, we will choose some criteria which are relevant to use in order to discuss when a company or country will benefit of suffer from the electrification. For each criterium, facts and decisions taken by the manufacturers and countries will be discussed and an analysis will be done. This analysis will be written by putting the strengths and weaknesses of the companies and by comparing to each other. Besides, according to data analysts and forecasters, we will look to the evolution of the EV compared to ICV till 2030.

Firstly, an overview of the actual automotive landscape and battery industry will be given through figures and facts about the commercial partnerships between the battery producers and the car manufacturers. We will identify the main players in those sectors which will be considered through the whole analysis. It is not unsurprisingly to say that strong partnerships will increase productivity and efficiency and result to a real advantage in a new electrified car industry.

Secondly, some criteria will be discussed by analyzing the main actors[2]. The strategic vision of the main actors in the EV industry, the EV sales, EV models and the progress on technological

[2] Car manufacturers, battery producers and countries/regions

knowledge through investments and patents will be investigated and analyzed. A SWOT analysis will also be done so that we can regroup the analyzed criteria into strengths and weaknesses. Additionally, the industrial policy on the automotive industry pursued by the EU and national governments like France, Germany, China, Japan, South-Korea and the United States of America will be studied. A last criterium that will be discussed is the demand and acceptance of the EV market.

Afterwards, we will have a look on the estimated evolution of the EV market share compared to the traditional ICV. This will allow us to see if the electrification of the automotive industry will really change the actual automotive landscape the next 10 years. We should bear in mind that these forecasts will give us a better idea of whether the goal of carbon neutrality by 2050 announced by many companies such as Toyota, Volkswagen, BYD, Ford and GM can be achieved.

The last part of this thesis will conclude the findings, analyses and discussions done in all sections. More important, a conclusion will be formulated on our research question which will give some indications concerning the winners and losers of the electrification of the automotive landscape. In addition, I will express my personal reflection on the subject and explain some limitations about this report. Indeed, by making this report, it came clear that not all comparison would be feasible because of the limitation of access on a lot of information, especially for Asian countries.

RESEARCH QUESTION

In this section, we will provide a more detailed explanation about the criteria which we will able us to find an answer to the research question:

"Which automotive manufacturers and EV battery producers are going to benefit the most economically from the radical change into electrified mobility and which countries will, thanks to its national policy, have a greater influence in the automotive industry?"

The first criterium concerns the strategic vision that the companies will adopt and their long-term goals they want to achieve. It is important to take it into account because it will highlight how serious the measures taken by those manufacturers can be considered and will also help to predict who will take advantage of the global electrification of the worldwide mobility. Their mid- and long-term plans and their current and future EV sales and models will have a great impact on their market share on the EV market in the first instance. Consumers will have more choices and possibilities to acquire an EV of the same brand because each model will have its own features[3] and will be ranged by price categories. The economical target, such as the EV share of total sales will also give an indication to what extent the car manufacturer is betting on electric cars in the following years. As a result, those car manufacturers aiming to become full electric in the long term by adapting their economic and corporate strategy in that direction, will contribute to make them a potential winner. Those claims on their strategic vision will be retrieved especially from their annual reports and press conferences. As these claims are made public, we can assume that they will respect their long-term vision and objectives, especially because that information will be essential for their investor relations.

Technological knowledge is another criterium that we will use to find out which company will benefit from the electrification of the automotive landscape**.** It seems pretty logic to assume that the players who are the most advanced in the needed technology to make high performed batteries and cars will have a real advantage on their competitors in the industry. This makes certainly sense if you consider the fact that the EV technology is still in development, considering the low market share of those electric cars. In this manner, we will not study the technical or scientific part of those technological advancement, but more on the

[3] Car body style, electric range, performance, advanced technology equipment, luxury

financial capacity and ability of the firms to invest in research and development. Indeed, companies which already have invested a lot in the past years will obviously have the capacity to continue their investments in the following years and decades. A summary of the R&D spendings of the main companies, retrieved from the EU Industrial R&D Investment Scoreboard, will be made. In addition, we will also look to the number of patents that the companies have registered on the European Patent Office & United States Patent and Trademark Office. This will also allow us to compare the capacity of each firm to register patents and thus invest in innovation and new technology. To cut it short, the amount invested in R&D and the number of patents registered will also give an indication which company will be able to invest more in EV technology and production, resulting in a potential beneficial of the increasing EV story.

The following criterium will be the industrial policy that the European Union and the national governments will adopt and apply in order to strengthen their national power in the automotive industry. By comparing the dimension and scope of those decisions, we should be capable to notice its impact, especially with China where the market share of EV sold has reached high percentages. State aid, restrictions and state intervention should be studied as it falls within the scope of national governmental decisions. Industrial policy can be divided in a vertical and horizontal dimension. The theoretical explanation of these dimensions, as well as the tools that the governments are intent to use, will be given and developed in the respective section. However, we can already assume that the greater the potential impact resulting from those political decisions and restriction are, the bigger state aid will contribute to pinpoint the winners and losers. The EV infrastructure and amount of EVs in a country will also play a big role as it will contribute to create an increasing market for EVs.

The acceptance of the consumers regarding electric mobility should also be considered. Indeed, if consumers do not believe the positive impacts on ecological and economical perspective to switch their habits regarding mobility to the electric alternative, then there is no big market opportunity to exploit and to take advantage of it. Based on scientific sources, an analysis will be made in order to find the working points which companies and governments have to work on. Therefore, the communication on the positive ecological impacts, tax benefits & purchase incentives on EV and the evolution of the charging infrastructure are important to focus on. To resume, the countries and companies which can

convince and expose the benefits of electrified mobility and the improvement of the EV infrastructure, will probably gain a better position to become a winner in the EV market.

After having analyzed and considered these criteria, we should be able to discuss which company could take advantage of the electric automotive landscape and lead the EV market in the future. In addition, it will also allow us to estimate the potential influence that some countries will have in the automotive industry.

Additionally, we must also keep in mind the actual influence of these protagonists in the automotive landscape. The market share of each car manufacturer and battery producer, but also the potential demand in different countries in which those companies operate, is also something to consider. Therefore, the EV sales and stocks in the biggest markets[4] will also influence the determination of the potential winners and losers in the EV market.

[4] China, Europe and United States

1. CONTEXT

AN ELECTRIC START WITH UPS AND DOWNS

The birth of electric vehicles has not started with Tesla. Instead, the first EV on the road was a result of breakthroughs by different investors and countries. Theoretically, the concept and creation of the first small-scale electric car was invented by innovators in the Netherlands, United States and Hungary in the 1800's. It is only in the mid and late nineteenth century that the first practical EV was built by inventors of French and English nationality (Department of Energy, 2014).

At the same time, a lot of innovations was made regarding the ICVs. Even when the demand for EVs was high in the early 1900s in the US thanks to the electric vehicle developments by Ferdinand Porsche[5], Thomas Edison[6] and Henry Ford[7], the introduction of the Ford's Model T penalized the accension of the electric vehicles due to its price and cheap fuel before being completely disappeared by 1935 (Department of Energy, 2014).

It is only when with the Arab Oil Embargo in 1973, resulting in high oil prices and shortages, that the interest in EVs has grown again to lower the dependence in foreign oil. A few decennia later, political decisions regarding emission regulations gave a boost in the development of the EVs in the US, which started seriously in the beginning of the 21st century (Department of Energy, 2014).

In 2000, Toyota released the first hybrid electric car[8] which was very successful around the globe and gave a second life to EVs. Six years later, Tesla Motor, who was a small Silicon Valley startup, announced the desire to produce luxury sport cars powered by an electric motor. This motivated other car manufacturers to accelerate their development of EVs (Department of Energy, 2014). Since then, almost all car manufacturers have released at least one electric model.

[5] Austrian-German founder of Porsche who developed the first electric vehicle Porsche-Lohner Chaise in 1900
[6] American inventor known for his invention of phonograph and incandescent electric light; but also for the development of an alkaline storage battery
[7] American founder of Ford Motor Company who developed the internal combustion vehicle Model T in the 1900s
[8] Toyota Prius

MAIN CAR MANUFACTURERS

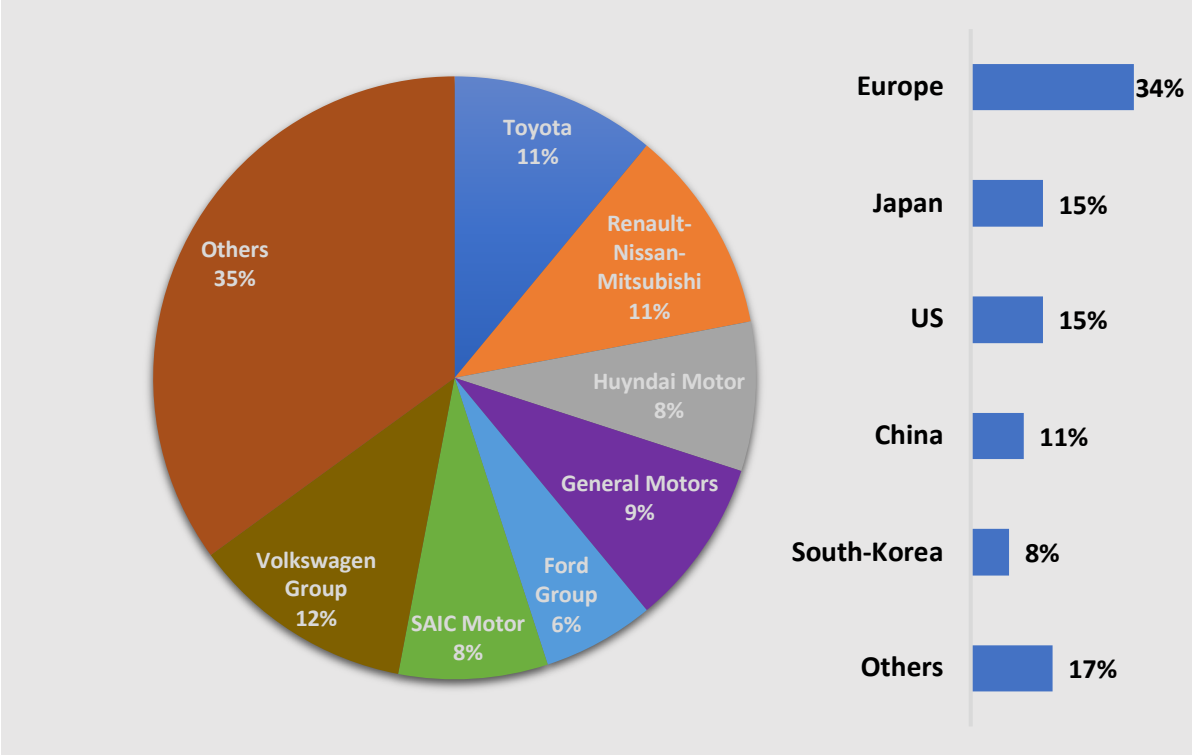

Figure 1 – Global share of main car manufacturers with corresponding nationality in 2018 (Bloomberg)

In the automotive market, we can notice that the competition is very though. According to Bloomberg, Volkswagen Group has the highest market share in terms of vehicles that are circulating on the road worldwide with 12%. The Japanese Toyota Motor Corporation and French-Japanese strategic alliance consisting of Renault, Nissan and Mitsubishi have 11% market share each. The first American car manufacturer, General Motors, stands on the 3rd place with 9%, followed by Hyundai and SAIC Motor with 8%. Ford Group is the second biggest American car producer with 6%. Considering only 'main' car manufacturers, we will not include for example PSA Group or Daimler AG in this thesis because they do not have reached 5% of world market share and are therefore represented in "Others". Concerning the market share at national level, the European car manufacturers are leading the market with 34%, which also include companies as BMW Group (4%), PSA Group (4%) and Daimler AG (4%).

Japan and the US are side by side with 15%, but as we count Renault-Nissan-Mitsubishi as an European Group, we have to consider Japan to have a more important market share than the United States in reality. China (11%) and South-Korea (8%) have also important and big companies which are playing an important role in the automotive industry. Note that Stellantis

has not been included in our analysis because the merger between PSA Group and Fiat Chrysler Automobiles took only place in 2021.

MAIN EV MANUFACTURERS

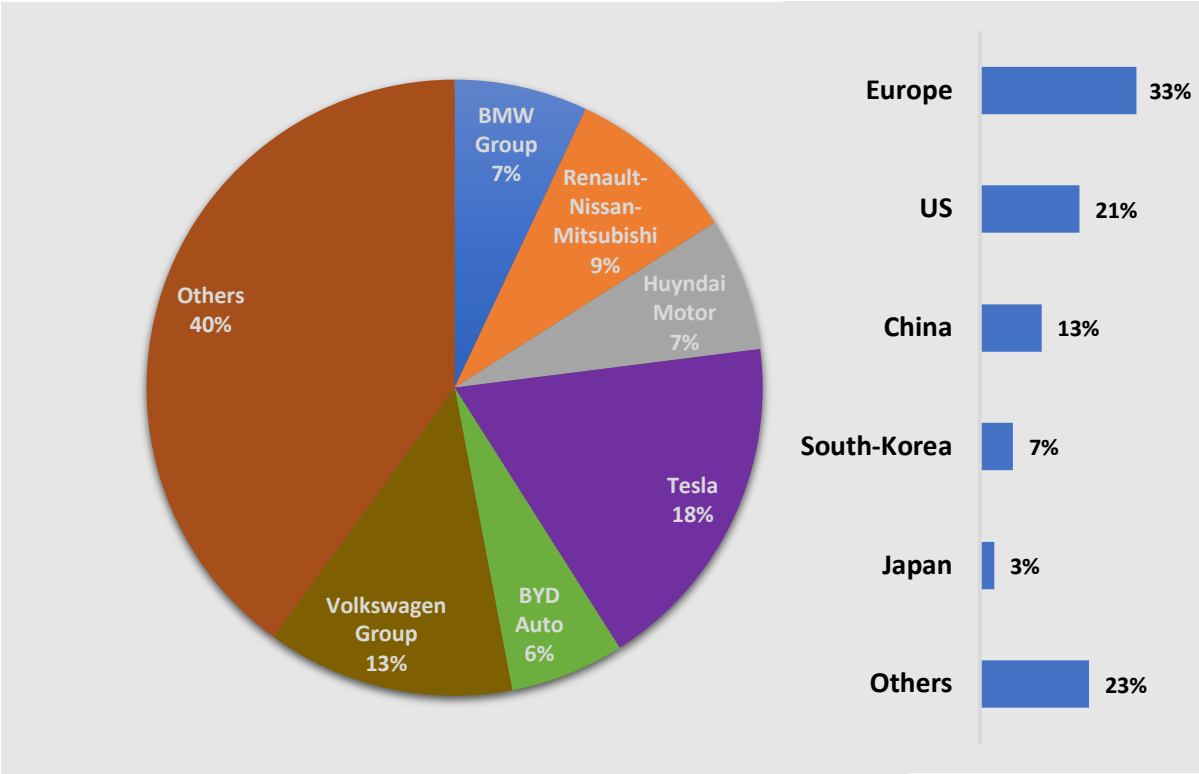

Figure 2 - Global share of main EV manufacturers with corresponding nationality in 2019 (McKinsey & Company and Statista)

In contrary to the global car market, we have a clear different situation in the EV market. Tesla, the only 100% electric vehicle manufacturer considering in this report, is also the market leader with a market share of 18% according to Bloomberg. This is not surprising when we know that Tesla made a huge bet to start the commercialization of EV in 2008. Behind Tesla, we find again Volkswagen and the Renault-Nissan-Mitsubishi Alliance with respectively 13% and 9%. Despite not having more than 5% market share in the global car market, 7% of the EV which are circulating on the roads are from BMW Group. Therefore, we will consider BMW as a 'main' car manufacturer. Hyundai and BYD Auto, which have 7% and 6% worldwide market share, will also be discussed in this work. Again, the cumulated European companies have the highest market share, but thanks to Tesla, we have the US on the second place. The most surprising information here is the low EV market share of Japan. However, this seems not to be weird when we can see that they prefer to invest more in hydrogen technology which is mentioned in the chapter tackling industrial policy.

MAIN BATTERY CELLS PRODUCERS

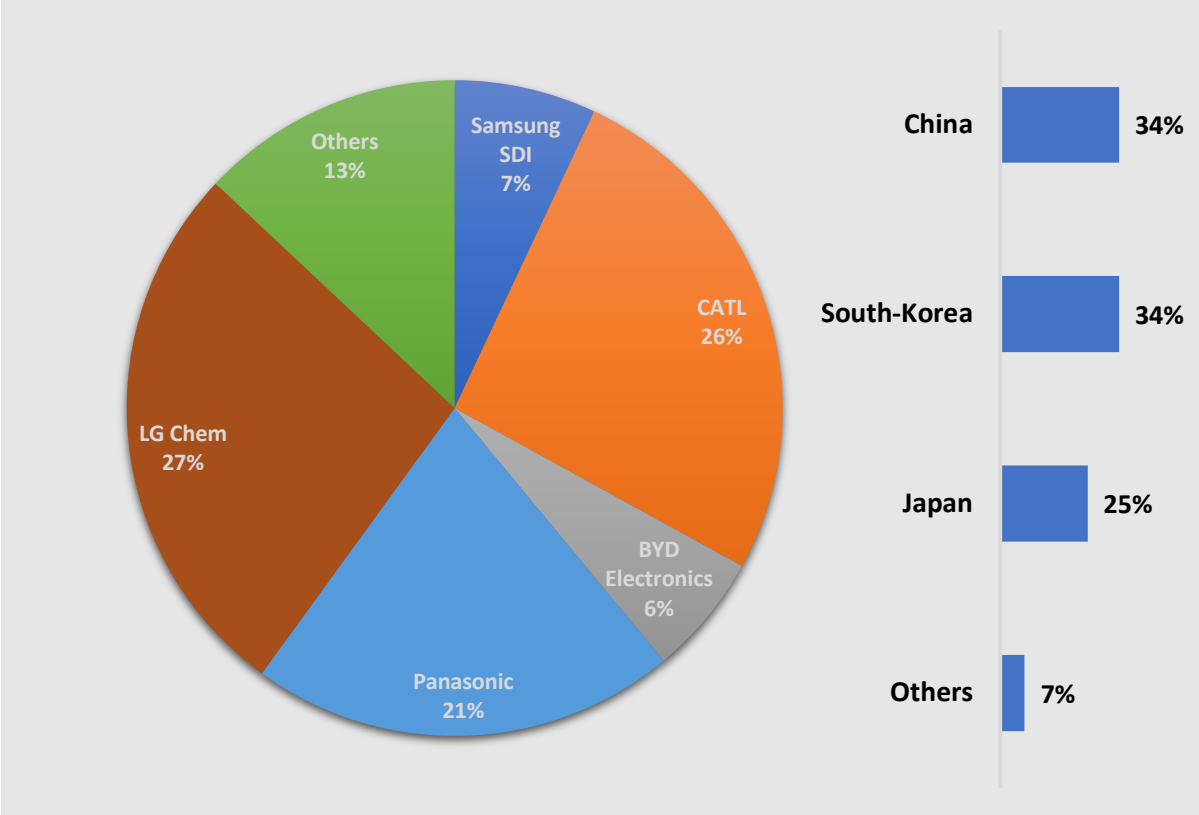

Figure 3 - Global share of main battery cells producers with corresponding nationality in 2020 (Bloomberg and Seeking Alpha)

In the battery market, there will be only 5 main battery cells producers which have a worldwide market share of 5%, which are all Asian companies. LG Chem is since 2020 the market leader with 27% market share, which has one percent more than its Chinese competitor CATL (26%). Still according to Bloomberg, we also have the well-known Japanese Panasonic, which is the closest battery provider of Tesla since a decade. With Samsung SDI (7%) and BYD Electronics (6%), we can notice that the market in battery cells is less competitive compared to the automotive market. However, an important fact is that we do not count the European nor American player among those Chinese, South Korean and Japanese companies in the battery industry. China and South-Korea are equally occupying 34% of market share, while Japan has 25%. Other companies as AESC and SK Innovation do not have the required 5% and therefore, they are not represented in this report.

COMMERCIAL AGREEMENTS AND BATTERY PRODUCTION PLANTS

There are only a few big battery producers who are supplying their battery cells to car manufacturers. To expose those commercial agreements effectively, an overview will be given here below with on the one side the suppliers in battery cells and on the other side the most well-known car manufacturers they partner with. In addition, a short analyze will be made regarding their production plants. As mentioned in the beginning of this paper, only the battery manufacturers with at least 5% of worldwide market share will be considered.

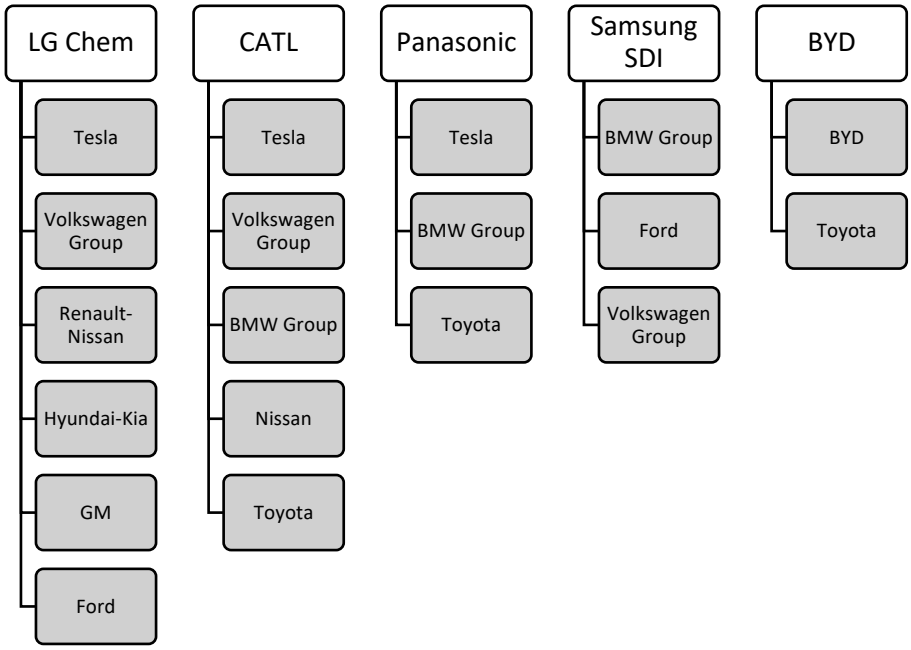

Figure 4 - Main EV manufacturers and their battery cell suppliers

LG CHEM

LG Chem is the leader in the EV battery market thanks to its commercial agreements with major car manufacturers such as Tesla, Volkswagen, Renault-Nissan, and General Motors. According to Financial Times, the South Korean company has dethroned CATL as market leader in the EV battery market and despite of the COVID-19, LG Chem has already $125 billions of orders planned till 2024. Besides, the market leader has production plants in the American State Michigan, China, Poland and South-Korea. Still according to FT, a production plant is currently under construction in Ohio (Financial Times, 2020). Reuters also confirms that LG is in advanced talks with General Motors to build another cell manufacturing plant in Tennessee. For this purpose, they plan an investment of $4,5 billion only for the American territory (Reuters, 2021).

CATL

CATL is not only one of the biggest suppliers in terms of volume to car manufacturers to produce their EV but has also the most commercial agreements with the producers of electric vehicles. However, we can notice that they do not have General Motors, Hyundai and Renault which are some big companies in the landscape of electric vehicles and cars in general. According to their annual report 2019, they produce 109 GWh which is equivalent of 1,8 million mid-size electric vehicles (CATL, 2019). Nonetheless, they will invest more than $4,49 billion in order to multiply their production capacity by three. These investments are mostly done to upgrade the existing production in their actual production plants, but also for the construction of new ones (Nikkei Asia, 2021). Between their yearly agreements with the leading EV producer Tesla and long-term partnership with the German BMW Group (BMW Group, 2019), the Chinese battery cell manufacturer has currently five production sites which are mostly situated on the Chinese territory. However, the Asian company has only one production base oversees and is built in the German region of Erfurt (CATL).

PANASONIC

The Japanese giant is since 2014 the principal supplier of battery cells for the leading EV company Tesla. The two companies have a close partnership since that year, the jointly operation of Tesla's Gigafactory battery plant in the American State Nevada is proving that (Asia Nikkei, 2021). So will Panasonic invest almost $100 million and add an extra production line in this American Gigafactory which will result in an increase of 10% in production capacity. In addition, the existing production lines will be upgraded and will allow to produce 5% more batteries at each chain of production (Asia Nikkei, 2020). However, the lockdowns due to the COVID-19 have negatively affected their overall sales for their financial year 2020 and early 2021. Nonetheless, statisticians forecast a positive trend for the years to come, especially thanks to the worldwide expansion of EV in the automotive landscape (Asia Nikkei, 2020). Concerning their activities in Europe, they are planning to expand their European production by building a new factory in Norway by collaborating with Equinor (Financial Times, 2020). Besides its principal agreement with Tesla, Panasonic also corporates with Toyota. According to Reuters, a joint venture between the two Japanese multinationals will produce lithium-ion batteries for the hybrid models of Toyota by building a factory in Western Japan which will be

operational in 2022 (Reuters, 2020). Besides their presence in Japan, US and soon in Europe, they have also three battery production plants in China (Panasonic).

SAMSUNG SDI

Samsung SDI is an important battery supplier for car manufacturers like BMW Group, Ford and Volkswagen. Operating already in Hungary since 2018 with a production capacity equivalent to make 50,000 EVs, they are upgrading its European battery production by investing $849 million and increase its capacity with 33% (Reuters, 2021). In addition, a potential deal is in making with Stellantis to build another European battery plant in Italy (Reuters, 2021). Still according to Reuters, Samsung SDI may invest $2,62 billion to set up a factory in the US which will help the shift to electrification and will especially supply Stellantis and Ford. Besides its Hungarian and potentially American factory, Samsung SDI has also production plants in South-Korea and China.

BYD ELECTRIC

The Chinese company BYD can be seen as the smallest of the five biggest EV battery suppliers. Indeed, it is the only who has no production sites outside the Chinese territory. Craving to supply their products to big car manufacturers in order to join actively the transition of electrification, they are looking for engineers to start their European expansion. However, there is no concrete deal, nor on the location, nor on the potential partners who will be collaborating with them (Reuters, 2021). Besides using their batteries to equip their own vehicles, the Chinese firm has also a joint venture with Toyota focusing on R&D of EV batteries and initially on the Chinese market. Because of COVID-19, the initial plan to increase its production to 100 GWh in 2020 has failed. However, with an actual production of 60 GWh, its planned investments of $2,4 billion will allow the battery producer to build two more battery plants in China and reach their goal of 100 GWh (Just Auto, 2021).

2. Criteria And The Main Actors In The EV Industry

A. Strategic Vision, EV Sales And EV Models

It is important to highlight the strategical vision, EV sales and BEV models of the car manufacturers in order to have a closer look on the future of the electrification in the automotive industry. To do so, we will consider only the car manufacturers that already have a significant market share in the EV market. Therefore, only those with at least 5 percent of market share will be considered in this section, which are Tesla (18%), Volkswagen Group (13%), BMW Group (7%), Hyundai Motor (7%), Nissan-Mitsubishi (6%) and BYD (6%).

The assumptions that we can do are the following:

- A strong strategic vision regarding electric mobility will probably have a positive impact for the future of the company. Those public claims of the car manufacturers must be taken with caution. However, the communication of their strategic vision will be heard by its stakeholders. Therefore, we cannot ignore the importance of those promises because it can influence the finances and investments of a company.

- The sales of electric vehicles are as important as the stock market share that we identified early in this thesis. It shows the capacity of a car manufacturer to sell a new product with new technology which is completely new for customers. It will also be interesting to analyze the evolution through several years. In this thesis, we will look at those sales from 2017 till 2021. It is from that year that the commercialization of EV became a major strategy for a lot of car manufacturers. We can assume that high EV sales will probably evolve positively in the future. However, we saw that some events, such as COVID-19, wars and high demand of car components that cannot be met by the suppliers can negatively impact the EV sales, even if they evolved positively through years.

- The EV product range is also something that can be seen as an important factor in our analysis. Logically, we can imagine that a large product range, and thus a larger choice of EV models, will gave an advantage in the electrification of the automotive industry.

TESLA INC.

Since the creation of the company in 2003, the core strategy of Tesla was to accelerate the world's transition to sustainable energy by offering green mobility through electric vehicles. In contrary to the other car manufacturers, the company of Elon Musk produces exclusively BEVs since the first day of their existence. With models competing in different segments, their CEO Elon Musk wants to make his brand and green mobility accessible and affordable to a maximum of people. Moreover, they are also developing batteries, renewable energy generation and offering storage solutions, which makes the combination of all their commercial activities more powerful (Tesla Inc.). Since 2017 till 2021, the American EV producer has sold more than 2,2 million BEVs, with almost a million in 2021. Actually, they have 6 models in sale (Tesla Inc.).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
18%	2,2 million	950,000	6

Table 1 - Key data Tesla

VOLKSWAGEN GROUP

"Shaping mobility – for generations to come." is the quote of their new strategic vision *Together 2025+*. The aim is ≈≈to actively shape the future of mobility in a sustainable way for present and future generations. Therefore, the German group promises electric drives, autonomous driving and digital connectivity in order to make the mobility cleaner, quieter, efficient and safe. In contrary to Tesla, VW Group is composed by a numerous of brands and must align their strategies together to optimally drive with the Group's vision[9]. The five modules to ensure the success of the development of their strategy are Governance, Performance, Brand Equity, Software-Enable Car Company and Excellent Leadership. Without going into details, they all support the sustainable, electric, and digital dimension of their global vision and strategy. By 2025, they want to bring more than 30 electrified models from the VW brand and more than 70 models cumulated through the whole group in the market while expanding their competences in battery technology and autonomous driving (Volkswagen, 2019). Their premium brand Audi is also planning 30 additional EV models and

[9] Volkswagen, Audi, SEAT, ŠKODA, Bentley, Bugatti, Lamborghini, Porsche, Ducati, MAN and Scania

have announced to phase out the production of ICVs by 2033 (Automotive News Europe, 2021). To achieve those targets, the German brand will invest €10 billion by 2025 (Audi). Since 2017, VW group has sold 1,4 million EVs whereof 750 thousand only in 2021. Through the whole Volkswagen Group, 34 models were already released worldwide (Volkswagen Group, 2021).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
13%	1,4 million	750,000	34

Table 2 - Key data Volkswagen Group

BMW GROUP

The BMW Group "Strategy NUMBER ONE > NEXT" arrow is oriented to the future, with the mission to offer first-class individual mobility and acting with sustained responsibility. By encouraging transparency and reliability in their whole supply chain and production, they believe that they are contributing to a more sustainable mobility in the future while making the Group one of the most profitable company in the automotive industry (BMW Group, 2020). In addition, they want to reinforce their leadership in innovation by investing more than 30 billion euros in R&D in order to improve the performance of their cars as well as the electrification, automated driving and connectivity of their commercial products and services. For 2023, they want to bring in 25 electrified models on the market, where 25% of all cumulative sales should be electric vehicles in 2025 (BMW Group, 2021). The German car manufacturer has sold 921 thousand BEVs since 2017, and 350 thousand last year. Today, BMW are selling 20 EV models (BMW Group, 2021).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
7%	921 thousand	350,000	20

Table 3 - Key data BMW Group

HYUNDAI MOTOR COMPANY

The South Korean multinational automotive manufacturer, who owns for a third percent Kia Corporation, has adopted a human friendly brand vision "Progress for Humanity" since 2019. The creation of more valuable time for whole humanity by providing mobility solutions allowing people to move and connect with each other will improve the journey of humanity.

Therefore, their mid- to long-term strategy 2025, which envelopes an innovation plan and a future mobility vision, is divided in two major commercial pillars: smart mobility device and smart mobility service. Their strategic management aims to secure a top-tier leadership in the electrification of the automotive industry, but also to increase the profitability of its ICVs and to improve the connectivity and digitalization of their platform-based services and business content (Huyndai, 2021). However, even if they plan to offer 16 EVs for 2025, they seem to believe and put more effort in the development of a hydrogen society with their 'FCEV Vision 2030' (Smith, 2020). This long-term roadmap will strengthen the leadership of the South Korean Group in the commercial production of the FCV with an annual capacity of 500 thousand units of fuel cell vehicles and 700 thousand fuel-cell systems by 2030 (Hyundai, 2018). As for today, Hyundai sells 11 EV models in the world. Since 2017, 946 thousand EVs has been sold and 375 thousand electric cars in 2021 (Hyundai, 2021).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
7%	946 thousand	375,000	11

Table 4 - Key data Hyundai

FORD MOTOR COMPANY

Founded by Henry Ford at the beginning of the 20th century, the American company Ford's vision is "*To help build a better world, where every person is free to move and pursue their dreams*.". Therefore, the car manufacturer has unveiled on the 20th of October 2020 their new strategy called *The Plan*: they want to generate growth, increase customer satisfaction and accelerate their transformation. By investing more in R&D, expanding their commercial offer, making their operations simple and modern, cooperating with other to acquire more efficiency and expertise, and offering unique electrified Ford vehicles, they want to achieve sustained profitable growth to build a better world for the future generations to come. For this purpose, they are also speeding up innovation in mobility and self-driving vehicles. Their current and future investments in EVs will reach $22 billion in 2025 while their investments in self-driving technology will attain $7 billion in that same year. For 2030, they want to offer only EVs in Europe with only 4 electrified models. In addition, 40% of the worldwide sold volume of commercial vehicles should be all electric in 2030 (Ford Motor Company, 2021). Concerning the EV sales during the last five years, Ford has sold 201 thousand EVs, and more than the half was in 2021. Today, they count 7 EV models in their product range (Ford, 2021).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
<3%	201 thousand	125,000	7

Table 5 - Key data Ford

GENERAL MOTORS COMPANY

Headquartered in Detroit, the American General Motors Company recognizes that an all-electric, carbon-neutral future is not an issue but an opportunity for them to reach a world with zero crashes, zero emissions and zero congestion. Promote safety, keep customers for life and build passionate and loyal brands are becoming part of their vision "We Are General Motors". In addition, creating sustainable solutions to ameliorate the communities in which we live and work is what they want to achieve. For 2025, they are committed to introduce 30 new electric vehicles on the global market (General Motors Company). Not only the electrification is an important chance to grow, but also developing self-driving vehicles will helping the transformation to a modern mobility. They forecast an electric sale of 1 million for 2025 with more than 3,000 R&D patents regarding electrification and an investment of $35 billion in EVs between 2020 and 2025 (General Motors Company, 2021). The American company had 13 EV models in 2021, with a total of 525 thousand EV sales in that same year. Since 2017, GM has sold 958 thousand electric car (General Motors, 2021).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
3%	958 thousand	525,000	13

Table 6 - Key data General Motors

TOYOTA MOTOR CORPORATION

The biggest Asian car manufacturer has declared a clear global vision as following: *"Toyota will lead the future mobility society, enriching lives around the world with the safest and most responsible ways of moving people"*. By improving consistently quality, innovating permanently, and contributing to the wellbeing of the planet, they strive to surpass the expectations of their stakeholders and customers. In comparison to the most main car producers, Toyota does not have a 100% electrified strategy. Indeed, their strategy seems to offer a multitude of options to their clients by promoting not only BEVs, but also HEVs, plug-in hybrid vehicles and fuel cell vehicles (Toyota Motor Corporation). However, their offensive

to lead the EV market does not seem to be less impressive, with more than 23,000 patents related to electrification technology. In addition, they are forecasting a total sale of 5,5 million EVs, which includes 1 million BEVs and FCEVs in 2030. As far their electrified offer concerns, they have already launched 13 models worldwide with an additional 15 new BEVs to come by 2025 (Toyota Motor Corporation, 2020). Since 2017, they sold 331 thousand BEVs and 120 thousand in 2021 (Toyota Motor Corporation).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
3%	331 thousand	125,000	13

Table 7 - Key data Toyota

RENAULT-NISSAN-MITSUBISHI ALLIANCE

One of the world's leading automotive alliances have put their strengths together to face the challenges of the ever-changing automotive landscape. To do so, they will play on all key technologies like autonomous driving, connectivity, electrification, and hybrid motorization (Renault-Nissan-Mitsubishi Alliance, 2020).

Individually, when we consider the French point of view, Renault launched with "Renaulution" their strategic plan to restore their competitiveness by benefiting from the Group's industrial assets and electrical leadership in Europe. In 2025, they aim to reach 30% of mixed sales to be electric vehicles and plan to have 8 fully electrified models to sell on the market (Renault Group).

On the other side, Nissan's corporate purpose "*Driving Innovation to Enrich People's Lives*" has defined their mission as "*providing unique and innovative automotive products and services that deliver superior measurable values to all stakeholders in alliance with Renault.".* For the financial year of 2023, they will offer 8 additional EV models where their total electrified product range will contain 10 electrified models (Nissan Motor Corporation, 2020). In addition, they plan to offer only electric cars in 2030, essentially in China but also on other key market where the Chinese electrified sales ratio is targeted at 60% and the European should be 50% (Nissan Motor Corporation, 2021).

The third automotive manufacturer in this alliance is the Japanese Mitsubishi Motors, which is headquartered in Tokyo. *"Create vibrant society by realizing the potential of mobility"*

reflects their vision which includes four missions: providing creative products and excellent service, contributing positively to the sustainable development of the whole society, acting sincerely and enhancing the value of the stakeholder by leveraging the Alliance. In its annual report 2020, they stated in their Mid-Term Business Plan "Small but Beautiful" that they will promote electrification, but mostly on the next-generation PHEV and HEV (Mitsubishi Motors Corporation, 2021). Concerning all electric vehicles and autonomous driving, they rely on the alliance, and especially Nissan, in order to play a role in those specific markets. For 2025, they only plan 5 EVs which will include 2 all-electric vehicles (Mitsubishi Motors Corporation, 2020).

The three companies totalize 18 BEV models in 2021 and sold in that same year 300 thousand BEVs. However, they sold together more than 1 million BEVs since 2017 (Renault, Nissan, Mitsubishi).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
9%	1,1 million	300,000	18

Table 8 - Key data Renault-Nissan-Mitsubishi Alliance

SAIC MOTOR CORPORATION LIMITED

SAIC Motor is the leading Chinese group in the automotive industry with 5,6 million vehicles sold in 2020. Building a global and innovative company that initiates the future in the automotive industry is what they want to achieve. Through a market-driver strategy, they want to create value for their stakeholders, but also with continuous innovation in connectivity, electric and autonomous driving, and an outstanding workforce. The Group has three own brands[10], but they also produce products by their joint ventures[11] which they sold in their home country (SAIC Motor). However, 47% of the 5,6 million vehicles sold are own brands, but in collaboration with its partners, the Chinese car manufacturer plans to have 60 own models, which will be PHEV, BEV and FCV (Reuters, 2020). Despite this, it seems that they want to become a worldwide leader in the hydrogen fuel cell cars with their "Hydrogen Strategy Plan", forecasting 10% of the Chinese market share in 2025 by producing 10,000 FCVs per year after having invested more than 3 billion yuan in R&D over the past 20 years and obtained more than 500 fuel cell related patents (SAIC Motor). The Chinese company sells 29

[10] MG, Maxus and Roewe.
[11] Baojun, Buick, Chevrolet, Iveco, Škoda, Volkswagen and Wuling.

BEV models worldwide. Since 2017, SAIC sold 619 thousand BEVs, which 250 thousand were sold in 2021 (SAIC Motor).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
3%	619 thousand	250,000	29

Table 9 - Key data SAIC

BYD AUTO

BYD considers solar power to be the biggest source of energy in the future, and therefore, aims to contribute to a sustainable mobility through electrification. Their mission is to focus on technological innovation for a better life through electric vehicles with the result to connect the city with zero emissions and zero pollution (BYD Company Ltd.). The special fact about BYD Auto is that they are the only company to make cars after having started as a battery manufacturer (BYD Company Ltd.). The Chinese giant has sold over 1,3 million BEVs since 2017, and almost 600 thousand in 2021 thanks to its 21 BEV models (BYD Auto).

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
6%	1,3 million	600,000	21

Table 10 - Key data BYD Auto

SUMMARY

Company	BEV sales (2021)	Actual BEV Models (2022)	EV Targets	Fully Electric?
Tesla	950,000	6	/	Since 2008
VW Group	750,000	34	- 20% sales (2025) - 70% EU sales (2030) - 50% US & CN sales (2030)	By 2030
BMW Group	350,000	20	- 25% sales (2025) - 7 million stock (2030)	/
Hyundai	375,000	11	- 1 million sales (2025)	By 2040
Ford	125,000	7	- 100% EU sales (2026) - 40% sales (2030)	By 2030
General Motors	525,000	13	1 million sales (2025)	By 2030
Toyota	125,000	13	> 1 million sales (2030)	/
Renault-Nissan-Mitsubishi	300,000	18	- 20% sales (2022) - 50% EU sales Nissan (2030) - 60% CN sales Nissan (2030) - 50% sales (2030)	By 2030 (Renault)
SAIC	250,000	29	30% sales (2025)	/
BYD Auto	600,000	21	/	/

Table 11 - EV data and targets (Annual reports & several sources)

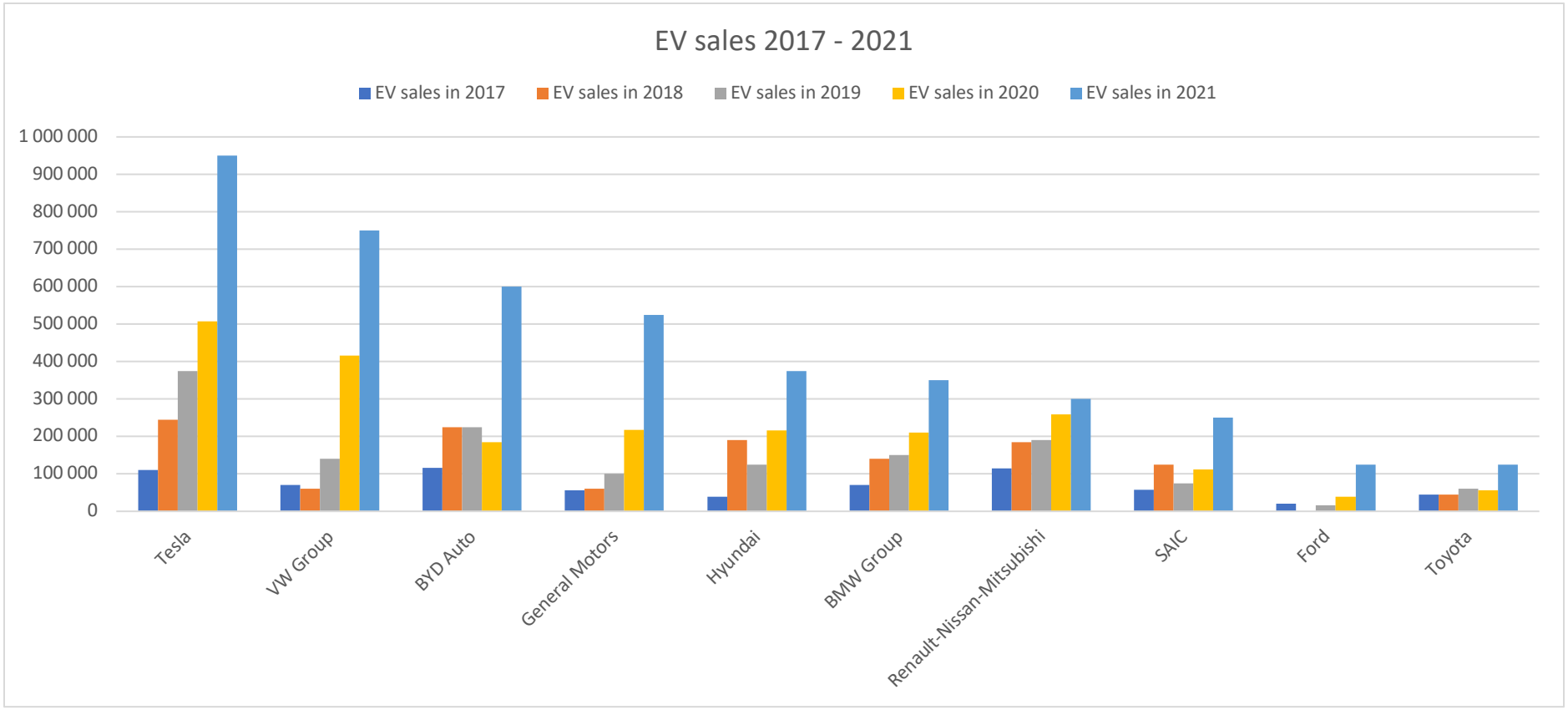

Figure 5 – EV sales from 2017 to 2021 (Several sources)

ANALYSIS

Tesla is by far the leader in terms of sales in BEV, but this was not always the case. In 2017, BYD auto sold more EVs than Tesla thanks to a growing Chinese EV market and the financial incentives that the Chinese government set up (see chapter Industrial Policy). However, the popularity in the US and Europe made Tesla booming their EV sales in comparison to BYD Auto. When we look to the latest EV sales of BYD in 2021, we can notice that BYD had sold three times more than in 2020. This phenomenon is also true for other companies, and the reason behind this can be the COVID-19. Indeed, as a lot of production plants was closed during 2020, it restarted at the end of 2020 and in 2021 to achieve high EV sales records for all car manufacturers (Nikkei Asia, 2022).

Today, in terms of EV sales, Volkswagen Group is the biggest challenger of Tesla. With its 34 EV models through different brands like Audi, Volkswagen, Seat/Cupra and even Porsche, the German car producer has a lot more electrified models than Tesla. It took them some time to compete against Tesla's models, but one of their strengths regarding Tesla is unsurprisingly the large product range they offer (Volkswagen, 2022). That same advantage has also BYD Auto and almost all the other main car manufacturers, Ford excluded who's selling 7 EV models today. However, Tesla is a given proof that a wide EV product range is not necessary a key factor for success. The American BEV producer has only 6 models today, but as a pioneer in the EV industry, the company of Elon Musk has been confirmed as a clear leader with high quality cars.

It is not a surprise that the evolution in EV sales is positive for all car manufacturers, as they all have released some EV models. The other competitors are almost in line regarding sales, but the low EV sales for Toyota can be very confusing. Indeed, those data is based on 100% BEV and thus, PHEV are not included in those sales. Therefore, we cannot underestimate the power of EV sales for Toyota because the Japanese company is also a pioneer in PHEV and EV. However, they decided a couple of years ago to concentrate themselves more in the commercialization of PHEV instead of BEV, but they have the financial and technological capacity to also attain high records in terms of BEV sales (Toyota Motors, 2020).

It seems obvious that the two Chinese car producers have great results regarding their EV sales, thanks to its domestic sales according to their annual reports and press conferences.

We can notice that SAIC and BYD Auto have tripled their EV sales since 2019, which is the highest progression compared to the other EV manufacturers.

The worst EV seller is Ford with only 125,000 units sold in 2021. This is not such a surprise when you consider the fact that they haven't sold any electric car in Europe, because they do not have any electric model available on the European territory. However, with an investment of $22 billion, Ford aims to increase their EV sales significantly, targeting 40% of EV sales in terms of its total sales worldwide by 2030. VW Group has also very ambitious EV plans by offering more than 75 EV models in 2025 and targeting 70% EV sales in Europe and 50% in China and the US. In addition, the German company foresees to offer only electric cars by 2030, alongside with their competitors Ford, GM and Renault. Hyundai, the only South Korean manufacturer in our list, has also great ambitions in terms of EV sales (1 million in 2025), with a long-term objective to go fully electric by 2040.

In general, we have the big players in EV sales which are Tesla, Toyota, VW Group and SAIC but also outsiders like BMW Group, Nissan and Hyundai as they proved to be efficient to sell its EVs referred to their EV share. Concerning BYD, they seem to be not that strong despite being the only one to also produce its own battery cells. If they want to play a bigger role in the global EV market, they will need huge ambitions in terms of international expansion in order to increase their commercial activities in exports.

CRITICISM

It is legitim to question if the objectives and targets regarding EVs are seriously considered inside the company. However, those EV claims and goals are retrieved from official sources like annual reports and press conferences and shared all around the world. It should be very unlikely that those companies will announce their long-term vision and goals without wanting to achieve them because of the high risk of seeing their investor relations deteriorate. Indeed, those claims can hugely influence their shareholders and will not leave without consequences if they will not respect and follow their promises. Therefore, those companies will at least try to achieve their long-term goals regardless of struggling to achieve them. Besides, as we will look to the political objectives in the following sections, we will assume that the EV visions of the companies are sincere and trustworthy.

B. Technological Knowledge

Technological knowledge is an essential aspect to consider if a company will excel in a fast-growing industry. The importance implies not necessary on its ownership like Tesla, who is a pioneer in the electric automotive industry, but also to the means that a company must acquire and develop those knowledges. We will have to compare the power of investments in R&D for the concerned actors in order to identify who has the ability to acquire new technology consequently and in a short period of time. As the electrification of the automotive industry is not that advanced, with also a lack of EVs offered on the market, we can easily consider that the identified strength to invest will play an important role in the competition of the electrified vehicle market. In addition, the number of patents will also give a clear indication of the company's ability to take advantage of a technological change in the automotive landscape. For practical reasons, we will only consider the companies which have already a huge impact in the automotive industry. Therefore, the car manufacturers with at least 5% of worldwide market share on the global or EV market will be discussed. Concerning the battery cells producers, we will also consider only those with a minimal 5% of market share.

C. Research And Development Expenses

Automotive Industry

Considering "The EU Industrial R&D Investment Scoreboard" of the European Commission, we retrieved the R&D spendings from 2015 till 2020. Those data will allow us to identify the car manufacturers which spend a lot in technological knowledge and are keen to follow the electrical evolution in the automotive landscape. An important limit of this criterium is that we cannot find out the proportion of those investments into R&D for electric vehicles. This means that we must consider the companies with high R&D spendings as one of their strengths, but it does not mean that those companies are automatically taking the advantage in this market. In the same logic, we cannot consider unquestionably the companies with low R&D spendings as disadvantaged in this market.

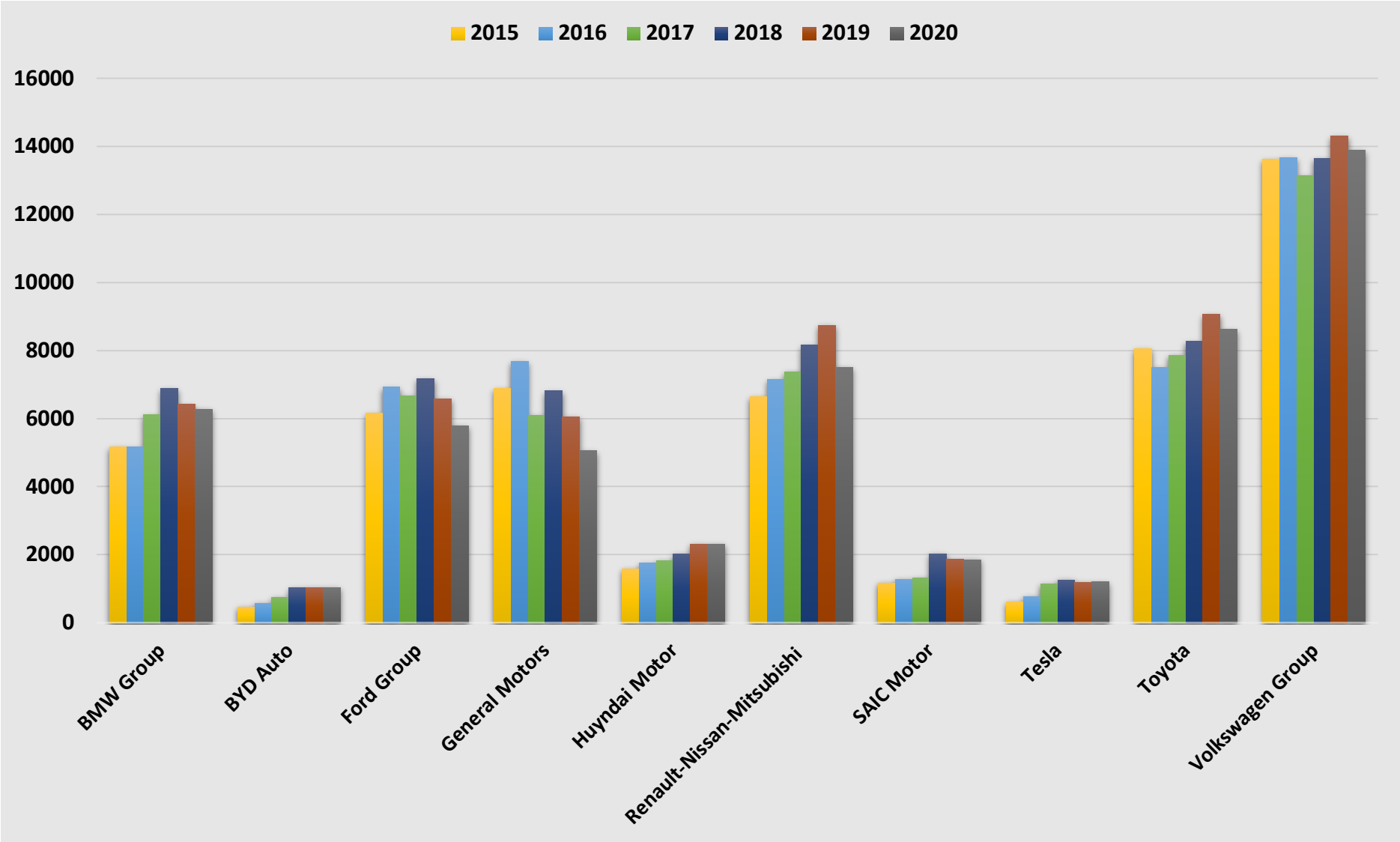

Figure 6 - R&D spendings from car manufacturers (2015 – 2020)

In general, can notice that the R&D spendings of almost all the companies evolved positively. However, Ford and GM are those which lowered their investments the most. This is not in the advantage of Ford that has also a low level of EV sales and BEV models. Furthermore, the R&D spendings were decreasing for all companies since 2019. A possible explanation can be the economic crisis due to COVID-19.

Volkswagen Group has the highest R&D spendings since 2015. An assumption is that the German Group includes a numerous of brands (Audi, Volkswagen, Skoda, Seat/Cupra etc.) containing a lot of models compared to its competitors. Indeed, having hundreds of models including 34 BEVs all over the world, we can say that the improvement of those existing models and the creation of new ones can easily explain the fact that the VW Group has the highest R&D spendings. This allows us also to believe that they have the capacity to release new models and to adapt themselves when big changes happen in the automotive market, and thus to its electrification.

BMW Group, Ford, GM, Toyota and the French-Japanese Alliance are approximately in the same line regarding their amount of investments. However, with Toyota and Ford having an inferior number of EV models, two hypotheses are possible: they invest not the same amount of their R&D in 100% electric vehicles as their competitors, or they have invested a lot with the aim to release more models in the coming years.

Surprisingly, Tesla and BYD Auto do not have high investments compared to the rest of the companies. For Tesla, this is maybe not such a surprise because they are a pioneer in BEVs and have already acquire a lot of technological knowledge since their creation in 2008. Moreover, the American BEV manufacturer has exclusively 100% electric vehicles, which totalizes 6 commercialized models worldwide. Based on the same assumption than for Volkswagen, a lower number of models requires less R&D spendings can be assumed. Concerning BYD, partnerships with Daimler AG (which includes Mercedes-Benz and Smart) and Toyota can be considered to formulate a reason for their low R&D spending (BYD Auto, 2020). In addition, the company is the automotive subsidiary of BYD company, which also includes the EV battery producer BYD Electronics. Having the capacity to produce its own batteries, gives the automotive subsidiary an advantage to its competitors. Those two factors are assumptions to explain the low R&D spending.

BATTERY INDUSTRY

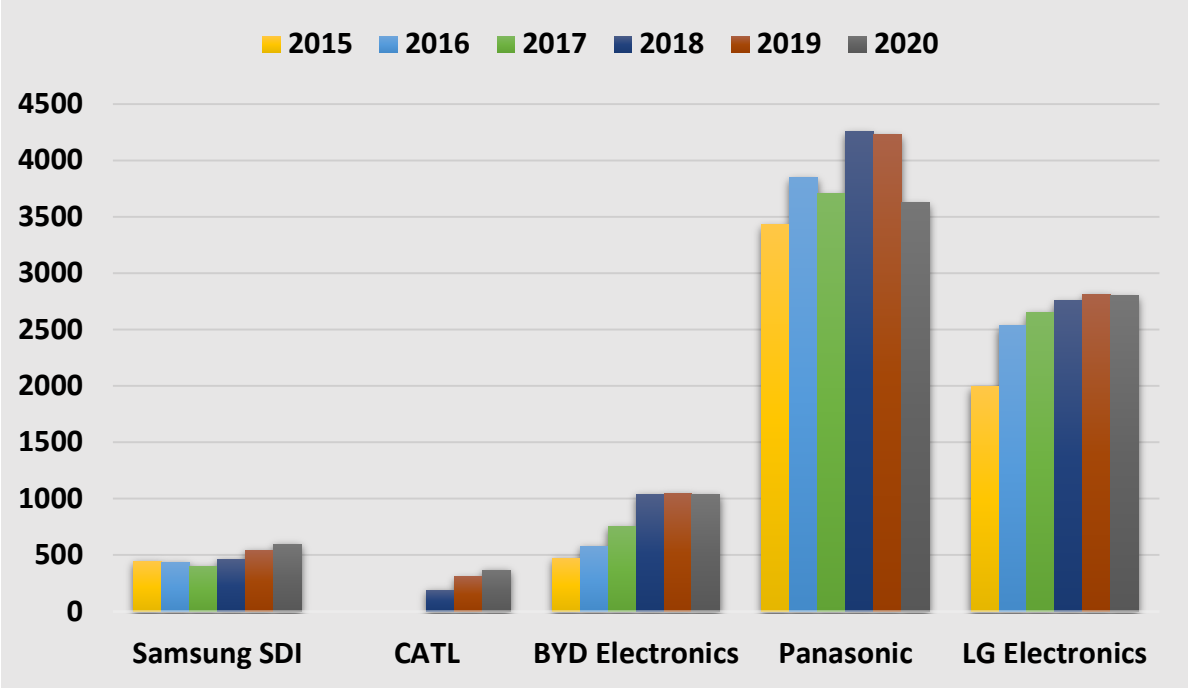

Figure 7 - R&D spendings from battery producers (2015 – 2020)

The battery producers do not have the same amount of expenses for R&D in comparison to the car manufacturers. Panasonic is the highest R&D spender since 2015 and has invested 3,6 billion of euros while BYD electronic has invested 3,6 times less in research and development compared to the Japanese company. LG Chem, who has the highest market share in the battery EV market, has only spent over € 850 million, but being part of LG Electronics, which has spent €2,8 billion, we can assume that the difference is not too big. At the bottom of the ranking including the 5 selected battery manufacturers, we find Samsung SDI and CATL. Again, even if CATL has the lowest spending in R&D, they have such consequent market share that we can consider that they are already advanced in the technology of battery cells a lot of years before 2015 (European Commission, 2020).

It is difficult to compare those data because the battery producers do not only sell EV batteries but also other smaller electronic components and products. In addition, the high R&D investments of Panasonic and LG can be a reason for having a high market share. However, this assumption is difficult to justify for CATL which has the second largest market share, but the lowest level of R&D spendings.

D. PATENTS

In terms of patents, almost all companies have a great number of registered patents. According to the European Patent Office and United States Patent and Trademark Office, only Tesla, SAIC Motor, CATL and BYD (Auto and Electronics) have less than 2,000 patents granted. All the other firms have more than 10,000 patents registered, except BMW Group which has around 7,500 patents. The assumption of this factor is as following: "A company with a high level of granted patents has an important force to innovate and thus to be a protagonist in technological evolution in their industry and market".

Here below, a summary of the data retrieved from the European Patent Office and United States Patent and Trademark Office is given in following table[12]:

Company	R&D Spending (average 2012-2020)	Number of patents
VW Group	12,959	10,000
Toyota	7,728	10,000
Renault-Nissan-Mitsubishi	7,002	10,000
Ford Group	5,975	10,000
BMW Group	5,482	7,500
General Motors	6,164	10,000
Hyundai Motor	1,695	10,000
SAIC Motor	1,321	100
Tesla	780	900
BYD Auto	663	1,800
Panasonic	3,769	10,000
LG Electronics	2,393	10,000
Samsung SDI	340	10,000
BYD Electronics	663	10,000
CATL	297	1,100

Table 12 - R&D and Patents Data (European Patent Office & United States Patent and Trademark Office)

[12] Dark green highlights the highest variable; Light green underlines the variables above the average of all companies; Dark red represents the lowest variable; Light red indicates the variables below the average

AUTOMOTIVE INDUSTRY

We notice in this table that the big car manufacturers have a lot of granted patents. Indeed, the European and American car companies have all more than 10,000 patents, including Toyota. We have to take into account that those patents concern not only the EVs, but also the internal combustion engines and other technologies such as autonomous driving, and in general all research that touches their commercial activities. BMW Group has the lowest number of patents compared to its European and American rivals, but they do it quite remarkable with 7,500 granted patents.

It is eye-catching that the lowest R&D spenders have also a low level of granted patents. Indeed Tesla, BYD Auto and SAIC Motors have less than 2,000 patents which is really contrasting with their competitors who have more than 10,000 patents. However, a theory of the low level of patents for Tesla is that they only sell 6 BEV models. The other companies also develop ICVs and FCV with a lot of models for different sub brands. Therefore, it is difficult to compare Tesla with the other car companies from that point of view. Knowing that SAIC Motors has a very close and strong partnership with Volkswagen, we can assume that they benefit from their technological knowledge. Lastly, the partnerships between BYD Auto and Daimler/Toyota can allow the Chinese company to benefit from their technological knowledge.

BATTERY INDUSTRY

Concerning the battery companies, we do observe the same assumption of a positive relation between R&D spendings and granted patents. Panasonic and LG Electronics have more than 10,000 patents on their name. Nevertheless, Samsung SDI and BYD Electronics have both also more than 10,000 granted patents in contrary to CATL who has only 1,100 patents. We could consider the same assumption as we did for the R&D spendings. CATL has a low level of patents and R&D spendings, but it did not prevent the Chinese company to have the second largest EV battery sales in the world.

CRITICS AND LIMITATIONS

We have to admit that there are some limits considering this criterium.

- It is difficult to know the attribution of patents for electromobility. The patents concern innovation across all the commercial activities and products of the companies. The aim was to isolate the patents that concerned only the research and innovation of EVs, but on the two official searching portals, it is not possible to isolate them efficiently.

- The use of the European Patent Office and the United States Patent and Trademark Office allowed us to find the total number of patents. However, we can put some interrogations about the accuracy of the amount of granted patents for the Asian companies. Indeed, as there is no Asian portal regrouping the patents of companies, we had no choice than taking the information from the European and American portal.

3. SWOT ANALYSIS

After having studied and analyzed some criteria, we can establish a SWOT analysis. SWOT stands for Strengths, Weaknesses, Opportunities and Threats. The aim of a SWOT analysis is to provide a realistic and reliable overview of the strengths and weaknesses of a company within its industry. In addition, it also allows to consider the opportunities of threats that can occur for the company (Helms & Nixon, 2010). Here below, we will give the theoretical explanation of those four concepts.

1) Strengths

   The strengths of a company can be seen as their assets. Therefore, this is an internal factor because it highlights the elements that the company does best.

2) Weaknesses

   In contrary to the strengths, the weaknesses of a company highlight what will prevent the company to develop and reach their strategic vision and goals. However, a similarity with the strengths is that it is also an internal factor.

3) Opportunities

   Opportunities are external factors which could be beneficial for the company if it handles it well in order to take advantage of it. Those chances or openings should have a positive outcome for the company.

4) Threats

   The other external factor of the SWOT is a threat that can occur in a negative way for the company. Indeed, an outside event which occurs in the market or industry and is harmful for the company is called a threat.

In the following pages, we will draw an overview of those 4 factors for the car manufacturers. We will sum up the strengths and weaknesses, but we will split them in order to sum first the criteria we saw before and then some other new strengths and weaknesses. Concerning the external factors, a lot of them will be the same because there are related to the market.

	SWOT Analysis			
	Strengths (seen criteria)	**Weaknesses (seen criteria)**	**Strengths (unseen criteria)**	**Weaknesses (unseen criteria)**
VW Group	- High market share - High EV sales - A lot of EV models - High R&D spendings		- Famous brands - Global supply chain - Large, diversified brand portfolio	- Weakened brand reputation after Dieselgate
Toyota	- High market share - High R&D spendings	- Low EV sales - Few EV models	- Pioneer in EV (PHEV) - Famous brand - Global supply chain - High production capacity	- Not premium brand - Low product differentiation
Renault-Nissan-Mitsubishi	- High market share - High EV sales - High R&D spendings	- Low EV sales	- Experienced and well-known brands in market - Economies of scale - Sharing internal culture	- No clear leadership - Low quality brands
Ford Group	- High R&D spendings	- Low EV sales - Few EV models	- Global recognition - Huge dealer-network	- Dependence on US market - Dependence trucks/SUVs

BMW Group	- High EV sales - A lot of EV models - High R&D spendings		- Famous premium brand - Excellent reputation - Successful partnership in China - Competence in EVs	- Less product differentiation - Small brand portfolio - Many legal cases
General Motors	- High EV sales - High R&D spendings	- Few EV models	- Joint ventures with Chinese companies - Strong presence in US - Timing and frequency of new model releases - Rare recalls	- Dependence on US market - Brand awareness - Dependence trucks/SUVs
Hyundai Motor		- Low EV sales - Few EV models - Low R&D spendings	- Excellence in safety and design of cars - Economic & durable cars - Strong presence in China	- Poor brand portfolio - Low presence in US - No presence in Japan
SAIC Motor	- A lot of EV models	- Low EV sales - Low R&D spendings	- State-owned firm - Highest sales in China	- Low awareness for SAIC domestic brands - Low presence outside Asia
Tesla	- High market share - High EV sales	- Few EV models - Low R&D spendings	- Pioneer in BEV	- Price of products compared to competitors

			- Strong partnership with battery-suppliers - Sturdy brand image	- Not able to meet the demand
BYD Auto	- High EV sales - A lot of EV models	- Low R&D spendings	- Price advantage - Own battery production	- Low international brand awareness

	Opportunities	**Treats**
VW Group	- Collaborations/partnerships - Diversified product portfolio - Expansion in emerging markets	- Fines (Dieselgate) - Ongoing lawsuits - Europe EV/CO2 regulations
Toyota	- Collaborations/partnerships	- Demand for BEV vehicles instead of PHEV - EV/CO2 regulations
Renault-Nissan-Mitsubishi	- Expansion in emerging markets - Development of EVs	- Can provoke synergies, M&A by competitors - Alliance image because of arrestation of Carlos Ghosn - Europe EV/CO2 regulations
Ford Group	- Offers eco-friendly cars - Global expansion through market penetration - Growth through product development	- Closure of production plants in Latin-America
BMW Group	- Focus on emerging markets - Offers eco-friendly mobility	- Europe EV/CO2 regulations

General Motors	- Timing and frequency of the new model releases - Strengthen Presence in Emerging Market - Diversify Portfolio	- Civil Lawsuits
Hyundai Motor	- Timing and frequency of new model releases	
SAIC Motor	- Market penetration at international level	- Diminution of EV subsidies and EV purchase bonus from Chinese government
Tesla	- Demand in BEV - Large market potential - Introduction of own battery production	- Limited EV infrastructure - Lithium supply - Cheaper alternatives
BYD Auto	- Market penetration at international level - National planning - Government support	- Patent dispute - Diminution of EV subsidies and EV purchase bonus from Chinese government

Table 13 - SWOT Analysis (retrieved from several sources

ANALYSIS AND DISCUSSION

We can notice that each company has its own strengths and weaknesses, but also some in common. Indeed, the big companies like Volkswagen, Toyota, Ford, Renault-Nissan-Mitsubishi and BMW are famous brands around the world while SAIC and BYD (and in a lower-level Hyundai) are locally in a very strong position, but less at international level. The biggest and most influential companies have also many partnerships which optimize their chances to expand their commercial activities in markets where their influence is not high.

The German group Volkswagen AG and Renault-Nissan-Mitsubishi have almost the same situation. They have good EV results and their global presences in Europe and Asia have similarities, the Alliance through its nationalities and Volkswagen via its partnership with SAIC Motors. In addition, they are also famous brands, but one is more considered as premium[13], and the other one lower quality brands. However, Volkswagen received negative press a few years ago due to Dieselgate, which is not really the case for the Alliance, although the arrest of Carlos Ghosn did not give Renault-Nissan positive publicity.

The American companies Ford and General Motors are not so different. Both benefit from a strong presence in the US, but this makes their financial situation febrile because their sales are too concentrated in one market. However, thanks to the electrification, they could take advantage by starting their expansion in emerging markets. Nevertheless, they will have to expand their EV product range in order to compete in different segments, as they are very dependent on trucks and SUVs. In contrary, Tesla has more influence in Europe and Asia than Ford and GM but has also the reputation of selling premium cars which are too expensive for modest families. The electrification of the market will be a huge opportunity for Tesla in order to sell more BEVs and thus to increase their sales but has to be careful that the charging infrastructure follows at the same pace.

Toyota and Hyundai have also some similarities. Their cars are known as solid and reliable, but Toyota is a real pioneer in EV, especially in plug-in hybrid cars. Moreover, its global supply chain and high production allow the Japanese company to have one of the biggest sales worldwide. However, both companies have little product differentiation. Hyundai also has a

[13] For example Audi, Lamborghini, Bentley, Cupra for Group Volkswagen

very strong position in China, which is remarkable for a non-Chinese company. However, their weak presence in the US and almost non-existent influence in Japan do not work in their favor.

Finally, we notice that the two Chinese companies are very close with their national government, which is not a surprise. This strength gave them the opportunity to be highly promoted at local level, preventing their competitors to easily enter the Chinese market. As a result, VW has entered the Chinese market by working with SAIC in order to sell their cars to the local citizen. However, the purchase subsidies and financial assistance provided by the Chinese government will decrease in the following years. This threat cannot be underestimated because China was the first country to push the electrification in their country a couple of years ago through state aid and subsidies[14]. On top of that, BYD is also the only company to also produce its own batteries, which should give them some price advantages and surety in their supply chain compared to their competitors. However, a common weakness is that their brand is less known outside their country, which will not facilitate the exportation of their products in emerging markets and in Europe.

There are some opportunities and threats which are not included in our table because they are applicable for all companies. Indeed, the investments in EV infrastructure, the quick change into electric mobility, industrial policy and awareness for the environment are opportunities for all companies because this is happening worldwide. However, some threats are also applicable for the whole automotive industry such as price increases of raw material, shortage of chips, insufficient supply of batteries and rude competition. In addition, the current war between Ukraine and Russia causes also complications in the supply chain for EVs.

[14] Which will be exposed in the next chapter

4. INDUSTRIAL POLICY

Investing in technological knowledge can be considered as an important factor to determine the successful outcome of a company, but industrial policy cannot be ignored or minimized. Measures that a state can take to modify the allocation of economic resources are for example taxation, subsidies, regulation of goods, services and factors of production. The result of those measures is to boost competitiveness and national growth (Defraigne , Wouters, Traversa, & Zurstrassen , 2022).

According to "*Which European industrial policy for a multipolar world in the 21st century?",* we can differentiate vertical and horizontal industrial policies. Vertical industrial policy are measures taken by a government towards a specific industry or company which is subject of a strategy for their national sovereignty. In contrary, horizontal industrial policy consists of instruments that have an impact on the different national industries in general.

In the next subsections, tools for both horizontal and vertical industrial policy will be exposed which are applicable in the framework of our research question. The different tools for both horizontal and vertical industrial policy which will be discussed are summarized in following table:

Horizontal Industrial Policy	Vertical Industrial Policy
A. Funding infrastructure B. Funding education and R&D C. Setting up environmental standards to ensure a sustainable growth	A. Protectionist measures B. Subsidies C. Picking the champions

Table 14 - Summary tools of industrial policy

4.1 HORIZONTAL INDUSTRIAL POLICY

As told above, horizontal industrial policy aims to have a general positive impact on potential growth on different sectors of the national economy.

A. FUNDING INFRASTRUCTURE

The infrastructure needed to give the companies the possibility to perform well through public services and efficient network of transport networks is something that can be funded by the

national governments. One of the biggest working points to make the transition to electrified mobility a success, is to provide charging infrastructure to EV drivers. Indeed, as analyzed in the section about the acceptance of the EV market, charging infrastructure is a key concern for potential EV users. Anxious car drivers worry about the low charging capacity that is accessible comparing to petrol stations. Despite having a numerous of companies such as ABB, Siemens, Tesla, Schneider Electric SE and others which can build the charging infrastructure, the funds for public charging points should essentially come from the national governments. Almost all regions are intensively investing in charging infrastructure which makes sense because you need to charge your electric vehicle in order to use it. However, not every country is investing at the same pace and with the same amount of money. Here below, you can find a table which summarize the current situation of the public charging infrastructure in 2020-2021 and the future investments in charging stations:

Country /Region	Actual charging stations	Number of charging locations per 100km (2020)	Target of charging stations (in thousands)	Amount invested (In million €)	EVs per thousand habitants
China	807,000	16	n.d.	1,200	3
Europe	352,000	6	1,000 in 2025 3,000 in 2029	20,000	6
France	46,000	4	100 in 2021	500	6
Germany	45,000	7	100 in 2021 1,000 in 2030	2,500	13
South-Korea	65,000	59	515 in 2025	3,200	5
US	99,000	1	500 in 2030	1,300	6
Japan	30,000	9	150 in 2030	n.d.	3

Table 15 - EV Public Charging Infrastructure (several sources)

In addition, we can notice in figure 8 the evolution of public charging stations over the past 6 years for the 5 important regions.

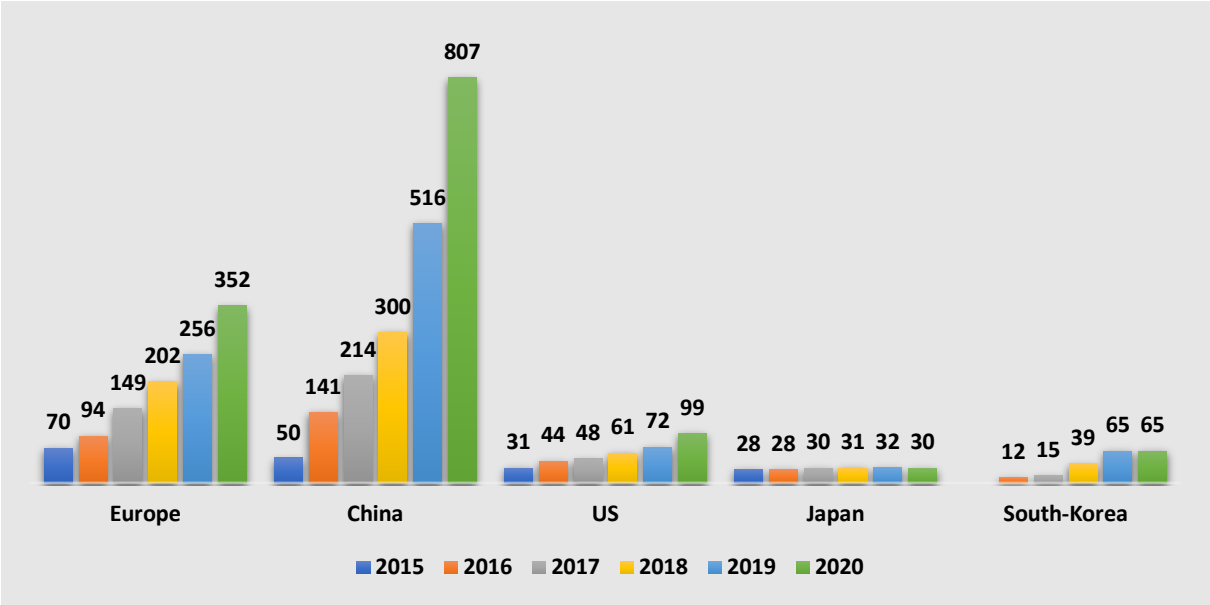

Figure 8 - Evolution of public charging stations (in thousand) since 2015 (Bloomberg)

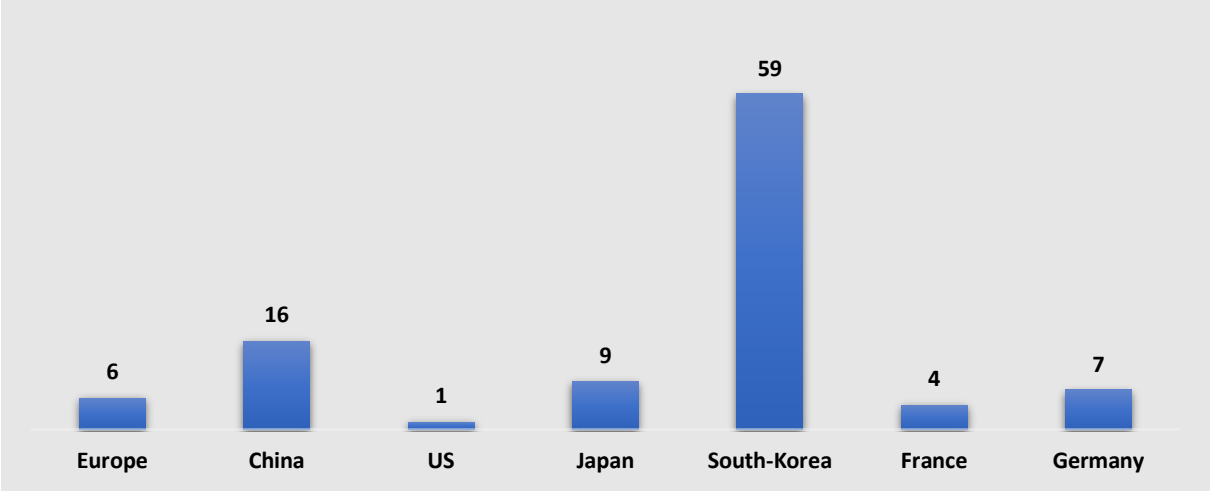

Figure 9 - Number of public charging stations per 100km in 2020 (Calculated through data retrieved from several sources)

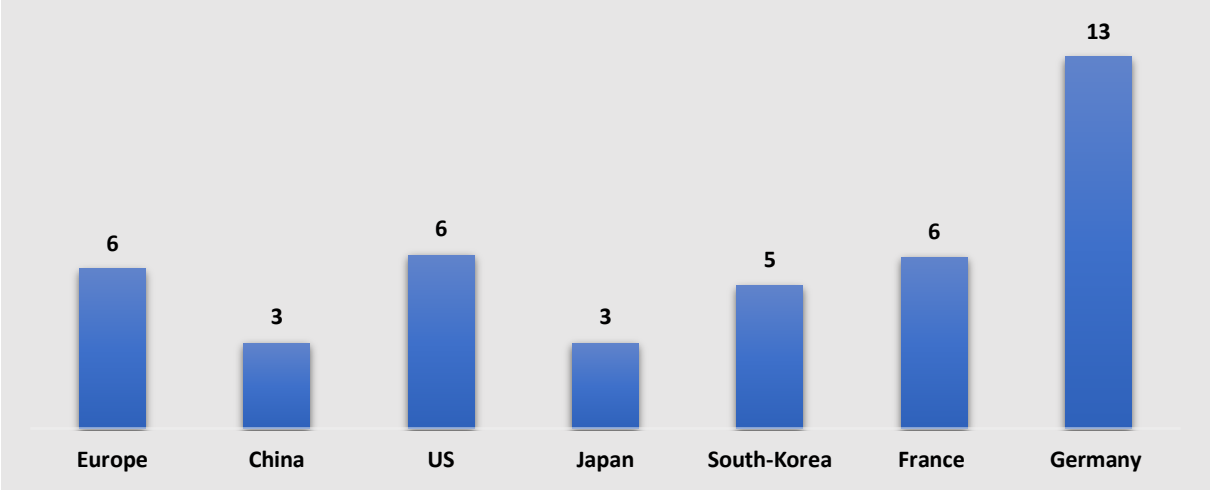

Figure 10 – Number of EVs per 1000 habitants in 2020 (Calculated through data retrieved from several sources)

ANALYSIS

Unsurprisingly, the Chinese country, which is also the biggest EV market in the world, has the most public (and private) charging stations with 807,000 EV chargers. Over the past 5 years, they have multiplied with sixteen the amount of charging points (Bloomberg, 2021). They do not have a concrete and defined target, but several sources like Bloomberg are claiming that they will continue at a high pace to further develop a competitive charging infrastructure. China has also 16 public chargers per 100km, which is a lot compared to the other countries. However, only 3 habitants per 1000 had a BEV last year, which is one of the lowest levels among the other nations.

Concerning Europe, we can also witness a positive evolution in EV chargers through the years, but it's less important than in China. According to Bloomberg, Europe has around 352 thousand public charging stations with Germany and France accounting for a quarter of them (European Alternative Fuels Obervatory, 2020). The Green Deal of the European Commission has set a target of 1 million public EV charging stations in 2025, even if analysts and audit have put a needed objective of 3 million stations in 2029, with a partial investment of 20 billion euros coming from the public authorities. On national level, Germany aims to reach 1 million public charging points by 2030 with an investment of €2,5 billion by 2023 (European Alternative Fuels Observatory, 2021). Concerning France, they have put only a concrete short-term objective of 100 thousand public EV chargers for the end of 2021 with an estimated investment of €500 million (Les Echos, 2020). On the whole European territory, there are 6 public EV chargers per 100km. The biggest number of public chargers are installed in the north of Europe in France, Germany, The Netherlands, Denmark, Norway and Sweden (European Alternative Fuels Observatory, 2021). Among 1000 Germans, 13 of them own an electric vehicle, which is more than the double compared to the Frenchmen. In addition, the German highways contain almost the double of public charging stations per 100km in comparison to the French highways.

The most surprising region to have a low number of EV chargers is the United States of America. The country of President Biden counts 99,000 EV chargers today, which is almost nine times less than China (Bloomberg, 2021). However, since the nomination of Biden as the US president in January 2021, they intend to invest €1,3 billion in new EV charging

infrastructure, with a target of 500,000 chargers by 2030 (Reuters, 2021). However, nothing has been confirmed yet. When we calculate the number of EV chargers in function of distance, we find that there is only 1 public charger every 100km. This is not only low compared to the other countries, but it is also problematic when we know that 6 per 1000 habitants own an electric car.

South-Korea has had a very strong evolution since 2016 concerning EV chargers. Indeed, they have multiplied by 9 their number of charging stations, reaching a peak at 90,000 public chargers in 2020 (Statista, 2020). According to Business Korea and Le Figaro, the South Korean government plans to increase the number of EV chargers to 515,000 in 2025 by investing almost €3,2 billion (Business Korea & Le Figaro, 2020). We can notice that this investment is more ambitious than the American one. The South-Korean country has a highest level of EV charger per 100km. However, with their 59 chargers every hundred kilometers, only 5 per 1000 habitants have an electric vehicle. This comes a little bit as a surprise according to the scientific article "*Analysis of public acceptance of electric vehicles: An empirical study in Shanghai*", where is states that the EV infrastructure is an important factor for people to consider EVs, but we can assume that it is not sufficient. Indeed, the price, range and quality of the cars are also factors that are important for consumers towards EVs (Ning Wang, 2018).

Finally, Japan is the country with the lowest number of EV chargers among the discussed countries and regions. Nevertheless, their highways contain 9 chargers per 100km, which is very remarkable in comparison to the other nations. With 31,000 charging stations, they plan to install 150,000 chargers by 2030 (Argus, 2021). However, they put more faith in hydrogen with investments reaching €15,5 billion to develop hydrogen technologies (Argus, 2021).

B. FUNDING EDUCATION AND RESEARCH & DEVELOPMENT

A national government can positively contribute to the R&D by funding research centers and universities. Through cooperation with the industrial firms, it should evolve the technological future standards which will give a clear competitive advantage in the market. For the further development of electric drive and efficient batteries, a state can therefore fund the R&D with national entities and work with the different manufacturers in the industry.

UNITED STATES

Used to fund research and development in batteries since a lot of years, the US Department of Energy's Vehicle Technologies Office collaborates with the industry and national laboratories for the improvement of batteries and electric drive systems. By lowering the costs and increasing the convenience of electric vehicles, they made important positive evolution regarding range, charging time and battery costs (International Energy Agency, 2019).

JAPAN

In the framework of its Green Growth Strategy, the Japanese government has announced working on R&D the technology of automotive batteries. This includes improving the performance of all-solid-state lithium-ion batteries and innovative batteries, increasing performance of battery materials, upgrading the speed, quality, and low-carbon production processes for batteries and their materials, and developing the reuse and recycling of those EV batteries (The Ministry of Economy, Trade and Industry, 2020)

C. SETTING UP ENVIRONMENTAL STANDARDS TO ENSURE A SUSTAINABLE GROWTH

Environmental standards and targets are results from national political agreements in order to encourage companies to contribute to a sustainable national growth. In our context, the national government can target the share of EV sales they want to achieve in the coming years. This will prevent less trades with ICVs thus give a positive impact on the environment. in addition, CO2 standards can be imposed to car manufacturers with the aim to stop the production of cars that pollute a lot. This will also contribute to achieve the goals that the national government have set in terms of EV sales and stock.

EV TARGETS

The Chinese government has targeted the share of EV sales on their territory at 20% in 2025 and more than the double by 2030 (France Stratégie, 2018). To achieve this target, China has also banned investments for ICV manufacturing if it does not meet the requirements on energy performance since 2018. In addition, they softened the limitations towards foreign investments aiming to attract more large foreign car manufacturers (International Energy Agency, 2021). In 2030, they hope to witness 45% of cars to be EVs on their road. Europe

hopes to reach an EV stock of 13 million by 2025, where France will have 5,3 million in 2028 and 7 million EVs on the German roads in 2030. On the side of South-Korea, 2,8 million EVs are targeted by 2025. In the US, we have several States where targets vary a lot, but if we take California, their objective is to sale 100% EVs by 2035. Finally, the Japanese government has the biggest ambition with only EVs circulating on their territory by 2035 (IEA, 2021).

CO2 REGULATIONS

Country/region	China	Europe	Japan	US
Standards	117 g CO2/km	95 g CO2/km	132 g CO2/km	114 g CO2/km

Table 16 - CO2 regulations (International Energy Agency)

Concerning the regulations that the countries have implemented, Europe has the most severe one. This will certainly force the manufacturers to put a lot of efforts in their policy to achieve these standards. When considering the low EV policies implemented by the US, it is surprisingly that they have the second most ambition standard. China is not far to be also very ambitious with 117 g CO2 per km. However, this seems not to be such a surprise after considering their ambition to become a world leader in the EV market, especially through their national battery suppliers CATL and BYD. Japan has the less strict imposed standard with 132 g CO2/km.

4.2 VERTICAL INDUSTRIAL POLICY

Vertical industrial policy are measures taken by a government towards a specific industry or company which is subject of a strategy for their national sovereignty.

A. PROTECTIONIST MEASURES

Protectionist measures such as tariffs, quotas and investment restrictions can be very effective to prevent massive and foreign competition in their territory and thus give the opportunity to national industries to acquire influence and strategic power in the domestic market.

China is the only country to have imposed truly protectionist measures regarding the foreign investments for EVs. Indeed, China listed investments of foreign manufacturers concerning

the production of complete vehicles as restricted in their Foreign Investment Catalogue published by NDRC (McCaleb, 2015). The only way for foreign companies to invest on the Chinese territory was to partner with a local car manufacturer through joint ventures. However, those restrictions were removed for EVs since 2018 and Tesla had directly concluded an agreement to build a factory to produce EVs in China. European manufacturers such as Volkswagen and Renault continued to invest in China through their partnership with SAIC and Dongfeng.

In addition, China had high importation tariffs of 25% till 2018. Since then, the Chinese government has lowered that percentage to 15%, but due to commercial war against the US, the Chinese government has imposed an additional 25% for vehicles which are produced on the American territory and imported into China (France Stratégie, 2018).

B. SUBSIDIES

Another tool of vertical industrial policy is state aid through subsidies. This can be granted to specific companies, but also to a specified industry of firms. That kind of aid can be used to promote R&D, but also for the building of infrastructure, the increase in production capacities or the improvement of production efficiency.

CHINA

Longing to reduce their dependence to petrol, China started the deployment of fuel-efficient vehicles and the use of alternative fuels since a few decades. To stimulate to expansion of EVs, they granted subsidies to the car manufacturers on EV production since 2013. Despite having propelled the country as the global leader in EV production and sales, it has resulted in a production excess. Therefore, the Chinese government announced in 2019 to stop those EV production subsidies and replace them into performance-based subsidies. Vehicle range, energy efficiency and battery pack energy are the three characteristics which will determine the level of subsidy that will be allocated to the car manufacturers. Compared to the minimum range of 150 km in the last decennium, the minimum required electric range must be at least 250 km in order to be eligible for any subsidy since 2019. In addition, China imposes the car producers to produce a mandatory share of EVs, with the aim to not have a low production of those types of ZEV (International Energy Agency, 2019). In his drive, the Asian country

imposed a mandatory production of 3-4% for each Chinese car manufacturer since 2019. This percentage will also gradually increase each year, which seems logic because the demand will also rise the following decennia (U.S. International Trade Commission, 2020).

Concerning its battery suppliers, the government grants also subsidies in order to allow the expansion of their production facilities and cost competitiveness (International Energy Agency, 2021). Moreover, improving the performance of batteries and stimulating the technological innovation have also been possible thanks to policy support and especially subsidies granted to their national battery manufacturers (U.S. International Trade Commission, 2020).

EUROPE, GERMANY AND FRANCE

In 2019, the European Commission approved a €3,2 billion[15] public support by seven European countries, leaded by France and Germany, aiming to establish an European battery production to compete against the Asian dominance. The origin lies on the initiative of an "European Battery Alliance" in 2017 where the transition to climate neutrality, and thus the electrification of vehicles, was already in important discussions between member states and industrial actors. The purpose is not only to finance the construction of a European battery production, but also to focus on the extractions of raw materials, development of cells and modules, improvement of battery systems and design processes for recycling end-of-life batteries and materials (European Commission, 2019). This so-called "Airbus-style consortium" for batteries should also unlock €5 billion private investments. In addition, the EU Commission has approved a second public support of €2,9 billion, involving additional actors to support the "European Battery Innovation" project, which should allow to unlock additional private investments of €9 billion (European Commission, 2021). In addition, the European Battery Alliance have attracted a €60 billion investments in 2019, while China had €19 billion in that same year (European Battery Alliance).

French President Emmanuel Macron has also announced that his country will invest €700 million in order to boost its battery production by building a factory in France because they aim to reduce their dependence on the Asian battery production (Reuters, 2019). The French

[15] France will grant up to €960 million; Germany approved a subsidy of €1,25 billion

government aims to invest in €3,6 billion in the automotive industry in order to be able to produce the same amount of BEVs in 2030 as the country did for ICVs during last decennium. In addition, €300 million are also planned for public EV chargers in the "*France 2030 investment plan"* presented by the first prime minister Jean Castex (French Governement, 2021).

German Chancellor Angela Merkel has also announced to invest €5 billion, where €1 billion will be allocated to support technology investment by sellers, €2 billion to improve and adapt the EV production lines of car manufacturers and €1 billion for EV buying incentives (Bloomberg, 2020). The German government has also announced that they will invest more than €3 billion to help the industry in their R&D mission regarding EV battery cells and its production till 2030. In addition, more than €3,5 billion are going to be invested in the production and installation for EV chargers (Ministère de l'économie des finances et de la relance, 2021).

SOUTH-KOREA

The Korean government has the ambition to enhance international sales of their EVs at more than 10% by 2022 in comparison to 2% in 2019. To do so, loan guarantees and liquidity support will be granted to its national car manufacturers for their ZEV export promotions (International Energy Agency, 2019). According to Bloomberg, South-Korea is also planning an investment of almost €30 billion in order to help its national battery manufacturers in their investments and R&D in the battery industry. The Asian country is also considering the battery industry as a crucial part of their national future economy, which support the expansion of their battery manufacturers by subsiding their production facilities in Europe (Bloomberg, 2021).

JAPAN

According to the Green Growth Strategy, Japan wants to support large-scale investments in the battery production through subsidies. By doing so, the Japanese government wants to reduce the cost of batteries by 50% in 2030 at the latest (Nikkei Asia, 2020). The indirect result of those granted subsidies should increase the overseas sales of EVs (International Energy Agency, 2019).

C. PICKING THE CHAMPIONS

National champions are domestic companies that are picked by a state in order to ensure its national economic growth and welfare.

South-Korea is clearly craving to support LG and Samsung SDI with incentives for their R&D investments with the aim to make them global leaders in the battery market (Bloomberg, 2021). In France, the government has supported the negative impact of COVID by granting Renault a loan of €5 billion (Reuters, 2020). This is important to consider because the French state owns a 15% stake of the French Group. On European level, Northvolt seems to be the important European competitor against the Chinese, Japanese and Korean battery producers because the main project of establishing an European production of car batteries will start through the Swedish start-up.

4.3 OTHER POLICIES AND AGREEMENTS

THE EUROPEAN GREEN DEAL

At the end of 2019, the new European Commission presented their so called “The European Green Deal” to the main European institutions and committees in order to tackle the climate challenges where the majority of European citizen, and even the worldwide population, is worrying about. Several aspects are to be considered in the framework of the automotive battery industry.

The main goal of this European Green Deal is to be climate neutral in 2050. This is a big challenge when you know that the transport is responsible for 25% of all greenhouse gas emissions in the European Union (European Commission, 2018). In order to reduce that percentage, the industries and citizen will have to switch from fossil fuel to electrified methods of transport and mobility. Since more than a decade, the car manufacturers have already made big investments in that matter, which is also notable by their product range where hybrid and battery electric vehicles are already sold.

Another important proposal in this Green Deal, is the circular economy action plan. The end of the battery's life cycle and its recycling have raised many concerns and questions. Considered as one of the market leaders in recycling lithium-ion batteries, Europe and

especially its companies[16] in the industry is aware that they are not yet developed enough to face the expected volume of used batteries in the years to come (Centre for European Policy Studies, 2018).

In addition, the whole battery supply chain should be developed and guided by sustainability. This means that either the origin of the raw materials, its exploitation, the transfer and the production will have to be done on a sustainable and responsible way.

GREEN NEW DEAL

In the framework of the American Green New Deal and its influence on the automotive industry, climate change is the main issue that is addressed where reducing the greenhouse gas emissions is one of the so-called "Green New Deal goals". To do so, a ten-year national mobilization plan[17] has been established where the electrification of the entire transportation system is introduced (The New York Times, 2019). In other words, the call for public and private investments in electric vehicles is expressed in this Green New Deal (Congress, 2019). In contrary to the European Green Deal that is adopted in the main agenda of the European Commission, the American version has no legislative power. Nevertheless, this resolution remains important and has put big pressure since the last decade.

[16] For example, Umicore, etc
[17] also referred as the "Green New Deal mobilization"

5. The Demand And Acceptance Of The EV Market

The idea to consider the EV as a standard is one thing but convince and push the society to go partially or fully electric is another concern that must be considered. According to the article "Analysis of public acceptant of electric vehicles: An empirical study in Shanghai", research have shown that technical performance of an electric vehicle is the most important factor in the consumers' acceptance process to EV. Furthermore, this article written by Ning Wang, Linhao Tang and Huizhong Pan have also investigate potential electric car consumers with German nationality and concluded that young and well-educated drivers, who are also aware of their economies, technological evolution, and the environmental protection, are keen to make the switch and acquire an EV. In addition, its convenience is also determined by the charging infrastructure which also plays a key role in the acceptance of consumers regarding electric cars.

Another important take-away of the article is the proportion of respondents which wants to buy an EV as second car (46%) compared to those who wants to replace completely their ICV (18%). It also seems that there is no doubt about the advantages regarding the EV technology performance. However, the interviewees cannot accept that an EV should cost more than an ICV, even if they think that the subsidies for buying an electric vehicle are generous compared to the electricity and non-fiscal subsidies.

In terms of more in-depth factors, battery life and more important the driving range are the most technical concerns of the consumers. On marketing and environmental awareness level, the car manufacturers must increase the publicity on the benefits of EV on the driving experience and environment to make more consumers recognize it. However, the factor that comes up the most is related to perceived risk, and more specific about the charging infrastructure. Therefore, only if both the government and EV producers collaborate by making a greater effort on marketing, R&D and charging infrastructure, they will improve the consumers' acceptance level regarding electric vehicles (Ning Wang, 2018).

6. The Current Landscape And The Electric (Re)Evolution

The latest data of EV sales and EV stock are displayed in charts here below. These statistics have been retrieved from official and specialized sources such as Statista, EV-Volumes and IEA.

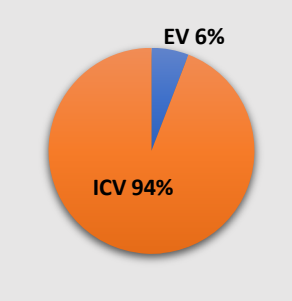

Figure 11 - Sales in CN (2020)

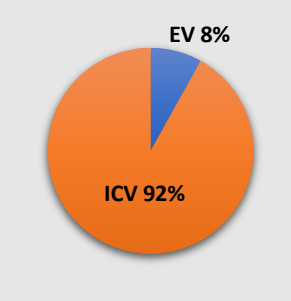

Figure 12 - Sales in EU (2020)

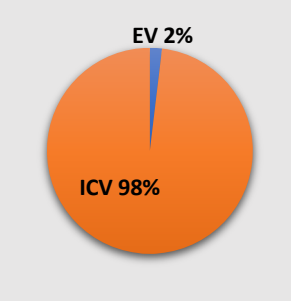

Figure 13 - Sales in US (2020)

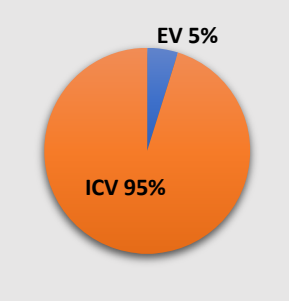

Figure 14 - Global sales (2020)

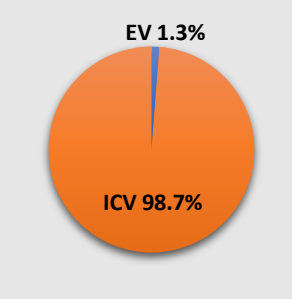

Figure 15 - Stock in CN (2020)

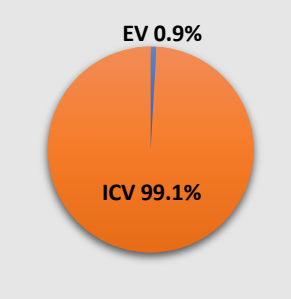

Figure 16 - Stock in EU (2020)

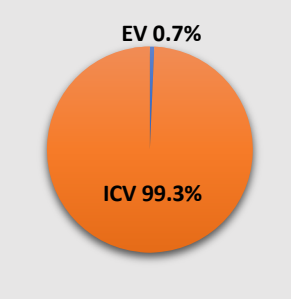

Figure 17 - Stock in US (2020)

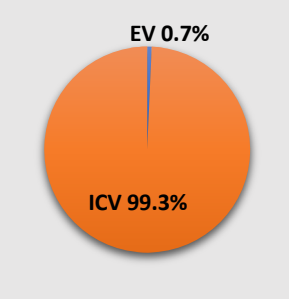

Figure 18 - Global stock (2020)

According to EV-volumes, we can notice that Europe (1,4 million) has sold slightly more EVs than China (1,3 million) in 2020. There are also less ICVs sold in Europe than in China, which results in a bigger EV share. The US is clearly not selling at the same pace with only 0,3 million EVs sold, which gave them a share of only 2%. Globally, the EVs count only for 5% of all cars sold in 2020 (EV-volumes). In terms of EV stock, we have a very low share of 1.3% in China which is slightly higher than in Europe (0.9%), US and at global level (0.7%). These statistics confirm that we are just at the beginning of the electric revolution in the automotive industry and that a lot must be done to achieve the EV targets that all car manufacturers have set for the next years.

Speaking about the next decennium, we can have a look to an outlook published by the International Energy Agency. This outlook has a scenario-based approach which has been

determined through market data, technological perspectives and policy decisions: the stated policies and sustainable development scenarios.

The stated policies scenario reflects all existing policies, political targets and ambitions that have been announced and put into legislation by the governments across the world. This scenario will thus forecast and estimate the consequences of all EV-related policies and regulations in terms of EV sales and stocks. Additionally, it includes the announcements and plans made by all companies involved in this industry (International Energy Agency, 2021).

The sustainable development scenario mirrors a more optimistic scheme where energy is accessible for all by 2030 and where the global climate goals defined in the Paris Agreement will be met. However, this scenario assumes that all EV targets have been reached, even if the current and announced political measures are not sufficient to achieve these EV goals and ambitions (International Energy Agency, 2021).

In the stated policies scenario, which is the most realistic one because it is based on the existing measures taken by all governments and industries, we can notice that China and Europe will clearly sell the most in comparison to the US and the other countries. However, if the environmental goals and EV targets are reached, Europe should be slightly dominating the EV sales against China (International Energy Agency, 2021).

In a most realistic scenario of stated policies, the global EV sales are multiplied by 8 in only 10 years' time and will reach 20%. This is very encouraging because when policy will become more stricter and will wipe out ICVs completely in the 2030's and 2040's, we can assume that the EV sales and EV stock will attain even higher figures in a record of time.

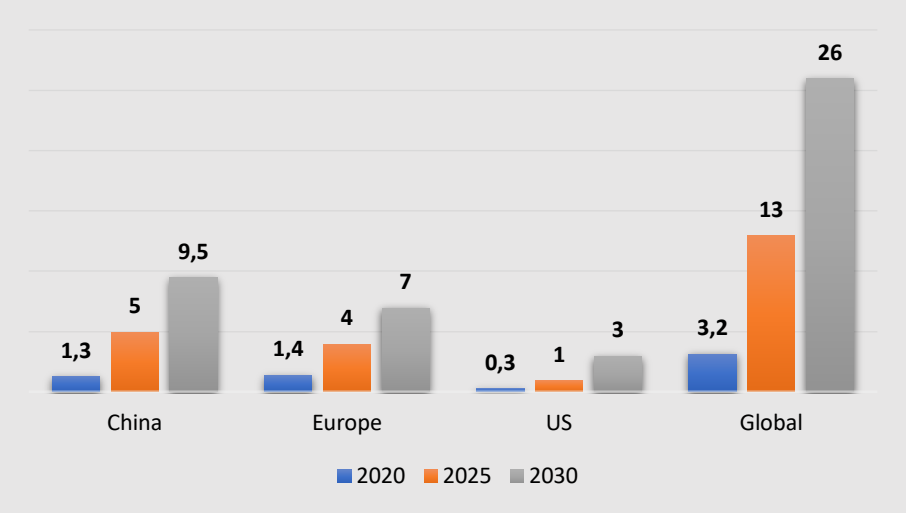

Figure 19 – EV sales in a stated policies scenario (in millions)

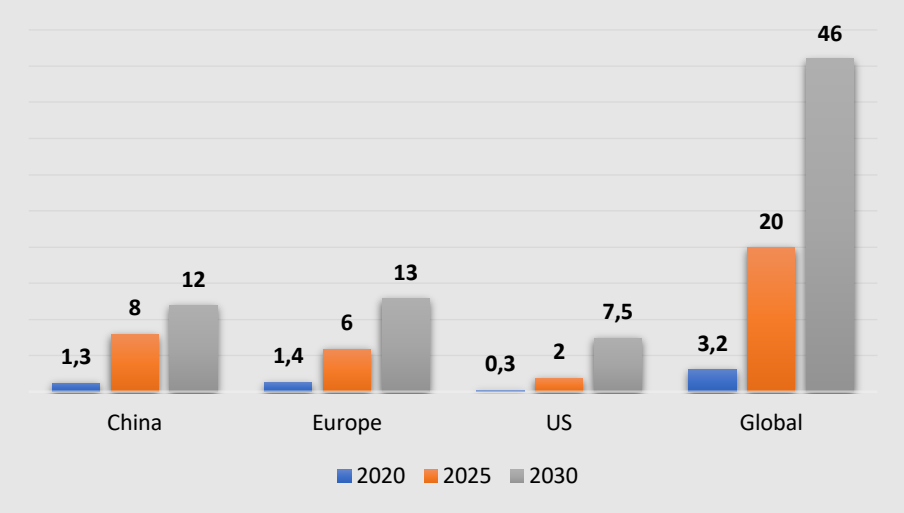

Figure 20 - EV sales in a sustainable development scenario (in millions)

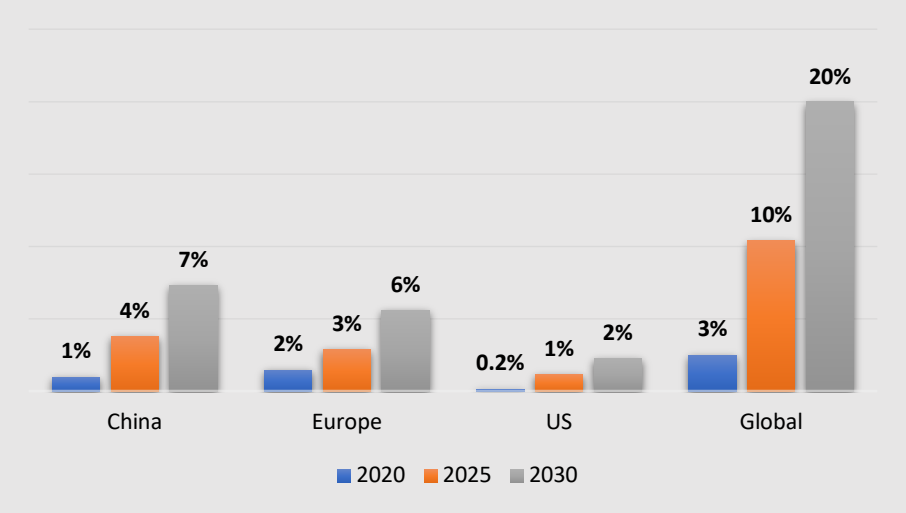

Figure 21 - EV sales in a stated policies scenario

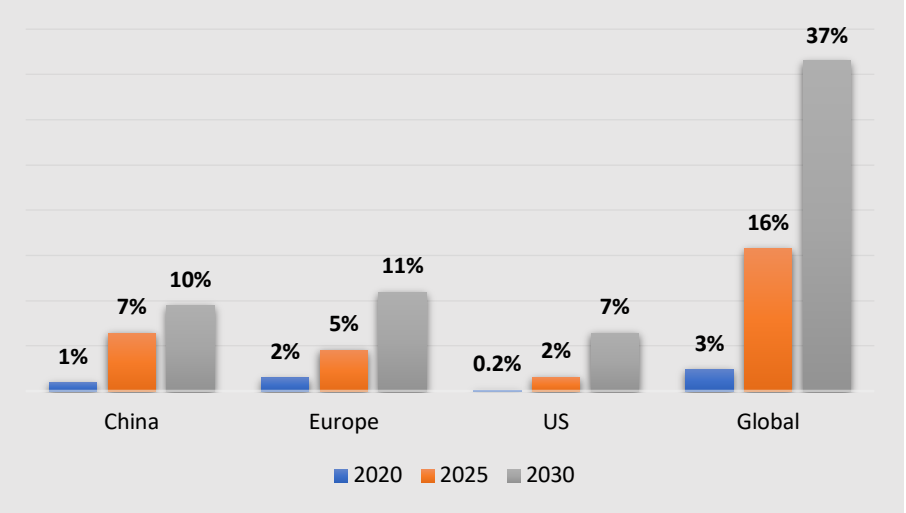

Figure 22 - EV sales in a sustainable development scenario

7. CONCLUSION

The objective of this thesis was to find out which car manufacturers and EV battery producers are going to benefit the most economically from the radical change into electrified mobility and which countries will, thanks to its national policy, have a greater influence in the automotive industry. We have studied different criteria such as the market share, EV sales, EV models and EV targets. Furthermore, we looked to the technological knowledge through the evolution of R&D spendings and the number of patents for each company.

Some of those criteria were possible to compare such as the strategic vision, EV sales and models. However, R&D spendings and patents were more complicated because we could not isolate those criteria in the context of electromobility.

We can notice that in terms of BEV sales, the biggest companies such as VW Group, Renault-Nissan-Mitsubishi, GM or BMW Group have a great evolution in parallel of the sales of the more traditional internal combustion vehicles. However, Toyota is lagging in those BEV sales and in the commercialization of BEV models. Tesla is also lagging to expand their product range, but as a pioneer in the mass-production of electric vehicles, it allows the company of Elon Musk to have since a decennium the highest level of EV sales. Thanks to the domestic Chinese market, BYD Auto can also a claim a high level of BEV sales and BEV models.

The technological knowledge is more complicated to discuss in term of electromobility and absolute values. Indeed, Volkswagen Group has the highest R&D spendings, but with more than hundred models across different brands, it seems also logic that the German Group is the biggest spender in the industry. In contrary, Tesla has one of the lowest levels of R&D investments, but we can also assume that they only invest in electromobility with only 6 BEV models. Falling apart from BYD Auto, SAIC and Hyundai, the other car manufacturers have similar R&D spendings. We can assume that they have a similar capacity in terms of investments and in terms of granting patents. The Chinese companies have a lower level of R&D spendings, but other explanations such as being part of a group or having close partnerships with high R&D spenders can be trustworthy assumptions in order to justify the lows levels of investments and granted patents.

As far the battery producers are concerned, Panasonic and LG are the biggest spenders in R&D, but we can also assume that the R&D spendings of the whole groups that Samsung SDI and BYD Electronics are part, will correct this underestimation of R&D spendings. However, CATL seems to be an isolate case. Indeed, the Chinese battery manufacturer has the lowest level in R&D investments and lowest number of granted patents. Knowing that the company has the second largest market share in the EV battery market, it is difficult to find an explication because we do not have enough access on information concerning this Chinese company.

Finally, by making a SWOT analysis of the strengths and weaknesses for the car manufacturers, we have summed the criteria mentioned. In addition, other unseen strengths and weaknesses were given in order to have a more complete overview for each company. By completing with the opportunities and threats, each company are using their strengths to counterbalance their weaknesses. Moreover, some weaknesses such as less influence on international level can be seen as an opportunity thanks to this industrial change into electromobility.

The next chapter concerned the industrial policy that the countries and Europe are pursuing in the automotive industry. It is not an easy task to discuss and compare because there is not always specific data available for the Asian countries.

However, based on the section tackling the industrial policy, we can assume that China and Europe are investing a lot in the development of the needed infrastructure for the production and use of EVs. China is already strongly established as the country that has the necessary standards, infrastructure and subsidies to promote battery production and EV. However, Europe is putting a lot of effort to accelerate the electric revolution and to catch up the Chinese government. With the future production of EV batteries, Europe will not only play a leading role in the EV market, but also in the EV battery industry.

Nevertheless, even if scientists have mentioned that EV infrastructure is a critical factor for promoting BEVs, South-Korea and Japan have the lowest level of BEVS per thousand habitants. Other factors such as price, convenience and range are also important for the market and we can assume that those factors are cumulative.

In contrary, US has an acceptable level of BEVs per 1000 habitants but has the lowest amount of public charging stations per 100km. The fact that Tesla is the market leader in the EV industry gives the US the possibility to raise its EV fleet, with the other American companies like Ford and GM. However, US does not have any plans to develop significatively the EV infrastructure, nor to have a significant investment plan in the EV and battery production on their own territory.

The last criterium concerned the demand and acceptance of the EV market. In this section, we concluded that environmental protection, technical evolution, EV prices and charging infrastructure play a key role in the decision making of potential EV consumers. The electric range and battery life are also important technical concerns of the consumers. This shows perfectly that investments in charging infrastructure, technological knowledge and subsidies will be crucial in order to influence consumers to replace their ICV with an BEV.

In a nutshell, here below some take-aways from this thesis:

- We are still in an early stage of electrification in the automotive industry and market ;
- Each company has its own strengths and weaknesses. Sometimes, their strengths can counterbalance their weaknesses, and their weaknesses can also be seen as opportunities to gain more influence in the EV market ;
- The strategic vision, evolution of EV sales and models, their technological knowledge and capacity to innovate are not sufficient to formulate a clear conclusion on the so-called winners and losers in the electrification of the automotive industry ;
- The regions/countries are dictating the pace of the electrification in the automotive market. However, not only the investments in production and infrastructure are important but also the purchase price, range and convenience of the all-electric cars ;
- The consequences of the COVID-19 and more recently the war between Ukraine and Russia will impact positively and negatively the evolution of the EV market and industry. Positively by accelerate the electrification in order to import less energy and produce alternative energies. Negatively because it will slow down the production of EVs and impact the supply chain.

8. Reflection, Limitations And Further Research

In the context of this thesis, I have retrieved information from international news organizations and newspapers like Bloomberg, Reuters and Financial Times. I have also taken a lot of information on the website and annual reports of the companies, as well as of official government sources and from the IEA. Even if these sources provide correct and detailed information, some limitations must be taken into consideration.

Firstly, the information for US and Asian companies were not always precise and complete in comparison with the European ones. For European policy and companies, there is more data and information available which gave a more complete image of the European companies.

Secondly, not all Asian sources were available in English. Some sources were shared in different languages, but sometimes I had to use translations tools to understand some documents, but they were not always efficient. Moreover, data concerning Japan and South-Korea were not always detailed as much as for Europe or even China.

In addition, it was not easy to find information for the US on their industrial policy. This can also be the result of Biden's administration that was elected and nominated 1 year ago. It will be important to follow up the coming years on the content of the industrial policy that President Biden will pursue.

In general, I tried to take information and facts from official sources which should be the most correct and objective possible. Besides, I did not want to take some general information where investments were announced without details because this would not have contributed positively to this report. This is for example the case of the United States where several sources announced massive investments in the EVs and infrastructure. However, there is no concrete and detailed information available about the amount and the way those investments will be spent. For this reason, it was difficult to add that information into our analysis because it would have been impossible to discuss and compare with the investments of other countries and Europe.

Concerning the main manufacturers, Stellantis has not been considered one of them despite being considered as the fourth-largest automaker with annual sales estimated around 8

million vehicles in the world (Reuters, 2021). I started this thesis last year when the merger between PSA and Fiat Chrysler was not already officialized.

It has also been very difficult to really distinguish which companies will benefit from the electrification of the industry. This is because each company has its own strengths and weaknesses, making it impossible to consider which strength is better than another or which weakness is less important than another.

We can notice through the EV market shares that the electrification of the automotive industry has just started since a few years. Some car manufacturers have announced their EV objectives only a short time ago. The electric revolution has just begun and political decisions are constantly adjusting their targets to reduce CO2 pollution through EV expansion. Additionally, alternative fuels like hydrogen will also gain in importance and potentially influence the outcome of our findings. Moreover, the war between Ukraine and Russia will also contribute to unexpected changes. On the one side, the supply chain has been affected negatively. On the other side, the Europeans and the whole world have seen that they suffer from dependency for foreign energy. For this reason, it will be necessary to monitor closely further evolution and analyze when the first important targets will be met.

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ANNEXES

FIGURE 1 - GLOBAL SHARE OF MAIN CAR MANUFACTURERS WITH CORRESPONDING NATIONALITY IN 2018 (BLOOMBERG)

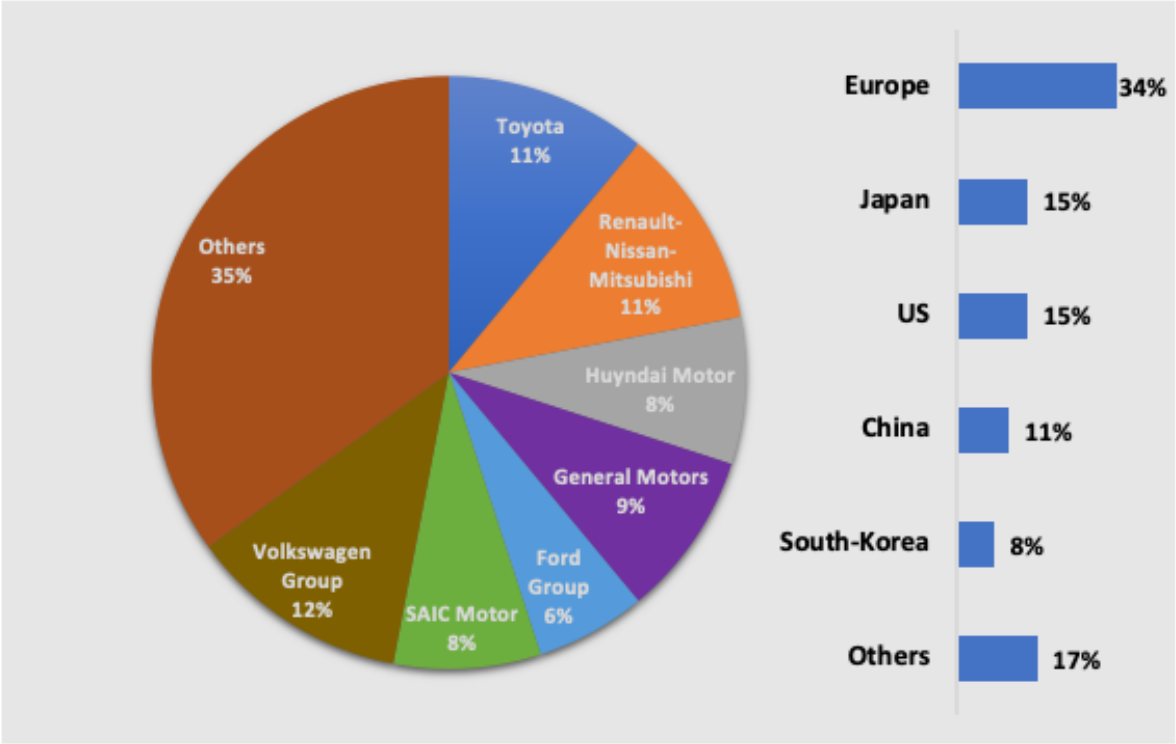

Figure 1 – Global share of main car manufacturers with corresponding nationality in 2018 (Bloomberg)

FIGURE 2 - GLOBAL SHARE OF MAIN EV MANUFACTURERS WITH CORRESPONDING NATIONALITY IN 2019 (MCKINSEY & COMPANY AND STATISTA)

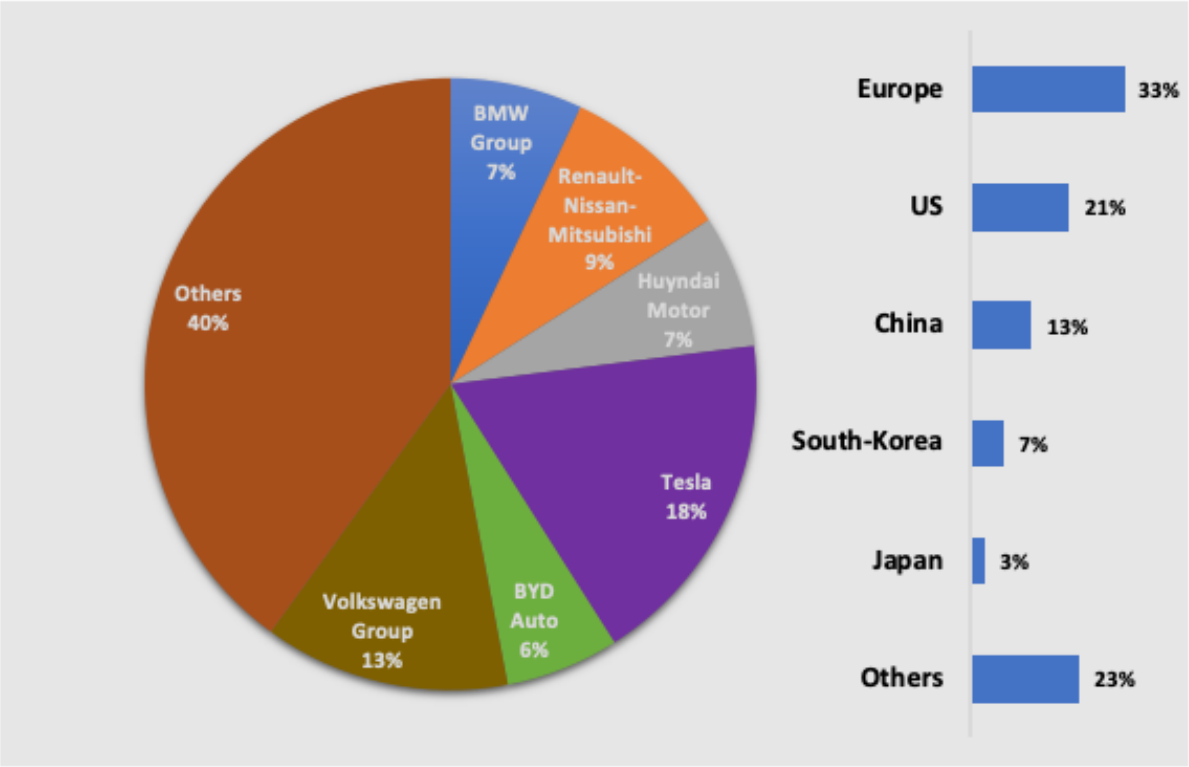

Figure 2 - Global share of main EV manufacturers with corresponding nationality in 2019 (McKinsey & Company and Statista)

FIGURE 3 - GLOBAL SHARE OF MAIN BATTERY CELLS PRODUCERS WITH CORRESPONDING NATIONALITY IN 2020 (BLOOMBERG AND SEEKING ALPHA)

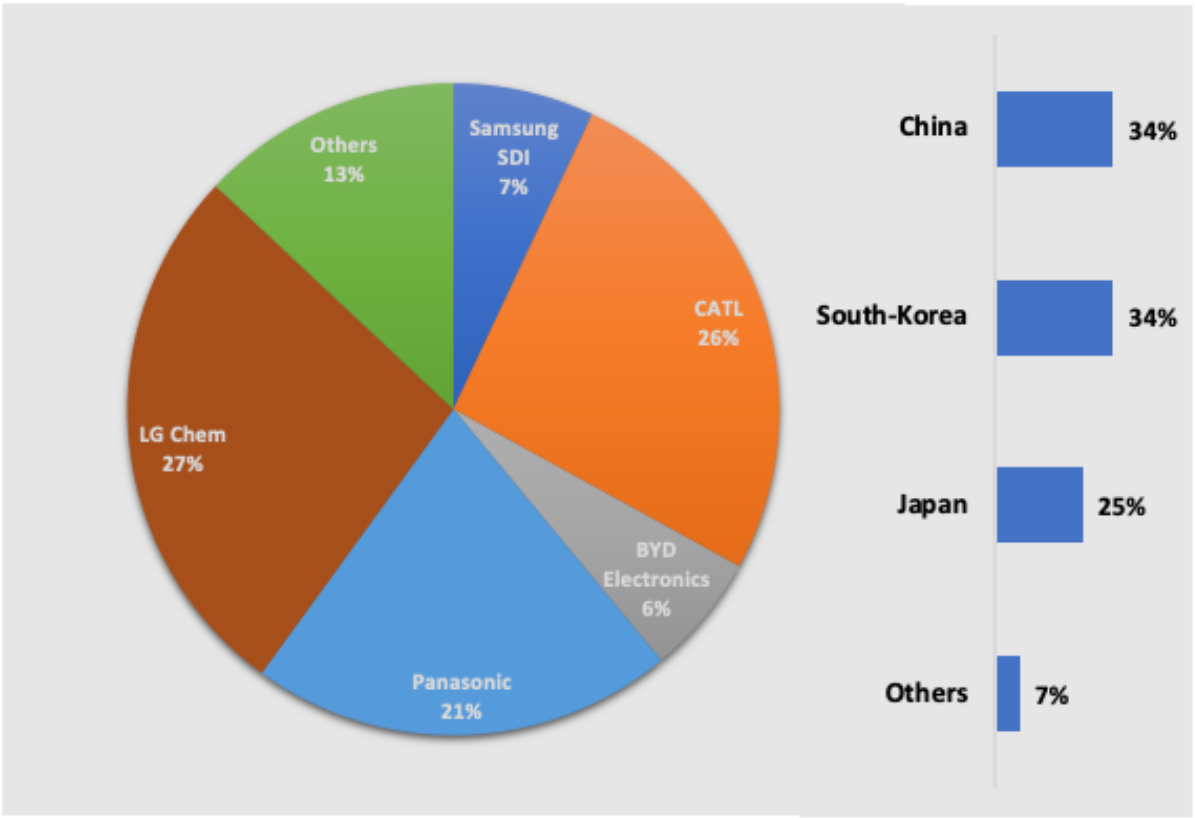

Figure 3 - Global share of main battery cells producers with corresponding nationality in 2020 (Bloomberg and Seeking Alpha)

FIGURE 4 - MAIN EV MANUFACTURERS AND THEIR BATTERY CELL SUPPLIERS

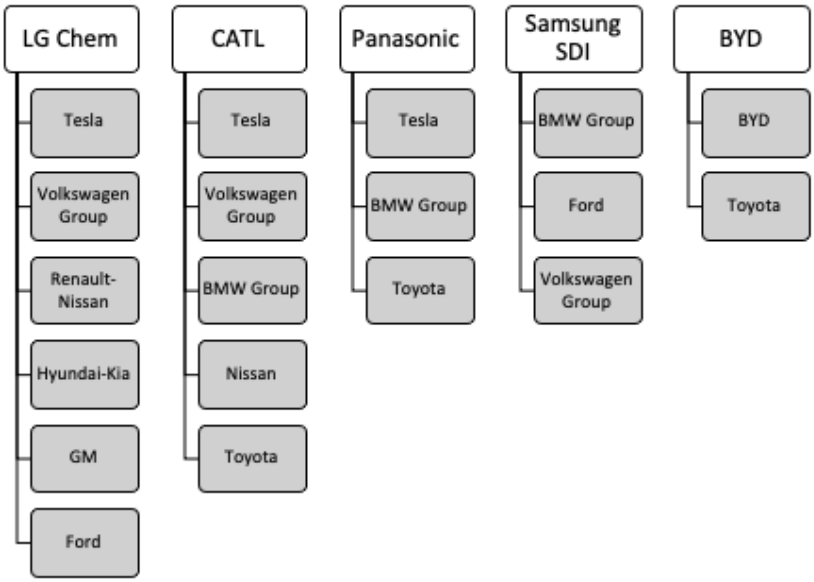

Figure 4 - Main EV manufacturers and their battery cell suppliers

FIGURE 5 - EV SALES FROM 2017 TO 2021 (SEVERAL SOURCES)

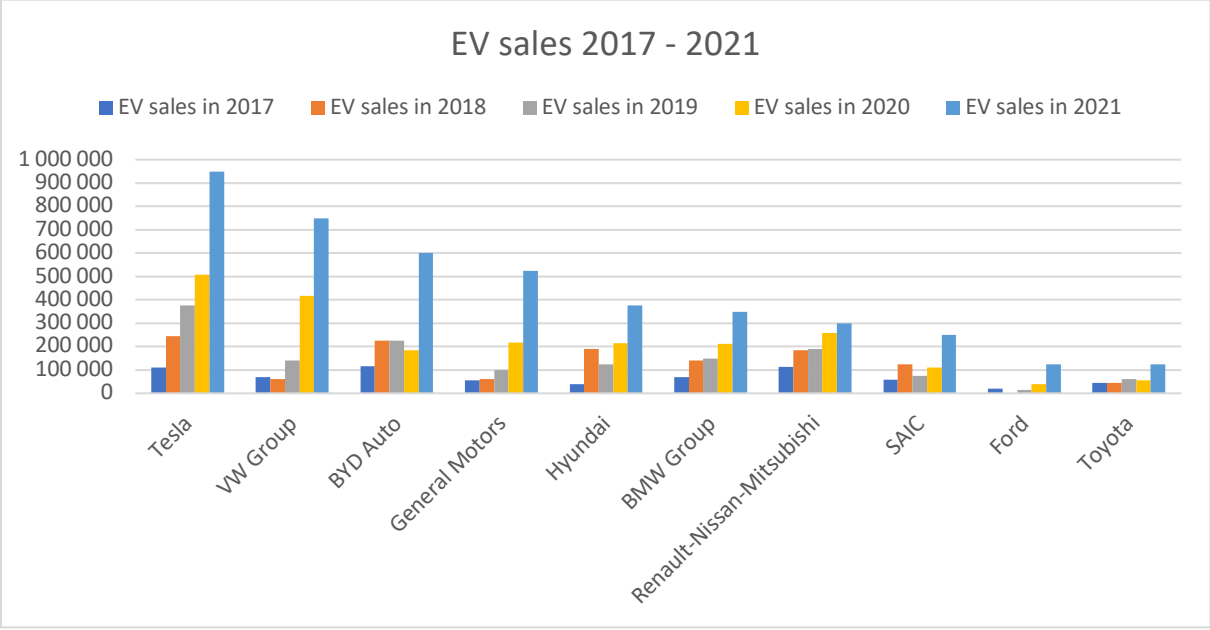

Figure 23 – EV sales from 2017 to 2021 (Several sources)

FIGURE 6 - R&D SPENDINGS FROM CAR MANUFACTURERS (2015 – 2020)

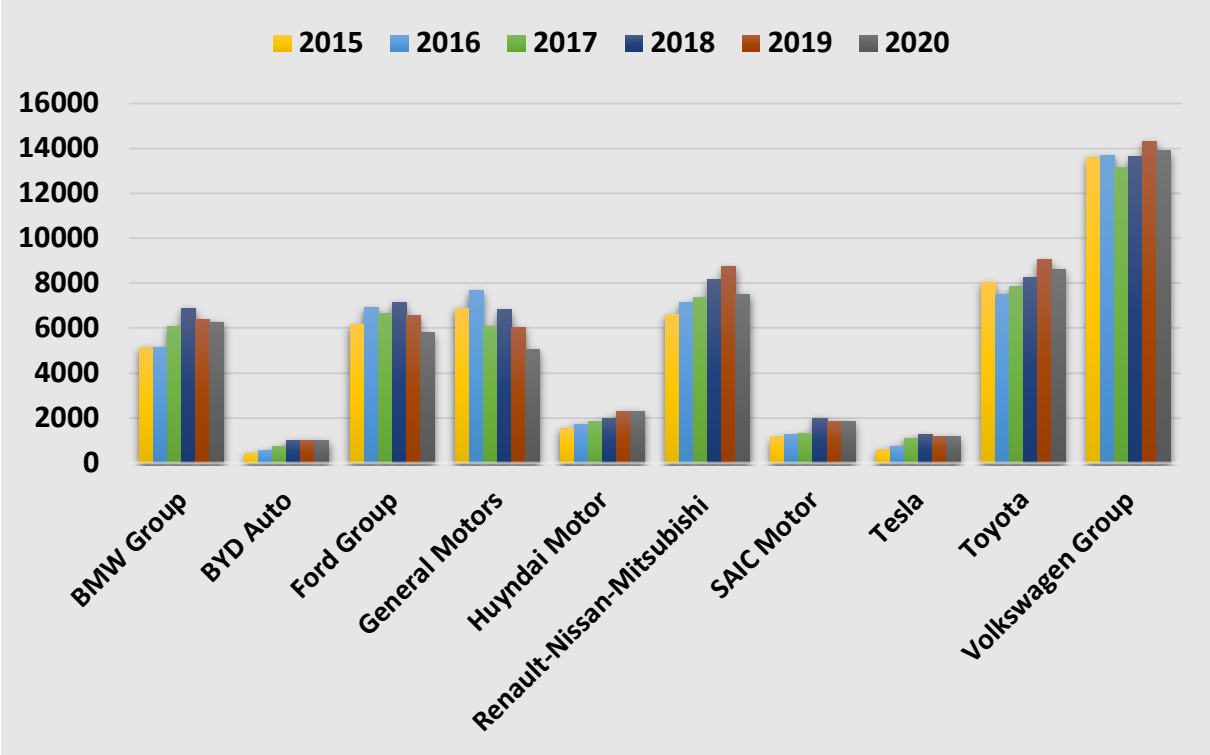

Figure 24 - R&D spendings from car manufacturers (2015 – 2020)

FIGURE 7 - R&D SPENDINGS FROM BATTERY PRODUCERS (2015 – 2020)

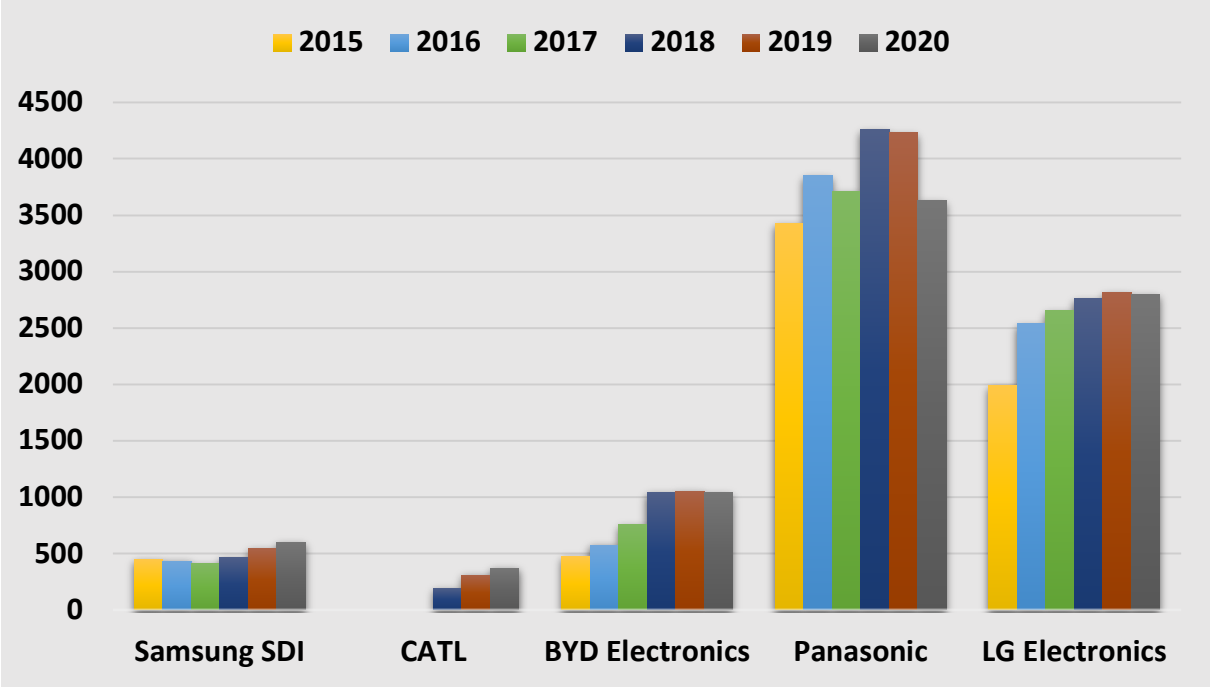

Figure 25 - R&D spendings from battery producers (2015 – 2020)

FIGURE 8 - EVOLUTION OF PUBLIC CHARGING STATIONS (IN THOUSAND) SINCE 2015 (BLOOMBERG)

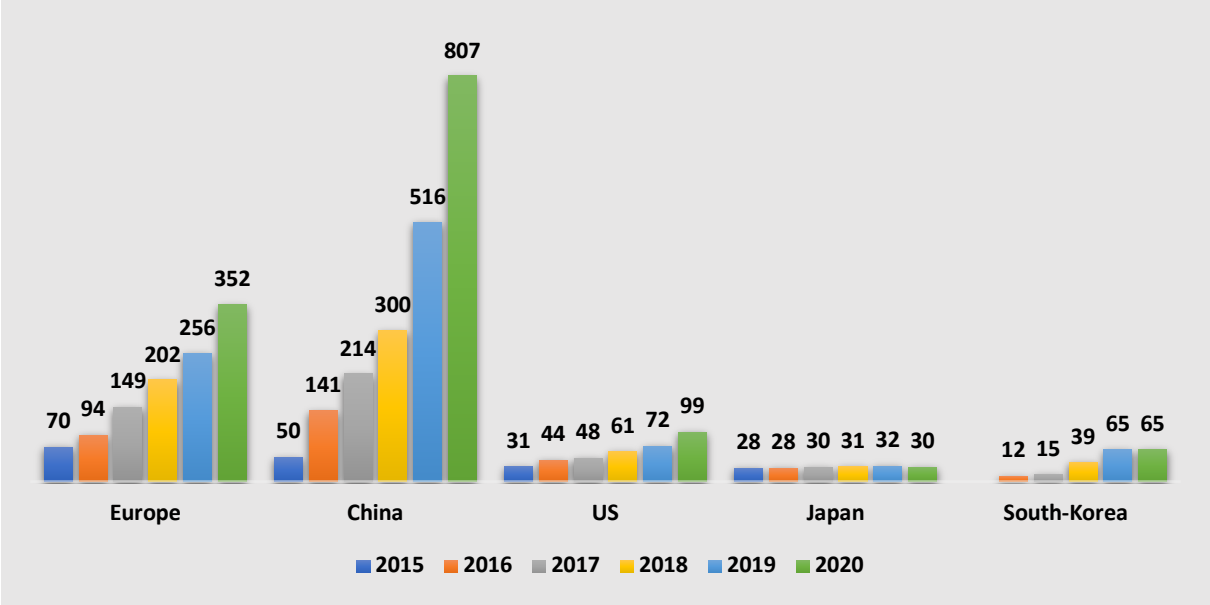

Figure 26 - Evolution of public charging stations (in thousand) since 2015 (Bloomberg)

FIGURE 9 – NUMBER OF PUBLIC CHARGING STATIONS PER 100KM IN 2020 (CALCULATED THROUGH DATA RETRIEVED FROM SEVERAL SOURCES)

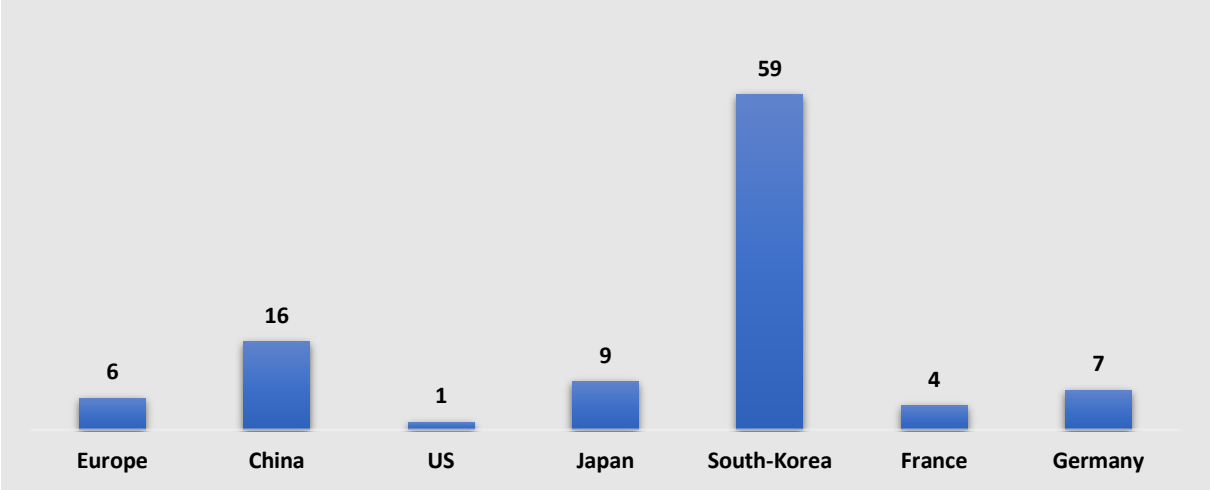

Figure 27 - Number of public charging stations per 100km in 2020 (Calculated through data retrieved from several sources)

FIGURE 10 - NUMBER OF EVS PER 1000 HABITANTS IN 2020 (CALCULATED THROUGH DATA RETRIEVED FROM SEVERAL SOURCES)

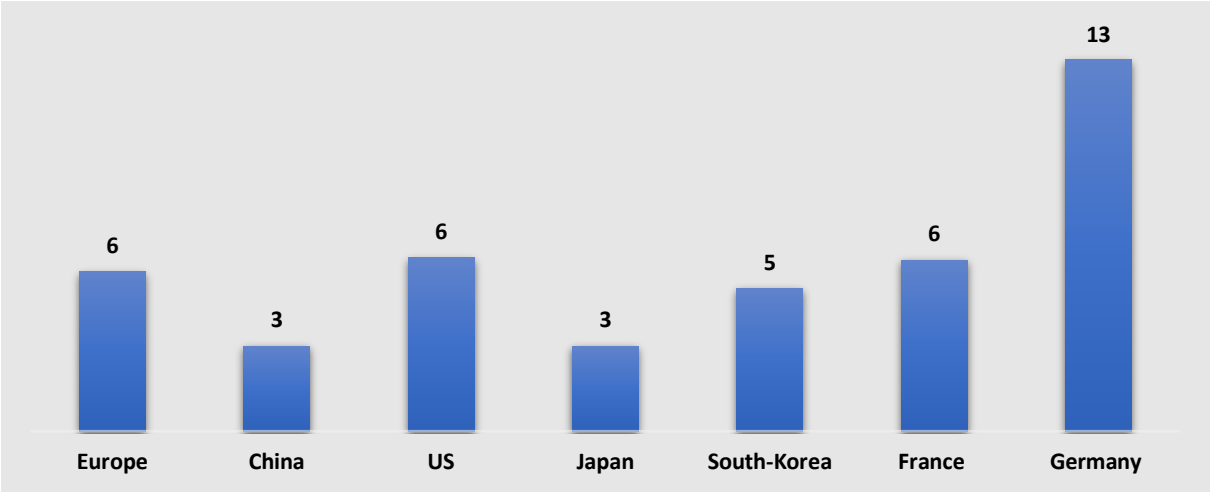

Figure 28 – Number of EVs per 1000 habitants in 2020 (Calculated through data retrieved from several sources)

FIGURE 11 TO 14 – EV SALES PER REGION (2020)

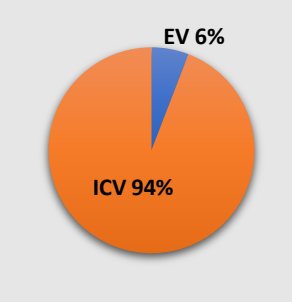

Figure 11 - Sales in CN (2020)

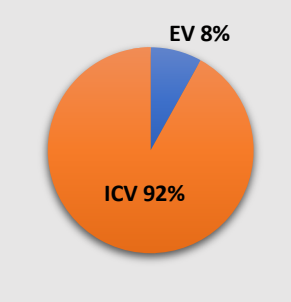

Figure 12 - Sales in EU (2020)

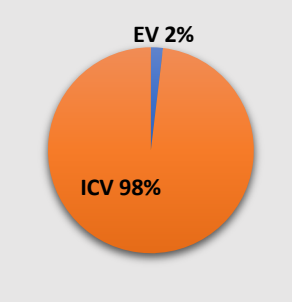

Figure 13 - Sales in US (2020)

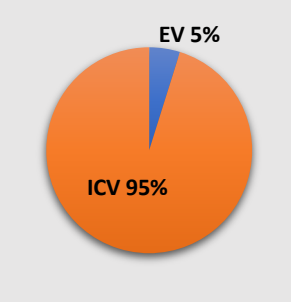

Figure 14 - Global sales (2020)

FIGURE 15 TO 18 - EV STOCK PER REGION (2020)

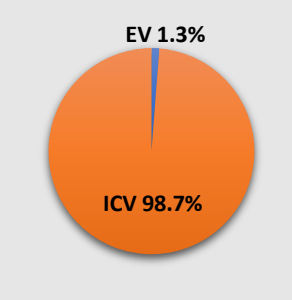

Figure 15 - Stock in CN (2020)

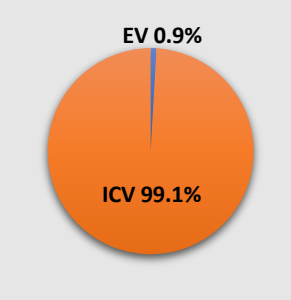

Figure 16 - Stock in EU (2020)

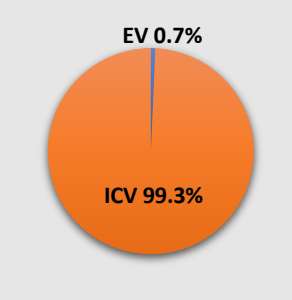

Figure 17 - Stock in US (2020)

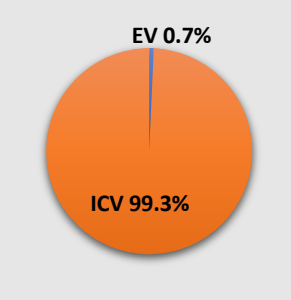

Figure 18 - Global stock (2020)

FIGURE 19 TO 22 – EV SALES IN A STATED POLICIES AND SUSTAINABLE DEVELOPMENT SCENARIO

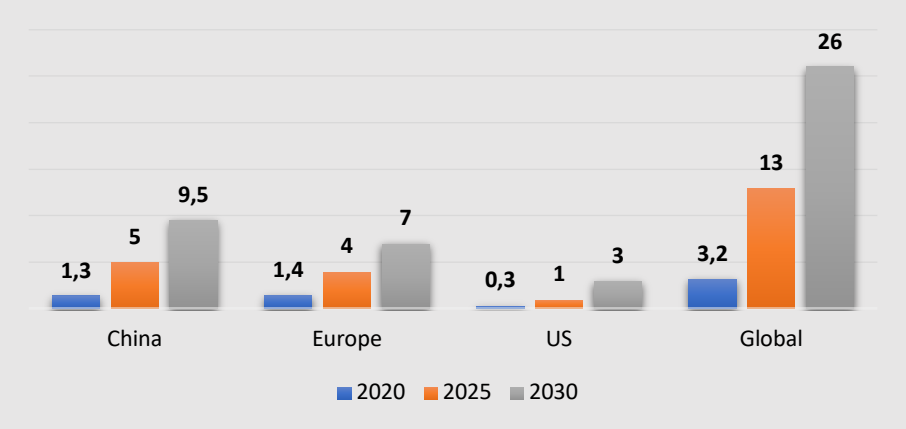

Figure 19 – EV sales in a stated policies scenario (in millions)

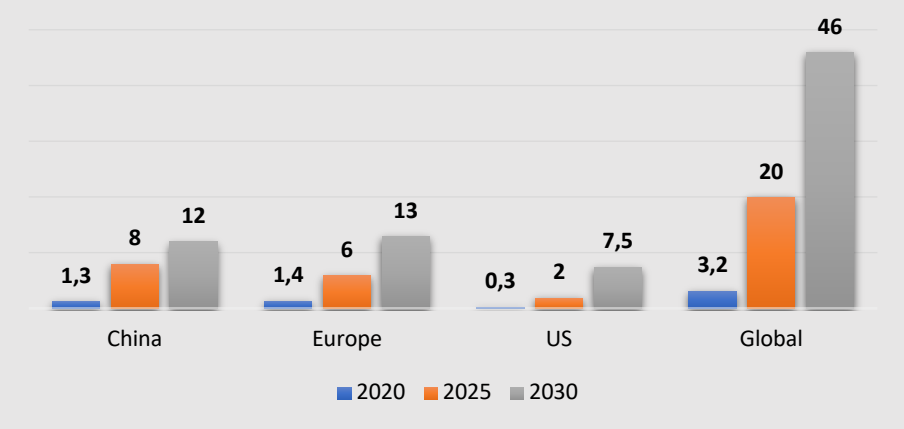

Figure 20 - EV sales in a sustainable development scenario (in millions)

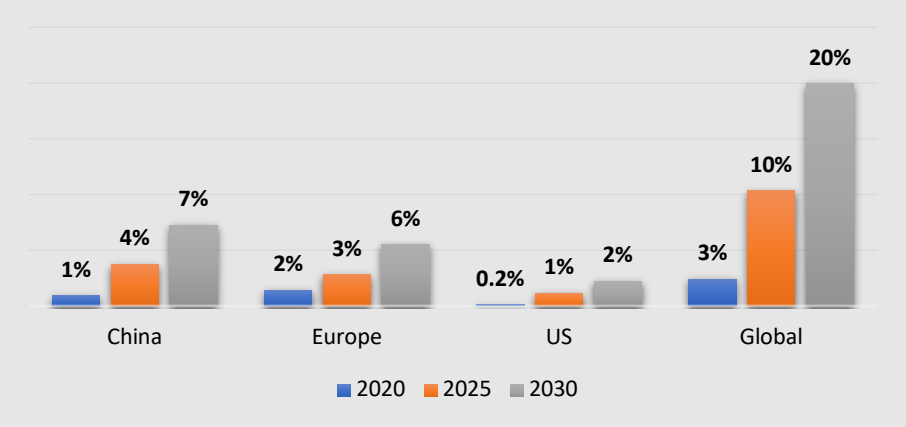

Figure 21 - EV sales in a stated policies scenario

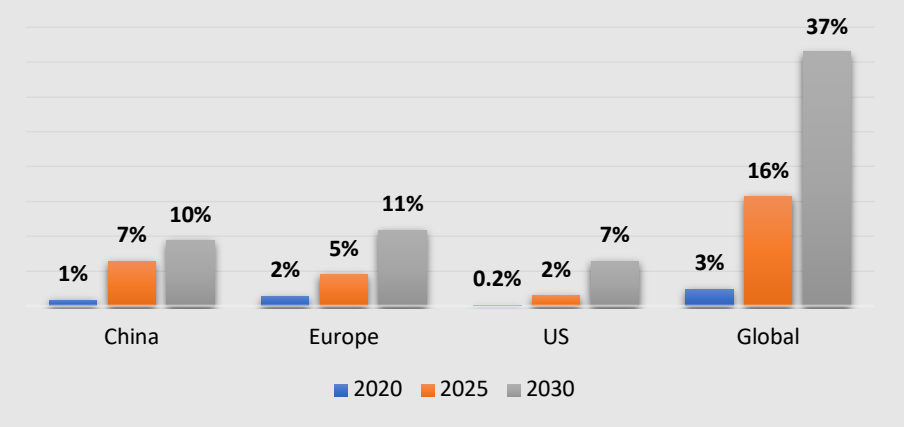

Figure 22 - EV sales in a sustainable development scenario

TABLE 1 – KEY DATA TESLA (ANNUAL REPORT & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
18%	2,2 million	950,000	6

Table 13 - Key data Tesla

TABLE 2 - KEY DATA VOLKSWAGEN GROUP (ANNUAL REPORT & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
13%	1,4 million	750,000	34

Table 14 - Key data Volkswagen Group

TABLE 3 - KEY DATA BMW GROUP (ANNUAL REPORT & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
7%	921 thousand	350,000	20

Table 15 - Key data BMW Group

TABLE 4 - KEY DATA HYUNDAI (ANNUAL REPORT & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
7%	946 thousand	375,000	11

Table 16 - Key data Hyundai

TABLE 5 - KEY DATA FORD (ANNUAL REPORT & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
<3%	201 thousand	125,000	7

Table 17 - Key data Ford

TABLE 6 - KEY DATA GENERAL MOTORS (ANNUAL REPORT & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
3%	958 thousand	525,000	13

Table 18 - Key data General Motors

TABLE 7 - KEY DATA TOYOTA (ANNUAL REPORT & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
3%	331 thousand	125,000	13

Table 19 - Key data Toyota

TABLE 8 - KEY DATA RENAULT-NISSAN-MITSUBISHI ALLIANCE (ANNUAL REPORTS & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
9%	1,1 million	300,000	18

Table 20 - Key data Renault-Nissan-Mitsubishi Alliance

TABLE 9 - KEY DATA SAIC(ANNUAL REPORT & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
3%	619 thousand	250,000	29

Table 21 - Key data SAIC

TABLE 10 - KEY DATA BYD AUTO (ANNUAL REPORT & SEVERAL SOURCES)

Market Share EV	BEVs sold (2017 - 2021)	BEVs sold in 2021	BEV models in 2021
6%	1,3 million	600,000	21

Table 22 - Key data BYD Auto

TABLE 11 - EV DATA AND TARGETS (ANNUAL REPORT & SEVERAL SOURCES)

Company	BEV sales (2021)	Actual BEV Models (2022)	EV Targets	Fully Electric?
Tesla	950,000	6	/	Since 2008
VW Group	750,000	34	- 20% sales (2025) - 70% EU sales (2030) - 50% US & CN sales (2030)	By 2030
BMW Group	350,000	20	- 25% sales (2025) - 7 million stock (2030)	/
Hyundai	375,000	11	- 1 million sales (2025)	By 2040
Ford	125,000	7	- 100% EU sales (2026) - 40% sales (2030)	By 2030
General Motors	525,000	13	1 million sales (2025)	By 2030
Toyota	125,000	13	> 1 million sales (2030)	/
Renault-Nissan-Mitsubishi	300,000	18	- 20% sales (2022) - 50% EU sales Nissan (2030) - 60% CN sales Nissan (2030) - 50% sales (2030)	By 2030 (Renault)
SAIC	250,000	29	30% sales (2025)	/
BYD Auto	600,000	21	/	/

Table 23 - EV data and targets (Annual reports & several sources)

TABLE 12 - R&D AND PATENTS DATA (EUROPEAN PATENT OFFICE & UNITED STATES PATENT AND TRADEMARK OFFICE)

Company	R&D Spending (average 2012-2020)	Number of patents
VW Group	12,959	10,000
Toyota	7,728	10,000
Renault-Nissan-Mitsubishi	7,002	10,000
Ford Group	5,975	10,000
BMW Group	5,482	7,500
General Motors	6,164	10,000
Hyundai Motor	1,695	10,000
SAIC Motor	1,321	100
Tesla	780	900
BYD Auto	663	1,800
Panasonic	3,769	10,000
LG Electronics	2,393	10,000
Samsung SDI	340	10,000
BYD Electronics	663	10,000
CATL	297	1,100

Table 24 - R&D and Patents Data (European Patent Office & United States Patent and Trademark Office)

TABLE 13 - R&D AND PATENTS DATA (EUROPEAN PATENT OFFICE & UNITED STATES PATENT AND TRADEMARK OFFICE)

	SWOT Analysis			
	Strengths (seen criteria)	**Weaknesses (seen criteria)**	**Strengths (unseen criteria)**	**Weaknesses (unseen criteria)**
VW Group	- High market share - High EV sales - A lot of EV models - High R&D spendings		- Famous brands - Global supply chain - Large, diversified brand portfolio	- Weakened brand reputation after Dieselgate
Toyota	- High market share - High R&D spendings	- Low EV sales - Few EV models	- Pioneer in EV (PHEV) - Famous brand - Global supply chain - High production capacity	- Not premium brand - Low product differentiation
Renault-Nissan-Mitsubishi	- High market share - High EV sales - High R&D spendings	- Low EV sales	- Experienced and well-known brands in market - Economies of scale - Sharing internal culture	- No clear leadership - Low quality brands
Ford Group	- High R&D spendings	- Low EV sales - Few EV models	- Global recognition - Huge dealer-network	- Dependence on US market

				- Dependence trucks/SUVs
BMW Group	- High EV sales - A lot of EV models - High R&D spendings		- Famous premium brand - Excellent reputation - Successful partnership in China - Competence in EVs	- Less product differentiation - Small brand portfolio - Many legal cases
General Motors	- High EV sales - High R&D spendings	- Few EV models	- Joint ventures with Chinese companies - Strong presence in US - Timing and frequency of new model releases - Rare recalls	- Dependence on US market - Brand awareness - Dependence trucks/SUVs
Hyundai Motor		- Low EV sales - Few EV models - Low R&D spendings	- Excellence in safety and design of cars - Economic & durable cars - Strong presence in China	- Poor brand portfolio - Low presence in US - No presence in Japan
SAIC Motor	- A lot of EV models	- Low EV sales - Low R&D spendings	- State-owned firm - Highest sales in China	- Low awareness for SAIC domestic brands - Low presence outside Asia

Tesla	- High market share - High EV sales	- Few EV models - Low R&D spendings	- Pioneer in BEV - Strong partnership with battery-suppliers - Sturdy brand image	- Price of products compared to competitors - Not able to meet the demand
BYD Auto	- High EV sales - A lot of EV models	- Low R&D spendings	- Price advantage - Own battery production	- Low international brand awareness

	Opportunities	**Treats**
VW Group	- Collaborations/partnerships - Diversified product portfolio - Expansion in emerging markets	- Fines (Dieselgate) - Ongoing lawsuits - Europe EV/CO2 regulations
Toyota	- Collaborations/partnerships	- Demand for BEV vehicles instead of PHEV - EV/CO2 regulations
Renault-Nissan-Mitsubishi	- Expansion in emerging markets - Development of EVs	- Can provoke synergies, M&A by competitors - Alliance image as a result of arrestation of Carlos Ghosn - Europe EV/CO2 regulations
Ford Group	- Offers eco-friendly cars - Global expansion through market penetration - Growth through product development	- Closure of production plants in Latin-America

BMW Group	- Focus on emerging markets - Offers eco-friendly mobility	- Europe EV/CO2 regulations
General Motors	- Timing and frequency of the new model releases - Strengthen Presence in Emerging Market - Diversify Portfolio	- Civil Lawsuits
Hyundai Motor	- Timing and frequency of new model releases	
SAIC Motor	- Market penetration at international level	- Diminution of EV subsidies and EV purchase bonus from Chinese government
Tesla	- Demand in BEV - Large market potential - Introduction of own battery production	- Limited EV infrastructure - Lithium supply - Cheaper alternatives
BYD Auto	- Market penetration at international level - National planning - Government support	- Patent dispute - Diminution of EV subsidies and EV purchase bonus from Chinese government

Table 13 - SWOT Analysis (retrieved from several sourc

TABLE 14 - SUMMARY TOOLS OF INDUSTRIAL POLICY

Horizontal Industrial Policy	Vertical Industrial Policy
D. Funding infrastructure E. Funding education and R&D F. Setting up environmental standards to ensure a sustainable growth	D. Protectionist measures E. Subsidies F. Picking the champions

Table 14 - Summary tools of industrial policy

TABLE 15 - EV PUBLIC CHARGING INFRASTRUCTURE (SEVERAL SOURCES)

Country /Region	Actual charging stations	Number of charging locations per 100km (2020)	Target of charging stations (in thousands)	Amount invested (In million €)	EVs per thousand habitants
China	807,000	16	n.d.	1,200	3
Europe	352,000	6	1,000 in 2025 3,000 in 2029	20,000	6
France	46,000	4	100 in 2021	500	6
Germany	45,000	7	100 in 2021 1,000 in 2030	2,500	13
South-Korea	65,000	59	515 in 2025	3,200	5
US	99,000	1	500 in 2030	1,300	6
Japan	30,000	9	150 in 2030	n.d.	3

Table 15 - EV Public Charging Infrastructure (several sources)

TABLE 16 - CO2 REGULATIONS (INTERNATIONAL ENERGY AGENCY)

Country/region	China	Europe	Japan	US
Standards	117 g CO2/km	95 g CO2/km	132 g CO2/km	114 g CO2/km

Table 16 - CO2 regulations (International Energy Agency)

LOUVAIN-LA-NEUVE | BRUXELLES | MONS | TOURNAI | CHARLEROI | NAMUR
Place des Doyens, 1 bte L2.01.01, 1348 Louvain-la-Neuve, Belgique | **www.uclouvain.be/lsm**