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Abbreviations and definitions

EV	Electric vehicle
BEV	battery-electric vehicle (100% electric)
HEV	hybrid-electric vehicle (partially electric)
PHEV	Plug-in hybrid electric vehicle (partially electric, chargeable)
NEV	new-electric vehicles (including HEVs, PHEVs and BEVs), especially oftentimes used in a Chinese context
ICEV	conventional internal combustion engine vehicle
FDI	Foreign Direct Investment
DM	Single Diamond-Model of international competitiveness (Porter) DDM Double-Diamond Model of international competitiveness; Rugman and D'Cruz
FYP	Five Year Plan (Industrial Policy of the Chinese government)
SOE	State owned enterprise (China)
METI	Ministry of Economy, Trade and Industry (Japan)
MITI	former Ministry of International Trade and Industry (Japan)
IPC	International Patent Classification
Keiretsu	set of companies with interlocking business relationships and shareholding; type of informal business group that work together in an alliance (Japan)

1. Introduction

1.1. Electric Mobility development in China and Japan

For the last decade, electric mobility has been gaining more and more importance amongst global automotive manufacturers (Roland Berger – Automotive Competence Center & Forschungsgesellschaft Kraftfahrwesen, 2018: p. 2-3). OEMs from all major automotive markets have been researching heavily within the last decade. The technology is contributing substantially to next-generation mainstream mobility, and thus continues to dominate research and development. Also in the East Asian region, the emergence of e-mobility has brought substantial change into the automotive market landscape. With China and Japan, two major economies have announced ambitious goals to become leading players in the emerging car- and batteries markets. China and Japan respectively embody two of the world's leading nations in terms of automotive manufacturing. Japan has been among the top three countries with most cars manufactured since the 1960s, surpassing Germany. Today, Japan is known as the third largest automobile market, and - until China recently overtook this position - was the largest car producer in the world (Statista, 2019). Both countries have shown tendencies to adapt to the ongoing shift in terms of mainstream mobility, but appear to follow different incentives that are leading them to diverging approaches.

As several multinational manufacturers hold partnerships and joint ventures with Chinese domestic manufacturers, a common assumption is that Chinese cars are based on multinational designs but inexpensively made, and thus generally not exported. The immense domestic demand, together with huge state-owned enterprises following governmentally defined business-plans heavily influence the focus of major Chinese manufacturers. Electric Mobility has been the latest focus-point the Chinese government wants domestic manufacturers to set. On the other hand, Japanese manufacturers seem to have chosen a much more specific niche-technology, hybrid-technology that no other domestic market has intensified as much. Both countries claim the status of a global automotive superpower, but still face very diverging realities, which lead them to completely different stages of electric mobility development. These diverging realities significantly influence their respective global competitiveness.

This thesis aims to discover differences and similarities in terms of electric mobility development within both countries' automotive sectors in order to evaluate their respective competitive capabilities concerning the ongoing global automotive EV shift.

1.2. Research Question and Relevance

An essential research objective of this thesis is to challenge the common assumptions of Japan being the technological leader, heavily investing in R&D, and China simply being the mass-producer of relatively uncompetitive EVs for domestic use. The thesis is intended to clarify what the respective stages of the Chinese and Japanese e-mobility development are, and how these presumably greatly differing positions contribute to the respective state of the domestic automotive sector. Further, based on the results, both countries' roles regarding the ongoing global EV shift are going to be examined. The underlying research question upon which this thesis is being constructed has been formulated as follows:

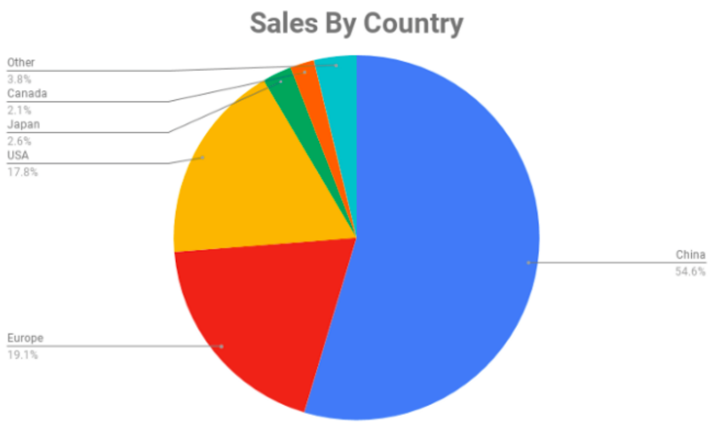
What are the differences and similarities in terms of electric vehicle development within the automotive industries of China and Japan?

Adding onto the overall research question, two additional sub-questions that this thesis will cover, have been formulated. Firstly, what are technologies that have been focused upon by the respective country, and secondly, how these differing approaches relate to China's and Japan's current competitive status regarding EV development. This thesis will furthermore cover all three forms of electric vehicles: (1) HEVs, (2) PHEVs, (3) BEVs, as defined by Horak and Pascha (2013) and referred to in chapter 2.1. However, as the categorization is based on the level of electrification, and full electrification is assumed to be the final goal this technology shift is aiming for, the focus primarily lies on BEVs. The scope of this research is intended to be from the early 1970s - after the first EV boom has started to come into play - until present day, especially highlighting the developmental progress that has been achieved during the last decade.

As for the relevance of this thesis - as stated above - electric mobility has been showing an extraordinarily strong tendency of becoming an important part of modern mainstream mobility. Graph I below shows global year-on-year sales growth of BEVs in percent, as well as its respective market-share from 2013 to 2018 (Medium, 2019).

Graph I. *Global Year-Over-Year Sales Growth of BEVs from 2013 to 2018***;** *Source: Medium, 2019.*

Global numbers of BEVs have been continuing to increase substantially. The BEV market-share grew from 0.17% in 2012 to over 2% in 2018 (Medium, 2019). As EV's remain rather inferior to combustion engine powered vehicles, the technology is not yet capable of replacing conventional technologies without requiring compromise on the customer's side. According to a study made by Growth Analysis, poor charging infrastructure and high prices result in a low adoption rate (Growth Analysis, 2013). Therefore, both countries' distinct interest in using this technology to reaching their respective goals becomes crucial. By taking a look at Graph II, which shows the distribution of global BEV sales in 2018 by country market-shares, China's immense potential and yet driving force in terms of the global EV shift becomes visible. Regarding BEVs, China accounts for 54.6% of global sales in 2018 (Medium, 2019).



Graph II. *Global BEV Sales Market-Share by Country in 2018; Source: Medium, 2019.*

China is by far the world's biggest manufacturer of both EVs, as well as combustion engine automobiles in general, with 23.71 million produced units in 2018 (Statista, 2019). It has shown the initiative to use this still not sufficiently developed technology in order to tackle international competition. Chinese rather late developed car manufacturers still struggle to catch up technologically, and thus struggle to reach international standards that would allow greater export capabilities. The scope of different appealing opportunities this new technology holds is vast and contains a variety of crucial aspects, such as energy security, promising future export opportunities, and the limitation of emissions. The fact that the Chinese government realizes these potentials, and tries to exploit them can be regarded as a substantial aspect for growing global competition in the field. No other automotive manufacturing country has come anywhere close to China's EV production capabilities yet. China's ambitious goals regarding this technological shift are remarkable, and need to be further analyzed in order to understand its current position and capabilities in close comparison to its most important competitor in this field, Japan.

Japan is the second biggest car manufacturer in the world, as it has produced a total of 8.36 million cars in 2018 (Statista, 2019). This means that indeed China produces three times the volume of Japan, but Japan still embodies China's closest competitor. Considering the fact that Japan's BEV share is just 2.1%, might lead to the assumption that Japan's impact in terms of the global EV shift is rather limited compared to China (Medium, 2019). However, as Japan has been focusing heavily on its field of expertise, HEVs, rather than BEV's, the country has been enormously contributing to the ongoing global EV shift. By accumulating all three types of EVs sold in Japan for 2018, the EV market-share is 39.9% (Mobi Navi, 2019).

Both Asian countries stand for automotive superpowers, as they embody the top of global automotive production. Given their role as global players, it is crucial to understand China's and Japan's differing status and intentions in terms of EV development. Hence, this comparison aims at clarifying China's and Japan's differing approaches towards EVs in order to understand how and to which extent both countries are contributing to the ongoing global automotive EV shift.

2. Literature Review

2.1. EV-Shift – Development of Electric Vehicles

There is a variety of different vehicle-types that can be identified as EVs. As for this thesis, the definition of what EV's contain, is based on Yamazaki's categorization of automotive propulsion technologies. He basically defines four categories of vehicles that are produced by Japanese manufacturers, being: (1) conventional internal combustion engine vehicles (ICEVs) that run with fossil fuels, (2) hybrid vehicles, (HEVs and PHEVs) that combine an internal combustion engine with electric engines, (3) battery electric vehicles (BEVs) or fully electric vehicles that can be operated without the use of fossil fuels, thus emission-free, and lastly (4) fuel-cell electric vehicles (FCEVs) that operate without lithium-ion batteries (Yamazaki, 2014: p. 155). Representing the western approach towards the definition of EVs, Horak and Pascha (2013) cluster EVs together into three categories based on their level of electrification: (1) HEVs, (2) PHEVs, (3) BEVs (Horak and Pascha, 2013). Gauss also distinguishes between conventional combustion engines and EVs, defining EVs as vehicles containing at least one or more electric motors (Gauss, 2014: p. 3). In general terms, there is a variety of different criteria that scholars define as crucial to look at in terms of the development of electric vehicles. Before evaluating the criteria necessary to be taken into account regarding the quantification of EV development, we need to take a look at the definition of an economic paradigm-shift, and the implications it holds in general terms. As already outlined above, the automotive industry has been undergoing a major structural change within recent years. According to Pohl and Yarime (2012), these structural changes embody a major paradigmatic change process (Pohl and Yarime, 2012: p. 1433). They argue, that "a technological paradigm has a powerful exclusion effect and defines an idea of techno-economic progress made in a multidimensional trade-off between technological and economic variables" (Pohl and Yarime, 2012: p. 1433). Thus, an economic-paradigm shift always implicates substantial technological change.

According to Tushman, amongst the major frame conditions are several technological alternatives that compete against each other which furthermore leads to "old technologies" improving significantly within a short period of time (Tushman, 1997). Further, technological discontinuities at sub-system level normally dominate the market during a technological paradigm shift (Tushman, 1997). This is what Rosenberg (1976) is referring to as the so-called sailing–ship effect. According to Kline and Rosenberg, paradigmatic technological changes imply periods of major uncertainty (Kline and Rosenberg, 1986). Adding onto that, Cusumano et al.(1997) stress the major economic challenges for the incumbent firms, which often fail to benefit by such changes, due to inflexibility and unsufficient planning (Cusumano et al., 1997). According to these definitions on an economic-paradigm shift, the current EV-shift can be seen as a major technological evolution that holds various implications for automotive manufacturing, as well as their underlying and supporting industries.

One of the first publications that has been made prior to the actual formation of the currently ongoing global EV shift is Ogura's analysis on Honda's development of electric vehicles. Ogura (1997) states that Honda has experienced five different stages of electric vehicle development from the mid 1980s until 1997: (1) Basic technology research, (2) research of applicable technology, (3) marketing research, (4) development of production model, and (5) fleet test (Ogura, 1997: p. 51). According to Kazama (2018), the first electric car had already been introduced in 1913, which relativizes the often claimed novelty of EVs these days (Kazama, 2018: p. 19). Furthermore, the ongoing global EV boom is not the first, but third one that the automotive industry has seen (Kazama, 2018: p. 19-21). Kazama further argues that the very first one had already found its peak in 1973, following the great oil shock of the same year (Kazama, 2018: p. 20). The second one followed in the 1990s, with the USA being the primary contributor, using the governmental California Air Resources Board in order to foster technology development (Kazama, 2018: p. 20). Lastly, the third boom came into play as sort of aftermath of the great Lehman shock, and the following automotive crisis rooting in Detroit, thus affecting the three major US automotive manufacturers GM, Ford, and Chrysler (Kazama, 2018: p. 21). The main insight is the fact all three major EV booms the automotive industry has seen so far were all routed in the USA. The common assumption here is that the ongoing EV shift has already shown further reach than all the other so far experienced temporary booms that all followed major economic developments.

According to Sperling and Brown et al.(2018), there are four reasons that account for the growing embrace of EVs within the last couple of years. Firstly, the environmental impact, which accounts for both cities in the industrialized world, as well as those in developing countries (Sperling and Brown, 2018: p. 25). Secondly, the technological evolution that accompanied automobiles over the years. By electrifying cars more and more, ranging from electronic devices that regulate the air conditioning or lifting windows, electrification became more and more present (Sperling and Brown, 2018: p. 26). Thirdly, electrification holds large potential for reshaping car design. As contemporary automobiles are designed for the mainstream usage of combustion engines, the current design can be subject to substantial adjustment for electric mobility (Sperling and Brown, 2018: p. 27). Lastly, they argue that electrification benefits the end-users too, by reducing dependence on foreign oil and consumer vulnerability to volatile fuel prices (Sperling and Brown, 2018: p. 28).

Dincer et al. (2010) developed a series of qualitative indicators that help quantify economic attractiveness and the environmental impact of alternative fuel/propulsion systems. Their subject of analysis are six different vehicle types, namely ICEVs, HEVs, hydrogen fuel cell vehicles, H2-ICE vehicles, and ammonia-to-hydrogen vehicles (Dincer et al., 2010: p. 2). Their study shows that hybrid electric vehicles and electric cars have advantages over the others (Dincer et al., 2010: p. 15). They further argue that the economics and the environmental impact associated with the different vehicle types strongly depend on their source of electricity (Dincer et al., 2010: p. 15). The authors elaborate that in four different cases: (1) “If electricity is generated from renewable energy sources, the electric car is advantageous to the hybrid vehicle” (Dincer et al., 2010: p. 15-16). (2) “If the electricity is generated from fossil fuels, the electric car remains competitive only if the electricity is generated onboard” (Dincer et al., 2010: p. 15-16). (3) “If the electricity is generated with an efficiency of 50–60% by a gas turbine engine connected to a high-capacity battery and electric motor, the electric car is superior in many respects” (Dincer et al., 2010: p. 15-16). (4) “For electricity-generation scenarios 2 and 3, using ammonia as a means to store hydrogen onboard a vehicle is the best option among those analyzed” (Dincer et al., 2010: p. 15-16).

Song and Aaldering (2019) are following a rather different approach by focusing on the measures that have been taken by OEMs in terms of intentions to the diffusion of electric mobility paradigm. They categorize firm reactions to this changed environment by implementing one of the three generic strategies, which are “exit”, “switch” and the “sailing ship effect”, or SSE (Song and Aaldering, 2019: p. 898). Their findings show that “although the ICEV technology has entered into maturity stage, a complete departure from conventional combustion engines is not in sight for the next few decades” (Song and Aaldering, 2019: p. 898).

2.2. How to measure economic development

2.2.1. The Diamond Model

After clarifying what the EV-shift exactly includes, the question of how to quantify these developments becomes crucial. When it comes to comparing two particular countries in terms of their industrial development stage, including the aspect of economical competitiveness, the Diamond Model introduced by Michael Porter embodies a main benchmark that finds its influence in numerous related publications. In his 1990 published book, *The Competitive Advantage of Nations*, Porter criticized conventional economic trade theories and their inability to explain the present economic phenomena satisfactorily. Therefore, he developed a new paradigm, called "the Diamond Model" which enables to explain country-, or more specifically, industry-competitiveness. In this model Porter defines four determinants of industry competitiveness: (1) Factor conditions such as the nation's or industry's position in factors of production, such as skilled labor and infrastructure, (2) demand conditions such as sophistication of customers in the home country or market, (3) related and supporting industries, and (4) business context such as conditions for organization of companies and the nature of their domestic rivalry (Porter, 1990).

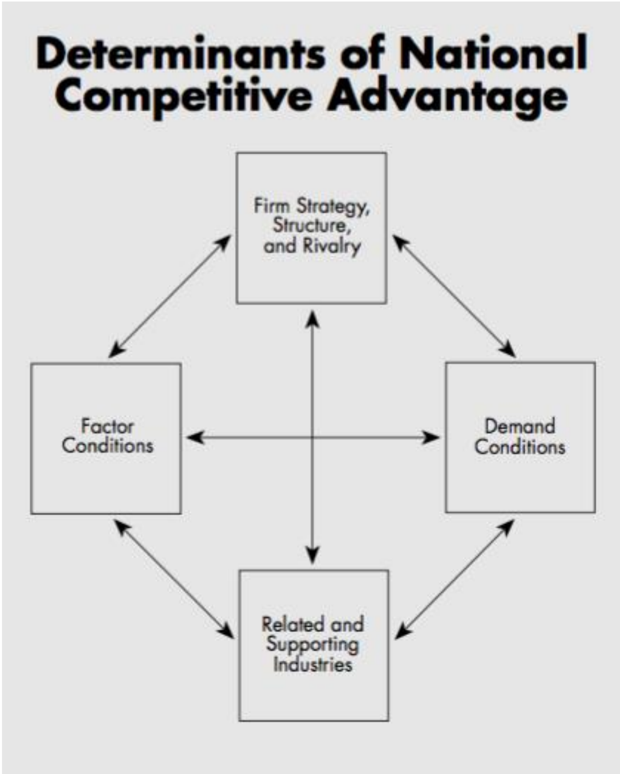


Figure 1. Porter's Singe Diamond Model (1990)

However, as Porter's model had gained popularity, Sardy and Fetscherin (2019) argued, that it does not explain the effects of multinational activities such as inbound and outbound FDI in the context of the global economy. Rugman and D'Cruz (1993) argued that the model does not apply to countries other than the U.S. Subsequently, Rugman and D'Cruz (1993), as well as Cho and Moon (2000) refined Porter's model and referred to it as the Double Diamond Model, or short DDM (Rugman and D'Cruz, 1993; Cho and Moon 2000). The most essential factor that makes the DDM model more suitable for contemporary international sector comparisons is the fact that it incorporates multinational activities and the role of the government into the model, instead of treating them as exogenous variables. In Sardy and Fetscherin's refined version, there are basically three important extensions to Porter's single Diamond Model: (1) The incorporation of multinational activities; (2) The operationalization of the competitiveness paradigm. A comparison of the sizes and shapes of the domestic and international diamonds shows major strategic differences; (3) it includes the government as an important variable which influences the four determinants of the Diamond Model. (4) It combines the domestic diamond and international diamond, as which is believed to make it more useful in terms of global comparison (Sardy and Fetscherin, 2009).

In addition to them, Cho and Moon put forward the concept of the "generalized double diamond", in which competitiveness has been defined as: "the capability of firms engaged in value added activities in a specific industry, in a particular country to sustain this value added over a long period of time in spite of international competition" (Cho and Moon, 2000: p. 117). At the same time, it has been stressed that the competitiveness of a small 'catching-up' economy is created (Cho and Moon, 2000: p. 17).

2.2.2. PEST analysis

Another possibility to evaluate business performance, and evaluate potential obstacles and difficulties on a macro-economic and macro-environmental basis, is PEST-analysis, or Broad Factors Analysis. Both abbreviations stand for a macro-economic framework that evaluates business performance in terms of macro-environmental factors. It was invented by the French scholar Francis Aguilar in 1963 and has been used as a tool for evaluating business performance for the environmental scanning component of strategic management. It consists of four main pillars, divided into political, economical, social and technological factors that are respectively broken down into several sub-categories according to the research subject.

PEST analysis has been run on the EV production to evaluate the performance of the Turkish automotive industry by Yilmaz and Selman. In their study, they were focused on evaluating the impact of the growing energy costs in connection with the fluctuations in the oil prices in recent years upon the demand for the EVs in the domestic Turkish automotive market. By reviewing political, economic, social and technological factors relevant to the discussion to determine the future expectations and to identify the positive and negative impacts of these factors. As for the political and legal factors, the authors analyzed national tax rates, investment towards R&D. The economic factors were characterized by employment, labor costs, the manufacturer's revenues, as well as geographical and social securities (Yilmaz and Selman 2010: p. 16). As for the social factors, the authors discussed consumer needs by referring to taxi drivers in Turkey, as a very large car-owning interest group. Eventually, the technological part was dominated by an elaboration on the importance of infrastructure extension (Yilmaz and Selman 2010: p. 16).

2.2.3. Governmental policy approach

On a more theoretical basis, there is also the common approach of analyzing how governmental policies contribute to the economic development of a certain industry. Laurent and Windisch (2011) follow this approach in order to provide an analytical framework for policy analysis fostering electric vehicle development. They defined five major types of instruments that governments use in order to steer EV development, (1) command and control instruments, (2) economic instruments, (3) procurement instruments, (4) collaborative instruments, and communication and diffusion instruments (Leurent and Windisch, 2011: p. 222-223). They applied this framework to a variety of different countries, including China and Japan, concluding that Japan focuses on purchase subsidies, and more so on taxation incentives, whereas China focuses heavily focuses on purchasing subsidies, taxation incentives, and public funding for infrastructure development. Leurent and Windisch argue, that the unique factor to China in this regard remains its local policy differences (Leurent and Windisch, 2011: p. 230). Although frequently used in terms of EV development, policy based publications do not include any economic key figures that evaluate industrial development per se. In the following two sub-chapters, the academic discourse on electric-vehicle development, especially the methodological approaches that have been used by researching scholars in the filed, will be analyzed.

2.3. Electric Mobility development in China

2.3.1. Governmental policy

The academic discourse on China’s EV market situation is heavily driven by speculations on its potential as mass producer and global EV provider, as well as the **importance of governmental policies**, five-year plans, and governmental involvement in general.

Tagscherer (2012) builds upon the policy-based approach and conducts a policy analysis that takes into account different policies aiming at domestic EV development, contributing to an evaluation of the current development. Her review looks especially at the impact of the different national policies on the development of electric vehicles and tries to analyze the relations between these policies as far as this is possible from an outsider's perspective. She concludes that the current strategy of the Chinese government concerning the development of electric vehicles is supported mainly by three major policy fields: (1) Support for R&D, (2) support for the related industry, and (3) Support for private and public consumption (Tagscherer, 2012: p. 1). Hao et al. narrow the policy approach down to a specific Chinese EV subsidy program and conducted a study on China's phase I and phase II electric vehicle subsidy schemes. They conclude their evaluation on governmental subsidy by stating that "China's EVSS is very necessary for BEVs to be cost competitive compared with CPVs in the short term", especially before 2015 (Hao et al., 2014: p. 731). In his publication on chances and potentials of EVs in a variety of globally important markets, such as the USA, Germany, France and China, Gauss goes a step further than Liu et al. by assuming that the government is rather promoting EV (Gauss, 2014: p. 57). He also approaches the topic upon the assumption that the government plays an essential role in China's EV development progress, thus appears to be very much in line with Tagscherer.

Heiden and Taube (2013) also focus on the governmental role and weight of policies, as well as Tagscherer does, but they add a scope of identified obstacles that holds back EV transition in China onto their framework. They argue that China's transition to electric mobility has been held back by five interlinking problems: (1) The lack of technology development that could lower down the production costs of EV components. (2) Insufficient production capacities of the automotive industry to support the potential demand in the near future. (3) Customers have so far been reluctant to buy EVs as the industry fails to present attractive domestic models, and lower prices. (4) The difficult challenge of providing an EV supporting infrastructure throughout a country of China's size. (5) The public policy issue (Heiden and Taube, 2013: p. 503). "Although the central government has shown its determination to boost Chinese EV development, policies remain highly influenced by provincial and municipal governments that draft their own policies adapted to local circumstances and catering to local interest groups, which oftentimes do not reflect central governmental incentives" (Heiden and Taube, 2013: p. 503).

Dunne (2018) is also focusing on the unique governmental role in terms of economic development and incentive provision, but also highlights the importance of international alliances and technological transfer in the case of China. He is putting equal emphasis on domestic, as well as international factors by equally highlighting the governmental power in contrast to technological transfer necessity (Dunne, 2018: p. 174).

2.3.2. Stakeholder-approach

Moving a little away from a solely governmental policy centered approach, Li and Zhang (2012) focus on stakeholder benefits and their significance for EV development. They provide a set of metrics for evaluating the overall benefits for all stakeholders in the EV industry, including the following four points: (1) the whole market scale of EV industry: battery, EV, E-mobility services, and etc., (2) the industrial core competencies: key technologies, international standards, and etc., (3) social benefits: pollution and emission reduction, energy saving, and etc., (4) Risk levels: investment recovery, pollution of used batteries, and etc. And an analysis model is developed for evaluation of the overall benefits for all stakeholders in the EV industry (Li and Zhang, 2012: p. 1-2). They argue that EV development is of strategic interest in China, because of the rising numbers of car owners, the aimed independence of oil by realization of the electrification of the power train. Therefore, “BEVs will play as an important strategic role for securing the future energy safety of China” (Li and Zhang, 2012: p. 1-2). “In order to reach these goals, most importantly, China has to find a way to catch up in international competition, gain future competitive advantages” (Li and Zhang, 2012: p. 2).

Liu et al. (2014) add onto that and conducted an even further reaching study on the influence of stakeholders for the progress in Chinese EV development. Within these categories, the governmental policies do still play an essential role, as they do in Tagscherer’s, as well as in Heiden and Taube’s publication, but become only one of six other important key factors in terms of EV development. They have defined six categories of stakeholders, namely (1) the central government, (2) EV manufacturers and companies, (3) service companies and agencies, (4) power supply, (5) consumers, and (6) the conventional car industry (Liu et al., 2014: p. 2171). The authors intended to evaluate which of the defined stakeholder-groups are promoting, defending, latent and apathetic groups in terms of EV development in China. They came to the conclusion that there are just two actively promoting groups, being the EV manufacturing companies themselves, as well as the service companies and agencies. Further, they evaluated the central government to be a defender, the power suppliers and consumers to be latent, and conventional car manufactures to be obviously apathetic (Liu et al., 2014: p. 2171). Adding onto the customer reluctance, Lin and Wu (2018) examine the factors that may affect the public's purchasing intention of electric vehicles via a survey. They propose an electric vehicle purchasing intention model that takes into consideration a number of demographic characteristic factors and attitude factors (Lin and Wu, 2018).

2.3.3. Multi-level approaches

Tyfield even moves a little further away from a primarily policy-based approach and conducts a multi-level perspective (MLP) analysis based on Foucault's framework on socio-technical system's transition is applied, in order to analyze China's mobility transition in a global context (Tyfield, 2014: p. 587). He concludes that "a socio-technical perspective such as MLP allows identification of brighter possibilities regarding disruptive innovation around EV and potential redefinition of the car, but problems facing transportation and the full societal implications go beyond" (Tyfield, 2014: p. 601).

Shang and Shi (2013) conducted a case study on the implementation of EVs in China's Shandong province. They used qualitative research methodology, conducted multiple case through the implementation of interviews with companies, industrial players and policy makers. They offer an original theoretical contribution through developing strategic capabilities of emerging business ecosystems, and furthermore provide a comprehensive structure on the low-speed EV industry in China. The authors conducted their analysis by identifying the current industrial challenges and potential research areas, exploratory case studies are carried out through the implementation of semi-structured interviews with firms along the supply chain, policy makers and industrial players (Shang and Shi, 2013: p. 62).

2.4. Electric Mobility development in Japan

2.4.1. HEV-focused technology approach

As far as the academic discourse of EVs in Japan goes, there is also a notable focus on EV policies, development, and infrastructural development, as has already been observed with China. Another fact that can be noticed, is that publications on EVs in a Japanese context tend to be heavily focused on HEVs, which could be explained by referring to their rather big market shares in Japan. An often claimed core-argument that determines the research approach is that Japan is superior to other automotive manufacturing countries in terms of EV-technology.

Horak and Pascha (2013) follow this approach and try to measurably quantify the superiority of East Asian car manufacturers South Korea and Japan in terms of EV development capabilities. They argue that "both countries' superiority is closely tied to heir activeness of patent applications". They furthermore focus on Toyota's huge success in terms of the hybrid-technology development in the late 1990s and early 2000s, the Japanese automotive manufacturers regarded Toyota as the new benchmark in terms of technological development, which thus lead to "herd-effect" that made the whole domestic industry adjust to the new benchmark. (Horak and Pascha, 2013: p. 484).

Yamazaki has also elaborated on the herd-effect of the Japanese automotive industry in terms of EV-shift. He gave the example of Toyota, who started hybrid technology development, which other Japanese manufacturer followed (Yamazaki, 2014: p. 155, 156). Nevertheless, "exogenous factors are also believed to be of high importance to the export-oriented Japanese economy, China's decision to restrict export of rare earth elements and rare material made Japan focus on R&D of domestically producible batteries without the use of those materials" (Horak and Pascha, 2013: p. 485). Another major stance of their study is Japan's early success in the development of e-mobility, as a result of leading automotive manufacturers intervening with leading tech companies, building joined ventures and focused on mutual interests and their development (Horak and Pascha, 2013: p. 486). However, "the success of the later invented plug-in hybrids was not as overwhelming as the Japanese manufacturers had expected it to be, due to higher prices of the car itself and a lack of charging areas" (Yamazaki, 2013: p. 156).

2.4.2. Governmental policy approach

Yabe et al.(2012) assessed CO2 reduction rate by setting the ratio of zero emission power generating sources as a parameter. An important feature of their paper is the study of an optimal long-term solution for the Japanese nation as a whole through the predictive assessment over the ultra long-term by using as parameters the ratio of zero emission power generating sources and the economic efficiency of HVs, PHEVs and EVs, all of which have a mutual influence on each other in price reductions resulting from mass production of batteries (Yabe et al., 2012: p. 530).

An opposing approach was made by Pohl and Yarime in 2012. They argue that Japanese national policy has so far had a limited direct role in the electrification of vehicles (Pohl and Yarime, 2012: p. 1431). They develop and use a combined framework that includes policy and firm level theoretical factors, using the functions of the policy-oriented technological innovation system complemented with some firm-level innovation management concepts. The core argument here is that in mature industries most activities relating to innovation take place in firms. Hence, a technological paradigm shift, requiring new knowledge, which can be easily generated by big companies (Pohl and Yarime, 2012: p. 1434). On the firm level, they define the following determining factors: (1) Knowledge, learning and network relations, (2) Lifecycles, (3) First-mover strategies, which they then eventually link back to industrial policies (Pohl and Yarime, 2012). Horak and Pascha evaluate the state of the Japanese automotive industry's status in terms of electric mobility. They are describing somewhat superiority of Japanese EVs by defining the following three key arguments: (1) a lot of knowhow and early market entry, (2) massive subsidization by the government in terms of: objectives, research and development (industry), purchasing incentives (consumption), (3) Excellent cooperation between government, industry and universities / research institutes (Horak and Pascha, 2013: p. 491). Adding onto this, in their study on the development of electric and hybrid electric vehicles in Japan, Pohl and Yarime identified even more factors. The authors evaluated a variety of factors that are most commonly referred to in terms of the Japanese success regarding EVs, especially HEVs. The most important ones are the following seven: (1) The intense competition on the domestic market, (2) Government policy, whose role is still being disputed amongst scholars. Basically there are those who emphasize the role of the Japanese government, and those who argue that the role of the Japanese industrial policies was negligible. (3) Entrepreneurial spirit of Japanese automakers, (4) Education and employment system, (5) Product and process development, (6) Supplier management, (7) Ownership structure (Pohl and Yarime, 2012: p. 1438). They furthermore focus on the very strong firm–internal product development capability, which was one of the most crucial factors enabling a successful development and introduction of technologically relatively complex HEVs (Pohl and Yarime, 2012: p. 1433). They further develop a framework to evaluate the technological paradigm shift within the Japanese automotive industry. They elaborate on firm–internal and firm–external factors, and define six dimensions of innovation: (1) knowledge, (2) expectations, (3) entrepreneurship, (4) growth, (5) institutions, and (6) externalities (Pohl and Yarime, 2012: p. 1442).

Åhman (2006) focuses on governmental support for developing vehicles with alternative powertrains that started in the early 1970s. According to him, BEVs were chosen by MITI as the most interesting option for the future as they had the potential to mitigate both local emissions and oil-dependence (Åhman, 2006: p. 436). Åhman argues, “the government role has been that of a conductor in the development process supplying both R&D support and artificially created niche markets, and easing the way for targeted technologies by means of legislation and standards” (Åhman, 2006: p. 433). He departs isolated policy-instruments by looking at the total effects of many combined programs and including framework conditions, such as institutional settings and business attitudes towards regulation.

Ando et al. (2014) contradict Yamazaki’s, as well as Pohl and Yarime’s rather negative conclusion on EV development in Japan by focusing on new policy implementations aiming at building a low carbon society and at promoting next generation vehicles to promote the development of 'smart communities'. According to them, one of the first model cases in terms of becoming a smart-city was Toyota City, which received governmental support for its infrastructural development towards an PHEV-friendly community (Ando et al., 2014).

2.4.3. Consumer-behavior based approach

A quite recent contribution to the discourse was made by Zhang et al. Their study was based on the three following profound research questions: (1) “Which factors mainly affect the adoption potential of BEVs?” (2) “What are the sensitivities and interaction of such factors to the adoption potential of BEVs?” (3) “What effective policies should be put forward by the government to respond to the proposed target?” (Zhang et al., 2018: p. 528). Based on three years of GPS data of 1.6 million people, Zhang et al.estimated the travel and adoption demands of BEVs in Japan. As Yabe et al. have already identified the importance of further infrastructure development, Zhang et al. state that the key technologies restricting the marketization of BEVs are those for efficient battery energy storage and quick charging at a low temperature (Zhang et al., 2018: p. 528). In addition, “the high prices of electric motors, batteries, and motor control systems increase the production cost of BEVs compared to ICEVs, which limits the market potential of BEVs to a certain extent, and can thus only be overcome by sufficing governmental support and subvention” (Zhang et al., 2018: p. 528). They state that sophistication of these support service systems will directly affect the demand for BEVs, and are thus strongly related to the of governmental policies towards CO2 reduction, and environmental friendly mobility (Zhang et al., 2018: p. 528). They further argue, “the promotion of BEVs will impact the development and operational efficiency of urban areas, which will further enhance EV sales, thus the development of BEVs is a challenging sociotechnical issue of both economic, as well as social importance” (Zhang et al., 2018: p. 528). The authors follow Yamazaki’s footprints and conclude in terms of the charging intervals analysis that, “compared to increasing the battery capacity, improving the public charging infrastructure and developing fast-charging technology are much more efficient at increasing the adoption potential of BEVs” (Zhang et al., 2018: p. 532).

Shen and Ma (2018) were developing a methodology to position nations’ efforts in a technology domain with a patent network analysis, conducting a case of the electric vehicle domain in China, Japan, Germany and the USA. A very essential part of their paper is covered by patent analysis, especially an evaluation on co-occurrence of IPCs that has been applied mainly to find clusters of patents (Shen and Ma, 2018: p. 1085). The comparison between the four nations includes data from two perspectives: (1) patents applied for by each nation, and (2) patents applied for in each nation (Shen and Ma, 2018: p. 1087).

3. Methodology

3.1. Approaching EV-development

This thesis will follow an eclectic approach by evaluating the most important criteria in terms of electric vehicle development. Based upon Porter's Diamond Model, the theoretical approach this thesis follows will be dominated by four pillars: (1) Factor conditions such as the nation's or industry's position in factors of production, such as skilled labor and infrastructure, (2) Demand conditions such as sophistication of customers in the home country or market, (3) Related and supporting industries, and (4) Business context such as conditions for organization of companies and the nature of their domestic rivalry (Porter, 1990). As this thesis aims at presenting an analytical framework, which enables a country comparison between China and Japan in terms of electric vehicle development, Porter's predefined pillars will be complemented by adding some additional criteria based on the evaluation of the academic discourse of electric vehicle development.

Since modern days EV business relies heavily on international alliances as well as the transfer of technological know-how, this thesis adds onto Sardy and Fetscherin's approach of the so-called double-diamond model. This approach combines domestic and international factors in order to enable a profound analysis of the development and competitiveness of a country's industrial sector. The analytical framework presented in Table I thus follows the concept of the double-diamond model, which has been punctually updated in order to enable a comparison of China's and Japan's EV development process, as well as their current state of industrial competitiveness.

3.2. Analytical Framework

3.2.1. Outline

The main reason why the analytical framework of this thesis was based upon Porter's original approach is threefold. Firstly, besides all flaws and adjustments that have been made by scholars over the years, Porter's diamond model still marks the most frequently cited framework that came up after researching the academic discourse on economic sector development. It embodies the basis of analysis for many studies that have been conducted. Secondly, even though barely anyone uses the model as it originally had been developed by Porter, the basis can still be regarded as valid and adjustable for many specific cases. Based on this, the analytical framework for this thesis will thus follow the same approach and consider Porter's diamond model as the rough basis that provides a basic direction. Thirdly, considering all the adjusted and redefined versions of Porter's diamond models more precisely, the basis for the individual criteria for the respective pillars of the analytical framework were provided by Sardy and Fetscherin. As their study embodies a multinational analysis of automotive industry development based on the double diamond model, the majority of their defined criteria has been adapted. However, as the analytical framework of this thesis intends to analyze a rather specific area of the automotive industry in two rather distinct countries some sub-criteria have been re-arranged. Table I. below shows analytical framework that has been designed for this thesis.

<table>
<tr><th colspan="2">Factor Conditions</th><th colspan="2">Demand Conditions</th><th colspan="2">Related and Supporting Industries</th><th colspan="2">Business Context</th></tr>
<tr><th>Domestic</th><th>International</th><th>Domestic</th><th>International</th><th>Domestic</th><th>International</th><th>Domestic</th><th>International</th></tr>
<tr><td rowspan="2">Production capabilities</td><td rowspan="4">Outbound and Inbound FDI, Alliances</td><td rowspan="2">Domestic EV sales, growth</td><td rowspan="4">EV export volume,
EV export growth development</td><td>Overall Industrial Production Growth Rate, Suppliers</td><td>Oil imports</td><td rowspan="2">Variety of domestic EV producers</td><td rowspan="4">Specialization</td></tr>
<tr><td>Power situation, generation</td><td>Oil exports</td></tr>
<tr><td>Research and Development</td><td rowspan="2">Societal adaption, and Costumer sophistication</td><td rowspan="2">Employment numbers in automotive industry</td><td rowspan="2">Import and Export value of EV components</td><td rowspan="2">Governmental policies</td></tr>
<tr><td>Infrastructure</td></tr>
</table>

Table I. *Analytical Framework.*

Each of the four pillars contains two dimensions, namely the domestic, as well as the international side, as suggested by Sardy and Fetscherin, in order to enable a precise multinational analysis. The sub-criteria that have been defined by analyzing the academic discourse on electric mobility development are elaborated on and explained in the following sub-chapters.

3.2.2. Factor Conditions

For Factor conditions, Porter’s original framework first and foremost includes criteria that determine a nation's or industry’s position in factors of production, such as skilled labor and infrastructure (Porter, 1990). The framework for this thesis will add onto this. For the sake of this thesis, **production capabilities** are obviously the most self-explanatory element regarding factor conditions. Hereby, the study is going to focus on both country’s capabilities in terms of production, meaning that numbers of all manufactured EVs are going to be the predominant subject of analysis.

Research and Development is another crucial factor that determines a states’ capabilities in becoming a technological leader. Heiden and Taube agree with Tagscherer on the importance of the government and state, especially governmental support for the development and commercialization of EVs in China. Hereby it needs to be mentioned that oftentimes R&D is included in governmental policies, therefore many scholars that are focusing on R&D importance, are researching this in accordance to governmental policies. This framework will cover general R&D, which is either conducted by private companies or funded by the government. R&D does not necessarily have to be part of governmental policies, and will thus be dealt with in a separate chapter. The role of the government is going to be dealt with separately in chapter 3.4. (Business Context).

As for factor conditions on the domestic side, **infrastructure** has been added. It is believed to be one of the most difficult to overcome obstacles in terms of making the EV-shift sustainable. In a Japanese context, especially Ando et al. (2014) are emphasizing the significance of a functioning EV-infrastructure by researching the example case of Toyota’s smart city project, which will be elaborated upon amongst the empirical part of this thesis in detail. Laurischkat et al.(2016) are highlighting the significance of alternative models opposing to traditional car ownership as very crucial for further implementation of EV technology (Laurischkat, 2016: p. 484). As they refer to car-sharing models or battery swap strategies, the infrastructure factor of the analysis will also look into already existing programs in that regard.

Regarding the factor conditions, the **international component** for analyzing EV-development becomes very crucial. Many scholars, such as Dunne argue that especially China’s efforts to strengthen its technological capabilities are determined by their international alliances (Dunne, 2018: p. 173). Based on this, primarily **outbound FDI, inbound FDI**, as well as **international alliances and joint venture activities** will be analyzed in order to evaluate the state of both countries’ international factor conditions. Outbound FDI activities will provide an insight to what extent international activities and technological transfer influence both countries' state of electric mobility development. Especially in terms of international alliances, Heiden and Taube are highlighting the significance of this factor, as they argue that without blue-prints for the popularization of green vehicles available from other countries, Chinese transition strategies centered on exploration and experimentation (Heiden and Taube, 2013: p. 498).

3.2.3. Demand Conditions

Domestic demand conditions most importantly contain domestic sales numbers and their growth rates. As addressed by Heiden and Taube (2013), in a Chinese context, customers have so far been reluctant to buy EVs as the industry fails to present attractive domestic models, and lower prices. They argue that insufficient production capacities of the automotive industry are unable to support the potential demand in the near future (Heiden and Taube, 2013).

According to Porter's original publication of the diamond model, demand conditions first and foremost include the sophistication of customers in the home country or market (Porter, 1990). As for demand conditions in an EV-context, the significance of data has been specified by adding EV-specific components. Domestic EV sales and their growth rates are highly valuable in providing some basic understanding of the market situation, thus are essential keys for analysis.

Societal adaption, and costumer sophistication have been major obstacles to the EV-shift in both countries to some extent. Heiden and Taube prioritize this point by stating that customers have so far been reluctant to buy EVs as the industry fails to present attractive domestic models, and lower prices (Heiden and Taube, 2013). Dunne is taking this a step further and argues that the concept of owning a car in principle interferes with the vision of making electric mobility the new mainstream mobility. He addresses the importance of a broader accessibility to EVs by increasing the promote more efficient transport systems (Dunne, 2018: p. 183).

On the international side of the scope, demand conditions are heavily influenced by export. Thus the **export volume of EVs**, as well as their **growth rates** are considered to be essential for this part. By evaluating the export quantities and tendencies, the respective state of the market can be analyzed. It is believed that the sole number of produced units is not sufficient in terms of understanding the state of both countries EV-development. The common misconception of China being a mass producer of low-quality products that are not exported, and Japan of being a moderate overall producer but powerful exporter is going to be addressed.

3.2.4. Related and Supporting Industries

The third pillar of related and supporting industries has been expanded by adding the sub-criterion of power generation and supply, as this factor ties in with the already mentioned infrastructural specialties that oftentimes pose obstacles to EV development.

The most important criterion for the domestic scope of this part is the overall **industrial production growth rate**. The overall status of the automotive industry sector is believed to be crucial regarding their EV-capabilities. As both countries are at very different developmental stages, the overall state of the industry is needed in order to put the extracted data into perspective before adequately analyzing it. The same goes for the automotive suppliers. As the automotive industry is a huge continuum of different sectors, the implications the ongoing EV-shift holds for the domestic industry itself, is enormous. As pointed out by Krieger et al., building up local supplier's capabilities is an essential obstacle that has to be overcome (Krieger et al., 2012). Thus, the overall growth rates of the domestic automotive industry have to be considered in order to connect the dots. Further, the existence and preparedness of domestic suppliers for EV-production become valuable in this context. The analysis will evaluate, whether both countries' capable supply chains that are suited for the ongoing EV-shift.

Another very valuable criterion is the **power situation and generation**, which goes along with the EV-shift. This point is highlighted by Yabe et al. who try to evaluate a possible long-term solution for the Japanese nation as a whole through the predictive assessment over the ultra long-term by using as parameters the ratio of zero emission power generating sources and the economic efficiency of HVs, PHEVs and EVs, all of which have a mutual influence on each other in price reductions resulting from mass production of batteries (Yabe et al., 2012: p. 530). In order to implement any sustainable form of mainstream EV-mobility, besides the already mentioned infrastructural component, the energy component has to be considered. Are there sufficient power generating capabilities, how expensive is energy and is there realistic potential for expanding the technology further?

Additionally, **employment numbers within the automotive industry** are another essential factor for this analysis. As Yilmaz highlighted in his analysis on the sate of the Turkish automotive industry, he referred to the related industrial sectors as *economic factors*, which he defined by employment, labor costs, the manufacturer's revenues, as well as geographical and social securities (Yilmaz and Selman 2010: p. 16). For this thesis' framework, social security has been excluded, as it is not believed to have a significant influence on answering the research

question on EV-development. However, labor, more specifically the employment rate within the sector is strongly emphasized. As already mentioned, the EV-shift has huge implications for the overall automotive industry of both examined countries, thus employment within the sector needs to be analyzed in order to get a better understanding of growth potential, significance of the technological shift for the respective economy.
On the international scope of the related and supporting industries chapter there are two main fields of interest for the analysis. Firstly, the countries' dependence on natural resources, mainly fossil fuel. Hereby, the **import and export numbers of oil and gas** are considered to be relevant, as these activities relate to other important areas, such as governmental policies, and ambitions of pushing R&D.
Secondly, the **import and export value of EV components** will be subject of analysis. As priorly mentioned, the supply chain is a crucial determinant of domestic industry stake and capability. As the automotive sector is a massively cross-linked one, it is once more necessary to take a look at the import and export value of EV-related components, in order to get a better understanding of how well the market is already embedded in the ongoing EV-shift.

3.2.5. Business Context

According to Porter's original framework, business context includes factors such as conditions for organization of companies and the nature of their domestic rivalry (Porter, 1990).
On the domestic side, the variety of domestic EV producers is going to considered. As it is essential to know how wide spread the technological shift has already become amongst the domestic industry competitors, domestic producers' EV-development activities are the main subject of analysis. Predominantly the question whether there is domestic rivalry amongst the main domestic manufacturers is going to be answered.
As the modified Double Diamond Model, or short DDM (Rugman and D'Cruz 1993; Cho and Moon 2000) incorporates multinational activities and the role of the government into the model, the criteria for business context has been arranged as Rugman and Cruz suggested, by adding the governmental component. **Governmental** influence, especially the role of **policies** can be understood as an important key element, for enabling an adequate comparison.

In a Japanese context, illustrated by Åhman, et al. highlighted the contribution of Japanese governmental policy incentives on the high amount of HEVs (Åhman, 2006: p. 436). In a Chinese context, Heiden and Taube also focus on the governmental role and weight of policies, as well as Tagscherer does, but additionally adding a scope of identified obstacles that holds back EV transition in China onto their framework. The analysis of governmental policies will follow the approach of Laurent and Windisch, especially the five major types of instruments governments use in order to steer EV development (Leurent and Windisch, 2011: p. 222-223). On the **international** scope of business context, specialization will be highlighted, as various times in the literature overview, this thesis will cover all forms of electric vehicles, thus leave room to discover both countries' **specialization**. Especially in a Japanese context the significance of specialization, as pointed out by Horak and Pascha (2013), become visible. As both countries follow different approaches in terms of technological specialization, the analysis of both countries' respective EV-approaches will help understanding their role in the global EV-shift.

3.3. Conditions and Limitations

The framework this thesis developed is intended to combine aspects from a great variety of publications of the academic discourse on EVs. The result of the eclectic approach taken include the four main pillars defined by Porter, as well as the supplement made by Rugman and D'Cruz (1993), as well as Sardy and Fetscherin (2009) by incorporating the role of governmental policies, and the distinction between domestic and international factors. The set of sub-criteria within each pillar is the result of the combination of theory and on-topic criteria extracted from the academic discourse on EVs. As the study exclusively focuses on EV development activities, some rather basic criteria defined by Sardy and Fetscherin that cannot be applied in an EV context have been removed. The rather extensive amount of sub-criteria is believed to ensure a balanced analysis of both country cases and furthermore enable an on point comparison of the results. As there is an extensive amount of criteria that has been mentioned by scholars, as touched upon in the literature overview prior to this analytical framework, it is not possible to include each and every single criterion that has been mentioned. The selection of criteria in the above presented table can be understood as the result of a thoroughly conducted process that has been aimed at answering the specific research question. Therefore, the scope for selection of the criteria has been put upon the specific frame of analyzing EV-development, rather than the development of conventional automobiles in general terms.

4. Empirical Part

4.1. Factor Conditions

4.1.1. Domestic

4.1.1.1. Production Capabilities

China

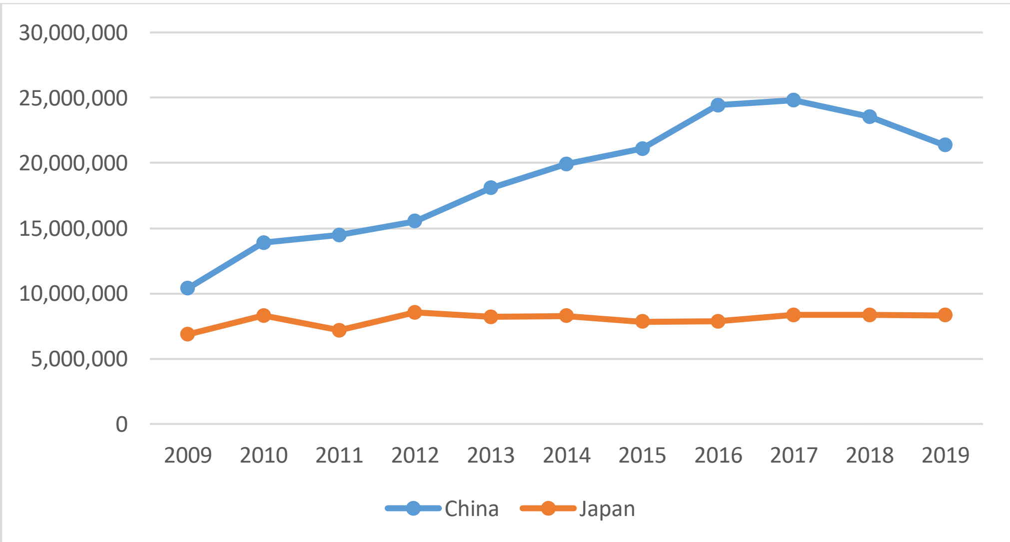
Chinas potential in mass-producing EVs is enormous. According to Tagscherer, governmental policies towards EV development and production in China show that there is a huge development potential, which makes analysts believe that China will become the largest market for electric vehicles in the future (Tagscherer, 2012: p. 1). “At the highest policy-making level, the Chinese government adopted the development of electric vehicles in its highest priority national plan, the 12th Five-Year Plan” (Tagscherer, 2012: p. 2). She further concludes that the current strategy of the Chinese government concerning the development of electric vehicles is supported mainly by three major policy fields: (1) Support for R&D, (2) support for the related industry, and (3) support for private and public consumption (Tagscherer, 2012: p. 1).

In their study on the influence of stakeholders for the progress in Chinese EV development, Liu et al. defined six categories of stakeholders, namely (1) the central government, (2) EV manufacturers and companies, (3) service companies and agencies, (4) power supply, (5) consumers, and (6) the conventional car industry (Liu et al., 2014: p. 2171). They came to the conclusion that “there are just two actively promoting groups, being the EV manufacturing companies themselves, as well as the service companies and agencies” (Liu et al., 2014).

In his publication on chances and potentials of EVs in a variety of globally important markets, such as the USA, Germany, France and China, Gauss (2014) goes a step further than Liu et al. by arguing that the government is rather promoting EV. He states that the Chinese government adopted recommendations on the promotion and development of renewable energy in 1999 (Gauss, 2014: p. 57). At the beginning of 2003, the government began drafting an EV-law, which was adopted at the end of 2005 (Gauss, 2014: p. 57). Gauss states furthermore that the main aims of this law are threefold: (1) to strengthen the important role of RES in the National Energy Strategy, (2) to break barriers in terms of development of RES, and (3) to create a market space for EVs (Gauss, 2014: p. 57).

The rapid development of Chinese automotive manufacturers during the reform era beginning in the late 1970s was mainly triggered by close cooperation with international OEMs in form of joint venture programs. These partnerships were typically initiated by international OEMs who intended to tap China's large market potential. However, despite the strict regulation of foreign investment in the Chinese market, the government allowed for limited partnerships and access, in exchange for technology, trying to make Chinese companies equally valuable in terms of their technological knowhow. Heiden and Taube evaluate, that "with their own technological expertise and innovation capability far behind the international competition, Chinese companies found themselves locked in the lower rungs of the market, making small, cheap and unsophisticated cars for low-budget buyers" (Heiden and Taube, 2013: p. 497). They argue that China's transition to electric mobility has been held back by five interlinking problems: (1) The lack of technology development that could lower down the production costs of EV components. (2) Insufficient production capacities of the automotive industry to support the potential demand in the near future. (3) Customers have so far been reluctant to buy EVs as the industry fails to present attractive domestic models, and lower prices. (4) The difficult challenge of providing an EV supporting infrastructure throughout a country of China's size. (5) The public policy issue (Heiden and Taube, 2013). They further state, "although the central government has shown its determination to boost Chinese EV development, policies remain highly influenced by provincial and municipal governments that draft their own policies adapted to local circumstances and catering to local interest groups, which oftentimes do not reflect central governmental incentives" (Heiden and Taube, 2013: p. 503). In the early 2000s, as no OEM anywhere in the world had been able to claim a major technological breakthrough in terms of alternative propulsion, or reached volume production in terms of EVs, there seemed to be a lot of potential competitors. Heiden and Taube comment, that "China believed that every automaker had to start from scratch as competitive strength in conventional vehicles did not translate into advantages for the development of electric ones" (Heiden and Taube, 2013: p. 497). Thus, the Chinese government announced that China should acquire international technology leadership and become the world's largest EV market. Heiden and Taube (2013) argue further, "there had been no breakthrough until 2012 due to limited options and the majority of Chinese people buying cheap local and, technically not advanced domestic cars. Incentives of local governments in a few cities to make e-vehicles more attractive to private buyers, did not achieve the intended goals" (Heiden and Taube, 2013: 500). They further argue that China's transition to electric mobility has been held back by five interlinking problems: (1) The lack of technology development that could lower down the production costs of EV components. (2) Insufficient production capacities of the automotive industry to support the potential demand in the near future. (3) Customers have so far been reluctant to buy EVs as the industry fails to present attractive domestic models, and lower prices. (4) The difficult challenge of providing an EV supporting infrastructure throughout a country of China's size. (5) The public policy issue. Although the central government has shown its determination to boost Chinese EV development, policies remain highly influenced by provincial and municipal governments that draft their own policies adapted to local circumstances and catering to local interest groups, which oftentimes do not reflect central governmental incentives (Heiden and Taube, 2013: 503). "In the meantime, Chinese companies tried to catch up by providing hybrid models. However, since this segment is dominated by Japanese companies, there was not much hope to break into this market. Therefore, Chinese planners preferred to skip conventional hybrids and leapfrog directly to PHEVs and BEVs. This strategy has failed so far as the development of key technologies proved significantly more difficult and time consuming than anticipated" (Heiden and Taube, 2013: p. 504).

The numbers of total passenger car production in China show that the country has reached production capacities of over 20 million units by 2015, and remained in this range ever since. The numbers of total passenger car production reached their peak so far in 2017, where a total amount of 24,806,700 cars were produced (Statista, 2020).



Source: Statista, 2020; JAMA, 2019; Marklines, 2020

Graph III. *Passenger car production in China and Japan 2009-2019*

Taking a closer look at the actual numbers of EVs that China produces, the numbers get more diversified. According to the China Association of Automobile Manufacturers (CAAM), overall vehicle production in 2019 totaled 25.721 million units, reflecting a 7.5% y/y decline,

while sales totaled 25.769 million units, reflecting an 8.2% y/y decline. Passenger car production reached 21.360 million units, showing a decrease of 9.2% compared to 2018. Sales of passenger vehicles totaled 21.444 million units, indicating a 9.6% y/y decline (Marklines, 2020). Proportions of passenger vehicle production and sales to total vehicle production and sales reached 83.0% and 83.2%, 3.4% and 1.2% lower respectively than the proportions in 2018 (Marklines, 2020). As for the EV-shares in production and sales, the Chinese statistics do not differentiate between each EV-type, but cluster them into one category, named NEV (new-electric vehicles, including HEVs, PHEVs and BEVs). Its production reached 1.242 million units, reflecting a decrease of 2.3% y/y, while sales reached 1.206 million units, reflecting a decrease of 4.0% y/y (Marklines, 2020).
Among NEVs, BEV the 2019 production numbers totaled in 1.02 million units, reflecting a 3.4% y/y increase, while sales were 972,000 units, showing a 1.2% y/y decrease. PHEV production and sales reached 220,000 units and 232,000 units, indicating 22.5% and 14.5% y/y declines respectively. As for Fuel cell vehicles (FCVs) , the production and sales numbers reached 2,833 units and 2,737 units, reflecting 85.5% and 79.2% y/y increases respectively (Marklines, 2020).

Overall vehicle exports in 2019 totaled 1.024 million units, reflecting a 1.6% y/y decline. Passenger car exports totaled in 725,000 units, showing a 4.3% y/y decline. Commercial vehicle exports totaled in 299,000 units, indicating a 5.7% y/y increase (Marklines, 2020).

	2019	**Share in percentage (2019)**	**Growth in percentage**	**2018**	**Share in percentage**
Passenger cars	25,721,000	100%	-7.5%	27,650,075	100%
NEV	1,242,000	4.82%	-2.3%	1,270,560	4.56%
PHEV	220,000	0.86% (17.71% of NEV)	-14.5%	251,900	0.91% (19.83% of NEV)
BEV	1,020,000	3.97% (82.13% of NEV)	3.4%	985,320	3.56% (77.55% of NEV)
FCV	2,833		85.5%		

Table II. *Production volume EVs in China (Marklines, 2020)*

The numbers show that even though the overall production of passenger cars in China has seen decrease within recent years, BEVs are still highly favored by Chinese OEMs. Production capabilities are very high and even increasing in times of decreasing overall production. As of 2019, BEVs accounted for 3.97% of the produced passenger cars volume, and even for 82.13% of all NEVs (Marklines, 2020). Chinese automotive production is therefore characterized by very high numbers of produced units, and a strong focus of BEV, rather than HEV and PHEV production, which together only account for 17.71% of all NEVs, compared to 19.83% in 2018 (Marklines, 2020).

Japan

An oftentimes claimed argument is that Japan is superior to other automotive manufacturing countries in terms of EV-technology. Horak and Pascha (2013) argue that, the superiority of East Asian car manufacturers South Korea and Japan is closely related to their activeness of patent applications. They furthermore state that due to the fact that their patent applications activity in the field of electric vehicles and battery, "development between 2006 and 2011 has been stable on the top of the the international rankings, Japanese manufacturers Toyota, Nissan and Honda could acquire the lead in development" (Horak and Pascha, 2013: p. 484). They conclude that due to Toyota's huge success in terms of the hybrid-technology development in the late 1990s and early 2000s, the Japanese automotive manufacturers regarded Toyota as the new benchmark in terms of technological development, which thus lead to "herd-effect" that made the whole domestic industry adjust to the new benchmark. (Horak and Pascha, 2013: p. 484).

Horak and Pascha conclude in describing the somewhat superiority of Japanese EVs by defining the following three key arguments: (1) A lot of knowhow and early market entry, (2) massive subsidization by the government in terms of: objectives, research and development (industry), purchasing incentives (consumption), (3) Excellent cooperation between government, industry and universities / research institutes (Horak and Pascha, 2013: p. 491). Adding onto this, in their study on the development of electric and hybrid electric vehicles in Japan, Pohl and Yarime identified even more factors. The authors evaluated a variety of factors, most commonly referred to in terms of the Japanese success regarding EVs, especially HEVs. The most important ones are the following seven: (1) The intense competition on the domestic market, (2) government policy, whose role is still disputed amongst scholars. Basically there are those who emphasize the role of the Japanese government, and those who argue that the role of the Japanese industrial policies was negligible. (3) Entrepreneurial spirit of Japanese automakers,

(4) education and employment system, (5) product and process development, (6) supplier management, (7) ownership structure (Pohl and Yarime, 2012: p. 1438).

Pohl and Yarime further argue that the very strong firm–internal product development capability was one of the most crucial factors enabling a successful development and introduction the technologically relatively complex HEVs (Pohl and Yarime, 2012: p. 1433). Pohl and Yarime divided the emergence of new technologies into various periods. According to them, the **first period,** starting in the mid 1970s, was characterized by the initial interest in the potentially oil-independent and locally emission-free BEVs. “The oil crises influenced Japan greatly and, in combination with the emission requirements of the Clean Air Act, contributed to an emerging interest in non-fossil fuel based technology” (Pohl and Yarime, 2012: p. 1439). During this period, “the first attempts of boosting BEVs were made, by using lead-acid batteries, which did not allow for commercially acceptable vehicles. Therefore, the government invested heavily in battery development research at this early stage. Eventually, BEVs were not attested a lot of future potentials, so the focus switched to FEVs for the remaining yeas of this first period” (Pohl and Yarime, 2012: p. 1439). According to Åhman, governmental support for developing vehicles with alternative powertrains started in the early 1970s. “BEVs were chosen by the MITI as the most interesting option for the future as they had the potential to mitigate both local emissions and oil- dependence” (Åhman, 2006: p. 436).

The second period starting in the 1990 was primarily dominated by the leading Japanese manufacturers investing in R&D of HEVs, then eventually dominated by Toyota’s success in mass production of HEVs starting in 1997 (Pohl and Yarime, 2012: p. 1439). This triggered the domestic competition amongst Japanese manufacturers, first and foremost the big three being Toyota, Honda and Nissan, which were also referred to by Yamazaki, Horak and Pascha (Yamazaki, 2014: p. 155, Horak and Pascha, 2013: p. 484). Interestingly, HEVs developed and emerged rapidly in Japan, despite the fact that there is a United States federal law designed to control air pollution on a national level, which is treated as one of the first and most influential modern environmental laws, the government has never subsidized HEV development directly (Pohl and Yarime, 2012: p. 1440). Åhman argues that “the government role has been that of a conductor in the development process supplying both R&D support and artificially created niche markets, and easing the way for targeted technologies by means of legislation and standards” (Åhman, 2006: p. 433).

Besides the industry itself, also the respective ministry – METI – got involved in the whole development process, and developed a roadmap, which aims at becoming more capable in terms of performance of lithium-ion batteries (Horak and Pascha, 2013: p. 486). Fuel cell technology was deemed important to industrial competitiveness in Japan and designated as a key technology by Prime Minister Koizumi in 2003 (Pohl and Yarime, 2012: p. 1440). Yamazaki argues that the main reasons why BEV sales in Japan are still very little, despite the fact that Nissan and Mitsubishi already offer quite competitive models, are the expensive prices, as well as the not yet sufficient mile range (Yamazaki, 2014: p. 156). Ando et al. (2014) contradict Yamazaki's, as well as Pohl and Yarime's rather negative conclusion on EV development in Japan by focusing on new policy implementations aiming at building a low carbon society and at promoting next generation vehicles to promote the development of 'smart communities'. According to them, one of the first model cases in terms of becoming a smart-city was Toyota City, which received governmental support for its infrastructural development towards an PHEV-friendly community (Ando et al., 2014). By highlighting the fact that the Japanese HEVs embody the first and yet only unconventional technology that hit the market with mass production, Pohl and Yarime develop a framework to evaluate the technological paradigm shift within the Japanese automotive industry. They elaborate on firm–internal and firm–external factors, and define six dimensions of innovation: (1) Knowledge, (2) expectations, (3) entrepreneurship, (4) growth, (5) institutions, and (6) externalities (Pohl and Yarime, 2012: p. 1442). At the very end of their study Pohl and Yarime raise a very interesting question on the linkage between governmental policy and new-technology vehicles, namely whether policy measures have created sufficient diversity. "Another implication linked to the long duration of the process is that there might be opportunities for intermediate solutions to be of commercial interest. The relative success of HEVs on the market is an example of one such potentially intermediate solution" (Pohl and Yarime, 2012: p. 1442). Pohl and Yarime agree on what has already been stated by Reingold. Toyota Hybrid Synergy Drive (HSD) technology was initially not meant to become mainstream and going into mass production, but attracting people to the brand again. "That made not just Toyota but also the Japanese manufacturers in general acquire a new image that successfully contributed to the emergence of the technology" (Reingold 1999; Pohl and Yarime 2012: p. 1443). EVs seemed to take longer time to become widespread because of their higher initial cost and inconvenience of frequent charges. However, large-scale production of EV/PHEVs has recently begun, and the possibility has arisen that adoption will proceed faster than our forecasts had predicted (Yabe et al., 2012: p. 530). Furthermore, "there is great uncertainty in augmenting zero emission power supplies in Japan, particularly after the huge tsunami followed by the severe accident in Fukushima 1 nuclear power plant" (Yabe et al., 2012: p. 530).

A quite recent contribution to the discourse was made by Zhang et al. Their study was based on the three following profound research questions: (1) "Which factors mainly affect the adoption potential of BEVs?" (2) "What are the sensitivities and interaction of such factors to the adoption potential of BEVs?" (3) "What effective policies should be put forward by the government to respond to the proposed target?" (Zhang et al., 2018: p. 528). Based on three years of GPS data of 1.6 million people, Zhang et al.estimated the travel and adoption demands of BEVs in Japan. They state, that "under the current construction conditions for public charging systems and charging technologies, the adoption potential of battery electric vehicles may not be as promising as previously expected, and the government still faces great pressure to respond to the market share target. Given the current level of battery technology, technical and policy improvements such as fast charging, reducing the production cost, perfecting the public charging infrastructure, and increasing purchasing subsidies were found to be more effective than improving the battery capacity at increasing the adoption potential of battery electric vehicles" (Zhang et al., 2018: p. 528). After the Fukushima Daiichi nuclear crisis, Japan increased imports of natural gas and crude oil in the short term to make up for the power shortage. Due to these tendencies, Zhang et al.could already evaluate this impact on power generation and consumption in his study, which Yabe et al., six years earlier on, could not. Although the production and sales of EVs have steadily increased, the annual demand for primary energy increased to 445.3 million tons of oil equivalent, and transportation accounts for 24.1% of the total energy consumption (Zhang et al., 2018: p. 527). As Yabe et al. have already identified the importance of further infrastructure development, Zhang et al.state that the key technologies restricting the marketization of BEVs are those for efficient battery energy storage and quick charging at a low temperature (Zhang et al., 2018: p. 528). In addition, the high prices of electric motors, batteries, and motor control systems increase the production cost of BEVs compared to ICEVs, which limits the market potential of BEVs to a certain extent, and can thus only be overcome by sufficing governmental support and subvention (Zhang et al., 2018: p. 528). They state that "sophistication of these support service systems will directly affect the demand for BEVs", and are thus strongly related to the of governmental policies towards CO2 reduction, and environmental friendly mobility (Zhang et al., 2018: p. 528). Further, "the promotion of BEVs will impact the development and operational efficiency of urban areas, which will further enhance EV sales, thus the development of BEVs is a challenging sociotechnical issue of both economic, as well as social importance" (Zhang et al., 2018: 528). The authors follow Yamazaki's footprints and conclude in terms of the charging intervals analysis that compared to increasing the battery capacity, improving the public charging infrastructure and developing fast-charging technology are much more efficient at increasing the adoption potential of BEVs (Zhang et al., 2018: p. 532).

As far as the production numbers go, Japan has a remarkable market share of HEVs. As for 2019, Japan produced 8,328,756 units of passenger cars (JAMA, 2020). A factor that has to be considered in the case of Japan is that almost all big Japanese OEM's have been outsourcing their production overseas. Taking a look at the number of passenger car units produced by Japanese manufacturers overseas, one realizes that the total number of Japanese branded cars is far higher than the number of cars domestically produced in Japan. In 2019, Japanese OEMs have produced 18.85 million units in overseas facilities, accounting for around 56% of all Japanese OEMs production volume. This marks a significant drop of almost 1 million units compared to 19.97 million produced cars in 2018 (Statista, 2020).

4.1.1.2. Research and Development

China

In a Chinese context, R&D activities of big OEMs usually relate closely to the outline of the current five-year plan. As Heiden and Taube agree with Tagscherer on the importance of the government and state that since government support for the development and commercialization of EVs in China has commenced, substantial resources were allocated to promote R&D, demonstration projects or the construction of related infrastructure. However, "without blue prints for the popularization of green vehicles available from other countries, Chinese transition strategies centered on exploration and experimentation" (Heiden and Taube, 2013: p. 498). A variety of domestic enterprises have by now successfully introduced electric vehicles, however there is still a long distance from research to mass production line, requiring a lot of engineering research and development. China still faces rather great deficits in the field of engineering and the government needs to increase research activities in this area. Electric vehicle technology is the main bottleneck in battery technolog due to that the current vehicle power battery's energy density is relatively low and more battery are assembled to improve the mileage of EVs, in order to make them competitive.

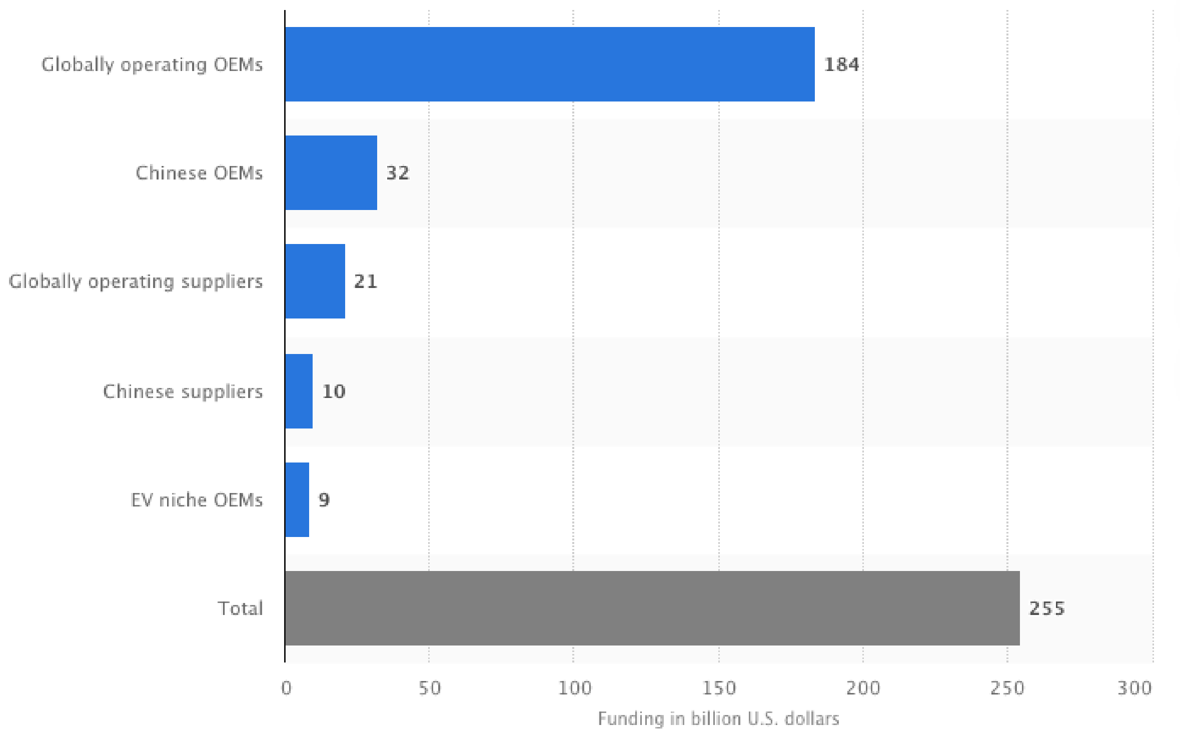
As China has been importing a lot of its technological knowhow through joint-venture programs with foreign, mostly Japanese and German automotive companies, the technology gap is still a major obstacle that prevents China from reaching higher export numbers. As the Chinese government has announced EVs to be a major focus in recent five-year plans, governmental involvement in R&D is intended to speed-up the technological development in order to enhance China's competitiveness in the field.

In order to close the technology gap to technologically more advanced automotive producers, like Japan, the Chinese government has been tackling the countries' R&D. Amongst these approaches, the most outstanding demonstration project is the special plan called '863' (Leurent & Windisch, 2011). For this project, the government has gathered relevant companies, research institutions and universities and has divided the project into five parts: (1) the power system technology platform, (2) the vehicle product, (3) the core component, (4) the public support platform and (5) common basic technology, which refers to the battery technology of EVs (Leurent & Windisch, 2011; Zhang et al., 2017).

As China embodies one of the global leaders in lithium-ion batteries for smartphones and tablets, China has already built up a solid knowhow-basis for this technology. This knowledge is considered to be the basis for further generation of propulsion solutions. Therefore, it can be regarded as the key factor that enables China to tackle its high EV goals. The '863' program has been focusing on reducing battery cost by material development, and further increasing battery life and optimization of operations. Chinese battery manufacturers expect costs in 2020 to be reduced by approximately 60% compared to 2012. This will reduce the cost of a typical new vehicle battery to between EUR 4,400 and EUR 6,500 (Hall & Lutsey, 2017). Adding to this ambitious program, according to the 'National Key Research and Development Program' for 2016-2020, additional 20 EV research projects will receive about EUR 90 million of funding from the government (Lu, 2018).

China is a major battery producer, mainly for consumer electronics, but within recent years, a great deal of research is underway regarding battery development for the automotive industry (Lowe et al., 2010). Therefor, many partnerships have been developed over the last couple of years for undertaking R&D in battery technology in China. As of 2017, the complete R&D spending of China accounts for 2.15% of its total GDP of 12.14 trillion USD (World Bank, 2020). In 2018, Chinese companies recorded a 34.4% growth in R&D expenditure, and reached USD 60.1 billion (China Daily, 2020). As the statistics on the biggest spending enterprises differ greatly upon the source, it is difficult to calculate how much spending the actual OEMs are conducting in terms of EV. Another factor unique to the Chinese economic landscape in this context is also the structure of ownership. Since the government is possessing large shares of big Chinese OEMs, it is assumed that a lot of the financial resources for conducting R&D is allocated by the government, which makes it difficult to track the actual spending by OEM.

Graph IV below illustrates the projected R&D funding efforts towards electric vehicles in 2023, with a breakdown by investor type (Statista, 2020). It is predicted that Chinese suppliers will spend some 10 billion U.S. dollars on electric vehicle-related R&D activities. Chinese OEMs and suppliers together are believed to spend around USD 42 Billion on EV research and development, accounting for around 16.5% of the worldwide spending in this field.



Source: Statista, 2020.

Graph IV. *Projected research and development funding efforts towards electric vehicles in 2023*

As for patent applications, China is heavily focusing on autonomous driving, which is why its number of patent applications in the automotive field is rather high but not necessarily related to EVs (WIPO, 2019).

Japan

In the context of technological research and development in Japan, Yamazaki (2013) has elaborated on the herd-effect of the Japanese automotive industry in terms of the ongoing EV-shift. He gave the example of Toyota, who started hybrid technology development, which other Japanese manufacturer followed (Yamazaki, 2014: 155, 156). Nevertheless, exogenous factors are also of high importance to the export-oriented Japanese economy, thus China's decision to restrict export of rare earth elements and rare material made Japan focus on R&D of domestically producible batteries without the use of those materials (Horak and Pascha, 2013: p. 485). Another reason for Japan's early success in the development of e-mobility is the fact that the leading automotive manufacturers intervened with leading tech companies, built joined ventures and focused on mutual interests and their development (Horak and Pascha, 2013: p. 486). However, the success of the later invented PHEVs was not as overwhelming as the Japanese manufacturers had expected it to be, due to higher prices of the car itself and a lack of charging areas (Yamazaki, 2013: p. 156).

Japanese OEMs have traditionally been focusing largely on HEV technology. However, in terms of R&D on a governmental policy level, HEVs have never been the main interest. Pohl and Yarime argue that "hybrids are not so easy to understand, whereas battery electric vehicles are", which made policymakers highlight BEVs, symbolizing their preference for simple messages (Pohl and Yarime, 2012: p. 1440). "Compared to HEVs of the Prius/Insight type and FCVs, which have no natural allies, BEVs also enjoy the support of the electric utilities, which envisage a new market for electricity" (Pohl and Yarime, 2012: p. 1440). Among other things, this change in preference towards BEVs resulted in the launch of a major battery research project, with public co-funding and participants from auto and battery makers, aiming at battery technologies beyond 2020. The change has also led to decreased ambitions relating to FCVs. However, one role of the government was to ensure that reasonable levels of fuel cell and hydrogen activities were maintained (Pohl and Yarime, 2012: p. 1441). Another research approach that was widely supported by governmental research funding is fuel cell technology. This technology was first deemed important to industrial competitiveness in Japan and designated as a key technology by Prime Minister Koizumi in 2003 (Pohl and Yarime, 2012: p. 1440). This technology has meanwhile lost, and regained interest by Japanese manufacturers, as some big OEMs, especially Toyota, are investing heavily in it. For the sake of completeness, a little more on this will be elaborated on in the infrastructural analysis in chapter. As this technology is however not directly related to EV, the elaboration on it will be fairly brief.

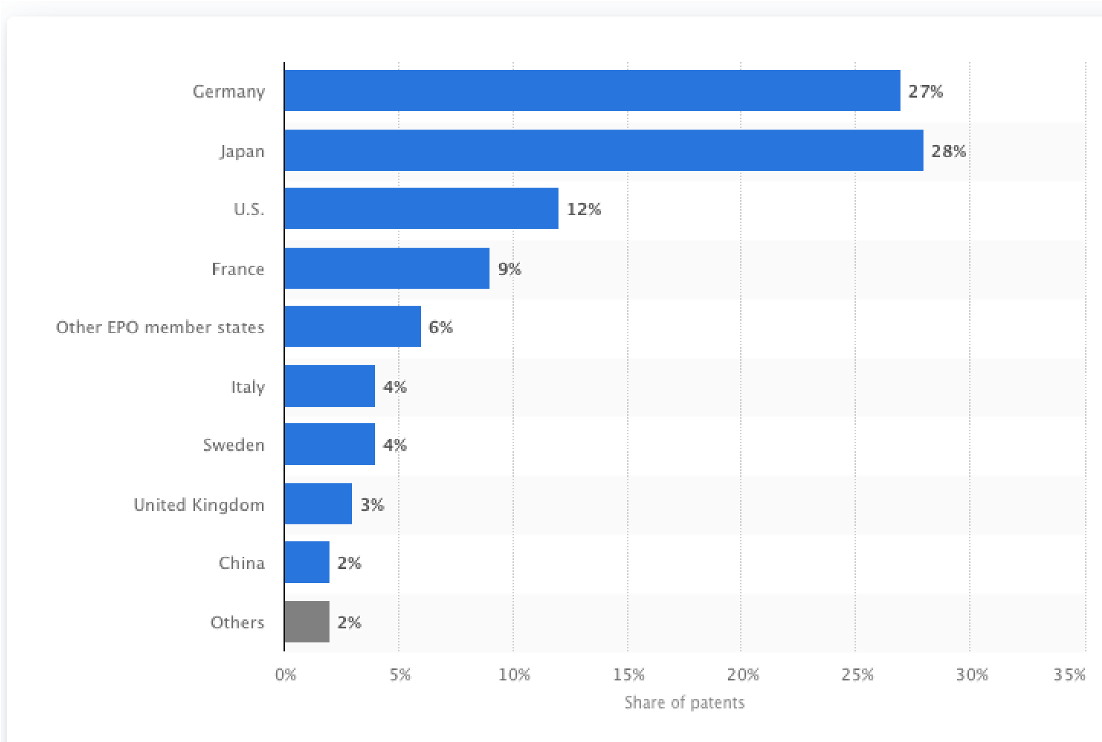
Amongst recent measures, the Japanese government has set in terms of R&D, the priority to battery technologies with the 'Initiative for Scientific Innovation of New Generation Batteries' (RISING), is one of the most exceptional projects. The RISING project was intended to be a key to keep Japan's leading position in the battery field. The 'New Energy and Industrial

Development Organization' (NEDO), which is funded by the government executed the program from October 2009 to March 2016 in corporation with twelve industrial players, eight academic institutions and four research institutions. Amongst the 24 participants, companies such as Mitsubishi, Nissan, Toyota and universities and research institutions like Kyoto University, Waseda University and the Advanced Institute of Science and Technology (AIST) participated in this project. It aims at strengthening the battery industry within Japan, to allow the market to survive the tough global competition and to develop innovative rechargeable batteries with high performances of greater than 500Wh/kg by 2030. This would not just outmatch batteries used in current vehicles but also enable car manufacturers to extend the driving range of EVs to that of conventional cars (Growth Analysis, 2013; Kyoto University, 2011). According to the roadmap of METI, by 2030, the costs of batteries should be decreased to 1/40 and the performance increased by 700% compared to their counterparts of 2006 (METI, 2011). Building on the RISING project, on May 18, 2016, NEDO announced with RISING II the launch of a new electric vehicle battery R&D project, hosted by Kyoto university and AIST. With over 30 participants, including ten car and battery manufacturers, sixteen universities and four research institutes, the project is going to be operated for five years until 2021, with a total budget of around EUR 1.4 Million. Despite this relatively small budget compared to the first RISING project, the government hopes to bring the visions of affordable and high-performance batteries even closer to reality by developing innovative batteries that can surpass the performance limits of lithium-ion batteries (Kyoto University, 2016; NEDO, 2016).

As of 2017, the complete R&D spending of Japan accounts for 3.21% of its total GDP of 4.86 trillion USD (World Bank, 2020). In total numbers Japan spent 191.3 billion dollars. By industry, manufacturing dominated with JPY 11.98 trillion, or EUR 102.3 billion, which accounts for 86.8% of all spending (Nippon.com, 2019). Within the manufacturing industry, transportation machinery manufacturing had the largest spending with JPY 3.06 trillion, or EUR 26 billion. Compared to the other G7 countries, Japan ranks 3rd in terms of spending in numbers (after the USA and China), 2nd in terms of ratio of GDP (after South Korea), and 3rd in number of researchers, after China and the USA (Nippon, 2019).

In 2018, the big three Japanese OEMs were among the top 10 spenders on R&D for AI, robotics, new-technology and electrification (Nikkei Asian Review, 2019). Toyota, Honda and Nissan were the top 3 spenders, increasing their spending in 4.8% (Toyota, Honda) and for 5.1% (Nissan) compared to the previous year. Amongst all three OEMs, electrification was a main field of research besides robotics, AI, environment, energy, autonomous driving and connectivity (Nikkei Asian Review, 2019).

As far as patents go, Japan has a very high number of applications. According to data from the World Organization for International Property (WIPO), Japanese PCT international applications for 2018 were 52,660, rising by 5.9% compared to 2017 (WIPO, 2020). The amount of patent application for the section of transportation was the third highest in the world, amounting in 5.6% of Japan's total applications in 2019 (WIPO, 2020). Taking a look on application filings in the EU, where most of recent R&D in terms of electrification is happening, Japan's strong position overseas becomes very visible.



Source: Statista, 2020.

Graph V. *EU automotive sector patent applications filed by manufacturers in 2018, by country or region of origin*

Graph V. shows the automotive sector patent applications by manufacturers in 2018. According to the statistics, Japanese OEMs have the highest amount of patent applications in the field, accounting for 28% of all applications.

4.1.1.3. Infrastructure

China

Infrastructural development remains a crucial obstacle to the EV shift that especially vast and still developing countries, such as China, face. There are basically two distinct types of EV infrastructure promotion conducted by countries: (1) By public-private partnerships with service operators or companies to promote new charging infrastructure, and (2) by planning and construction of infrastructure as public work. According to the academic discourse on this, China can be regarded as type 2 (Hall & Lutsey, 2017). There are several measures, a government can implement, in order to promote infrastructural development, including the planning and construction of charging stations, demonstration projects, the creation of interface standards and the investment encouragement through funding, tax incentives and low-interest loans (Figenbaum et al., 2015; Growth Analysis, 2013). In recent years, the Chinese government has been actively planning and building new infrastructure for electric cars, mainly through the two main state-owned enterprises (SEOs) in the energy sector, State Grid and Southern Power Grid. This means that they are not only the manager of charging facilities, but also the supplier, what makes the management of charging stations simple (Zhang et al., 2014).

Currently, there are three main programs that have been coordinated and funded by the government to achieve China's goal to build 120,000 fast charging stations and 500,000 total public stations by 2020. The 'pilot cities' program, the 'state grid national fast charging corridors' and the 'regional investments by automakers' program (Growth Analysis, 2013; Hall & Lutsey, 2017). As part of the 'pilot city' program, the government has designated and funded 88 cities for the development of an infrastructure network, led by metropolises such as Shanghai, Beijing and Shenzhen. Pilot cities are required to provide one charge point for every eight electric vehicles, and charging stations are ought to be no farther away than one kilometer from any point within the downtown area of the city. If they meet these conditions, local governments can receive up to EUR11 million for the construction of charging stations (Lu, 2018). Due to the coordination by the cities in cooperation with the funding of the SEO State Grid, the number of charging points has expanded dramatically in China in recent years (Wang et al., 2017). Adding onto the 'pilot city' program, the government is also actively involved in improving charging networks and working to construct fast charging points within cities and along major linking intercity routes. An illustrative example of this is the State Grid Corporation, who plans to build 10,000 charging stations and more than 500,000 charge poles by 2020, with investment being reported to reachEUR4 billion (Hall & Lutsey, 2017).

Also, in cooperation with the government, some Chinese manufacturers have constructed charging stations to benefit drivers of their vehicles. However, stations of differing car manufactures are often interoperable because there is yet no common user interface in China (Hall & Lutsey, 2017). In 2011, the Ministry of Science and Technology, infrastructure companies, automotive component suppliers, and automakers collaborated to develop a national standard for the charging method and connectors. However, despite formulating these standards for charging connectors and general requirements for electric vehicle charging stations, first specialized development guidelines for the infrastructure promotion of EVs were not issued until 2015, resulting in reduced consumer utility for EV users. Currently, State Grid Corporation has joined with industry partners to develop a seven-pin vehicle/charger connector that will enable both, normal and fast charging of EVs (Hall & Lutsey, 2017; Tagscherer, 2012; Zhang et al., 2017).

As part of its commitment to promote electric vehicles, the Chinese government announced plans in late 2015 to build a nationwide charging-station network to fulfil the power demand of 5 million electric vehicles by 2020. This intended network is supposed to serve residential areas, as well as business districts, public space and inter-city highways. In 2017, the number of existing charging points was 213,900, containing 130,500 slow and 83,400 fast charging stations. (IEA, 2018). Moreover, the Government's New Generation Artificial Intelligence Development Plan, announced in 2017, displays the country's intentions to become not just a global leader in terms of the EV-shift but also regarding artificial intelligence, including autonomous driving technology. China also heavily invests in infrastructure and building highways and general roads that are compatible with connected and autonomous vehicles (WIPO, 2020). Roads in Beijing's E-Town are among 44 roads (total 123 km) marked out for testing AVs (WIPO, 2020). Besides Beijing, extensive testing is also taking place in 15 other cities around China, including Shanghai, Shenzhen and Guangzhou in Guangdong province, Hangzhou in Zhejiang province, Wuhan in Hubei province and Chongqing, showing Chinese infrastructural efforts are going far beyond the borders of EV-technology (WIPO, 2020).

As of January 2019, the Chinese Electric Vehicle Charging Infrastructure Promotion Agency (EVCIPA) reported 808,000 EV officially registered EV chargers in China. Different data sources suggest that the number of EV chargers in China could be even higher (Hove and Sandow, 2020). As China still continues to be regionally diverse, first-tier cities have taken the lead in EV charging infrastructure starting around a decade ago. Earlier central government policies, in particular the EV pilots under the 10 major Chinese cities tackled these developments. At the end of 2018, Beijing, Shanghai and Guangdong Province (home to Shenzhen and Guangzhou) accounted for just under 40% of charging posts in all of China (EVCIPA, 2020). Nevertheless, EV charging infrastructure is growing rapidly throughout China. The majority of provinces added over 1,000 new charging posts in 2018. Several provinces grew the number of charging posts by over 100%. Most provinces in China now have more than 2,000 public charging posts (Hove and Sandow, 2020).

Japan

In Japan, quite similarly to the USA and France, the government usually plays the role of an investor rather than the role of a builder and manager of charging stations. This means that construction and management is left to companies that can enter this market through fair competition (Zhang et al., 2014). First projects regarding infrastructure promotion had started in the year 2009, when METI (the Japanese Ministry for Economy, Technology and Infrastructure) in cooperation with local governments launched the ‘EV & PHV Town ‘concept. This program was conducted in 18 municipalities across the country with the goal of raising public awareness while expanding charging facilities and equipment. The project allowed officials to test out various kinds of concepts in different environments such as 24-hour charging at convenience stores and vending machines or the promotion of low-carbon transportation using EV buses and taxis (NEV, 2013). After the program ended in 2010, data was studied and evaluated, and in 2013, the METI initiated a program of even greater scale, the so called ‘Next generation vehicle charging infrastructure deployment project’. With a budget of EUR 800 million, the Japanese government supported local governments and highway operators with the purpose of strategic and quick deployment of charging infrastructure and to expand the charging station network nationwide to 100,000 normal and 5,000 quick chargers by 2020. In order to get the actors to cooperate in this program, METI did not only subsidize the cost of chargers but also up to 2/3 of the installation costs for the municipalities and organizations who intended to install public chargers (CHAdeMO, 2013; Hall & Lutsey, 2017). In July 2013, together with four of the the main Japanese OEMs, another project was initiated by the government. Toyota, Nissan, Honda, Mitsubishi Motors and the government together started the ‘PHV/PHEV/EV Charging Infrastructure Promotion’ project (CHAdeMO, 2015).

For this project, the four car manufacturers founded a new company, the Nippon Charge Service, with the goal to help building a charging network that offers more convenience to drivers in Japan. The new company promoted the installation of chargers by offering financial assistance to businesses or municipalities that had applied by April 2014 and that had established charging spots in key locations, such as charging stations at commercial and lodging facilities, highway service and parking areas, convenience stores and service stations on regular roads. Together with government subsidies the grants from Nippon Charger Service covered the entire cost of installation and almost 7,500 stations are now part of this network, with continued funding at least through 2018 (Hall & Lutsey, 2017). What's more, with the Nippon Charge Service, the four automakers also provided car owners with a universally accepted charging card that allows drivers to charge anywhere in Japan. (CHAdeMO, 2015). Other programs launched by METI include home charging infrastructure programs that supported owners that had set up charging poles at the parking places of their homes. METI also gave subsidies to apartment owners and car park business owners for such cases, both on charger and construction costs. Furthermore, the government provided subsidy to major oil companies to support their business transition away from traditional towards electric cars (Nagatsuka, 2013). Moreover, the Japanese were able to introduce common fast charging facilities and equipment. Starting in 2010, chargers by CHAdeMO were adopted as unified standard form and the government subsidied the adoption of CHAdeMO chargers as part of their programs. The CHAdeMO organization was established in 2010 to create a technical standard for fast- charging devices for electric cars and major auto manufacturers in the United States and Europe and Japan. It is not just proposed as a national solution for Japan, but also as a global industry standard in the competitive market (Aoki, 2014; Lesage, 2016). As of 2018, there are more than 27,000 publicly available charging spots in Japan. 7,500 of these charging spots are covered by CHAdeMO chargers of mostly around 50 kW, with most oft he facilities being installed at car-dealerships (around 2,300), convenience stores (around 1,000), at parking lots of shopping malls (around 400), and nearly 400 along highways (Inside EVs, 2018).

4.1.2. International - Inbound and outbound FDI and Alliances

China

The rapid development of Chinese manufacturers during the reform era beginning in the late 1970s was mainly due to close cooperation with international peers in form of joint venture programs that intended to tap China's large market potential. However, "despite rigorous regulation of foreign investment which traded market access in exchange for technology, spillovers were insufficient to put Chinese companies on the same page with their foreign counterparts. With their own technological expertise and innovation capability far behind the international competition, Chinese companies found themselves locked in the lower rungs of the market, making small, cheap and unsophisticated cars for low-budget buyers" (Heiden and Taube, 2013: p. 497). The authors argue that China's transition to electric mobility has been held back by five interlinking problems: (1) the lack of technology development that could lower down the production costs of EV components. (2) Insufficient production capacities of the automotive industry to support the potential demand in the near future. (3) Customers have so far been reluctant to buy EVs as the industry fails to present attractive domestic models, and lower prices. (4) The difficult challenge of providing an EV supporting infrastructure throughout a country of China's size. (5) The public policy issue (Heiden and Taube, 2013). Although the central government has shown its determination to boost Chinese EV development, "policies remain highly influenced by provincial and municipal governments that draft their own policies adapted to local circumstances and catering to local interest groups, which oftentimes do not reflect central governmental incentives" (Heiden and Taube, 2013: p. 503).

China finally understood that to get more advanced technology, it would need increased foreign participation. In 1984, the Volkswagen AG and SAIC Motors established the first joint venture in the Chinese automotive industry, which led great ambitions by international OEMs. In 1994, the same time the Chinese government introduced the 50% limit on foreign ownership, showing signs of restriction and making its position once more clear. One striking illustration of how Chinese acquisition of American technology can accelerate China's EV industry is the Shanghai- GM joint venture's signing in January 2017 of a USD 1 billion contract with A123 Systems to supply batteries for future joint venture products. A123 Systems, an American MIT spinoff that had gone bankrupt, was acquired by China's Wanxiang Group in 2012 and produces inside China as well as in the United States. China could develop batteries and EVs in relative isolation from the rest of the world, but the quality would be questionable. China continues to wrestle with ways to secure foreign technology while keeping overall control of the industry (Dunne, 2018: p. 175). The rapid development of Chinese manufacturers during the reform era beginning in the late 1970s was mainly due to close cooperation with international peers in form of joint venture programs that intended to make use of China's large market potential. In the early 2000s, as no manufacturer anywhere in the world had been able to claim a major technological breakthrough or entered volume production with regard to EVs, the race seemed to be entirely open. The Chinese believed that every automaker had to start from scratch as competitive strength in conventional vehicles did not translate into advantages for the development of electric ones (Heiden and Taube, 2013: p. 497). The Chinese government proclaimed that China should strive for international technology leadership and become the world's largest EV market. However, there had been no breakthrough in 2012 yet in China. “Limited options, locals buy cheaper, technically not advanced domestic cars. Incentives of local governments in a few cities to make e-vehicles more attractive to private buyers, did not achieve the intended goals” (Heiden and Taube, 2013: p. 500). The authors argue that China’s transition to electric mobility has been held back by five interlinking problems: (1) the lack of technology development that could lower down the production costs of EV components. (2) Insufficient production capacities of the automotive industry to support the potential demand in the near future. (3) Customers have so far been reluctant to buy EVs as the industry fails to present attractive domestic models, and lower prices. (4) The difficult challenge of providing an EV supporting infrastructure throughout a country of China’s size. (5) The public policy issue. Although the central government has shown its determination to boost Chinese EV development, policies remain highly influenced by provincial and municipal governments that draft their own policies adapted to local circumstances and catering to local interest groups, which oftentimes do not reflect central governmental incentives (Heiden and Taube, 2013: p. 503).

In the meantime, Chinese companies tried to catch up by providing HEV models. “However, since this segment is dominated by Japanese companies, there was not much hope to break into this market. Therefore, Chinese planners preferred to skip conventional hybrids and leapfrog directly to PHEVs and BEVs. This strategy has failed so far as the development of key technologies proved significantly more difficult and time consuming than anticipated” (Heiden and Taube, 2013: 504). One factor heavily associated with the strong growth in the sales of NEVs in China is the government’s incentive subsidy which is already in the process of being reduced and will be eliminated entirely in 2020. In early 2019, the government announced that it issued a notice to further refine the subsidy policy to promote the sales of NEVs, including more stringent technical requirements, changes to the standards, and reductions in the subsidy amounts, with the notice being effective starting from June 26, 2019 (Marklines, 2020).

Already in October 2015, Tesla Motor announced its negotiations with the Chinese government on producing its electric cars domestically in China. Local production has the potential to reduce the sales prices of Tesla models by a third, thus improving weak sales (Spring, 2015).

In April 2019, the NEV credit system was established as part of the government’s new regulation aimed at improving fuel economy of passenger cars, as well as promoting the popularization of new energy vehicles and boost sales. This strategy is also commonly known as the double-credit policy, which obligates companies manufacturing or importing passenger cars to produce or import a fixed percentage of NEVs, set by the government (Marklines, 2020). As a result, foreign equity OEMs are willing to create alliances with Chinese OEMs already manufacturing EVs in China in order to obtain the benefits. As for the certification for manufacturing vehicles, Chinese OEMs are engaged in activities such as consigning EV production to large or medium-sized OEMs, or acquiring other OEMs. In July 2019, China’s Ministry of Industry and Information Technology (MIIT) issued a modified draft version of its NEV mandate policy, also known as the double-credit policy that some had complained was too favourable to NEVs and led to an increase in the actual fuel consumption of traditional ICE-powered vehicles (Marklines, 2020).

Table III below shows that almost every globally active automotive OEM holds joint/ventures with at least one, most of the time even two Chinese OEMs.

Foreign OEM	**Chinese JVs**	**Established in**	**Shareholding ratio (%)**
Toyota Motor	FAW Toyota	Aug. 2002	50:50
	GAC (Guangzhou Toyota)	Sept. 2004	50:50
General Motors	Shanghai GM	Jun. 1997	50:50
	SAIC-GM-Wuling	Jun. 2002	50.1:34:15.9
Ford	Changan Ford	Apr. 2001	50:50
	Changan Ford Mazda	Mar. 2006	50:35:15
Volkswagen SAIC public	Shanghai Volkswagen	Apr. 1985	50:50
	FAW-Volkswagen	Feb. 1991	50:50
Honda	Guangzhou Honda	Jul. 1998	50:50
	Dongfeng Honda	Jul. 2003	50:50
Nissan	Zhengzhou Nissan	Mar. 1993	80:20
PSA (Peugeot-Citroen)	Guangzhou Peugeot	Mar. 1985	22
	Dongfeng Peugeot Citroen	May 1992	32
	Dongfeng Peugeot	Oct. 2002	50:50
Hyundai Motor	Dongfeng Yueda KIA	Nov. 2001	50:25:25
	Beijing Hyundai	Oct. 2002	50:50
Fiat	Nanjing Fiat	Apr. 1999	50:50
BMW	BMW Brilliance	May 2003	50:50
Renault	FAW	---	---
Mazda Motor	Changan Ford Mazda	Mar. 2006	50:35:15
	FAW Mazda	Jan. 2007	70:30
Suzuki Motor	Changan Suzuki	Jun. 1993	65:35
Mitsubishi Motors	South East Motor	Apr. 2006	34:33:32

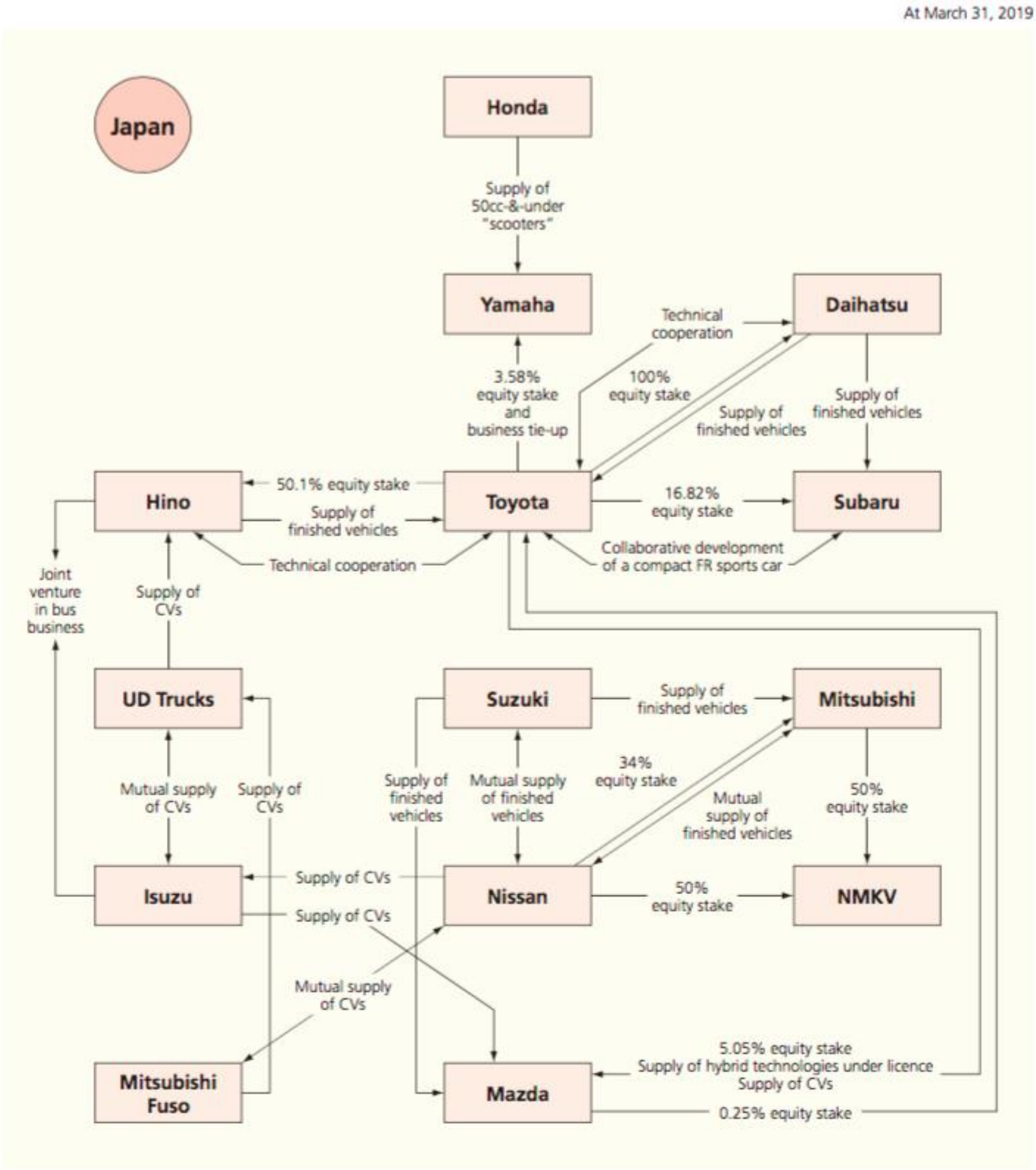
Source: Marklines, 2020; China Auto Web, 2020)

Table III. *Joint ventures of foreign automotive OEMs in China*

Nearly every globally active OEM holds joint-ventures with at least one Chinese domestic manufacturer. As the market remains very fluid, thus joint-venture activities are constantly changing, there have been some recent amendments as well. Renault-Nissan for instance announced the ending of its joint-venture with Dongfeng in April 2020 (Nikkei Asian Review, 2020). Recently, the Chinese government has shown ambitions to further improve domestic OEMs performance and knowhow by opening up its foreign ownership limitation that have been remaining in place ever since the mid 1990s. President Xi has announced the further opening of the Chinese automotive industry in early 2018, releasing an official reform schedule in May 2018. It includes, (1) removing the limit of foreign ownership on special-purpose vehicles and NEVs, (2) removing the limit on foreign ownership on commercial vehicles, and (3) removing the limit of foreign ownership on passenger vehicles including the allowance of more than two joint-ventures per foreign OEM (PWCCN, 2019). Further, the Chinese government has committed to implement these gradual lifting of its inbound FDI restrictions within five years (PWCNN, 2019).

Japan

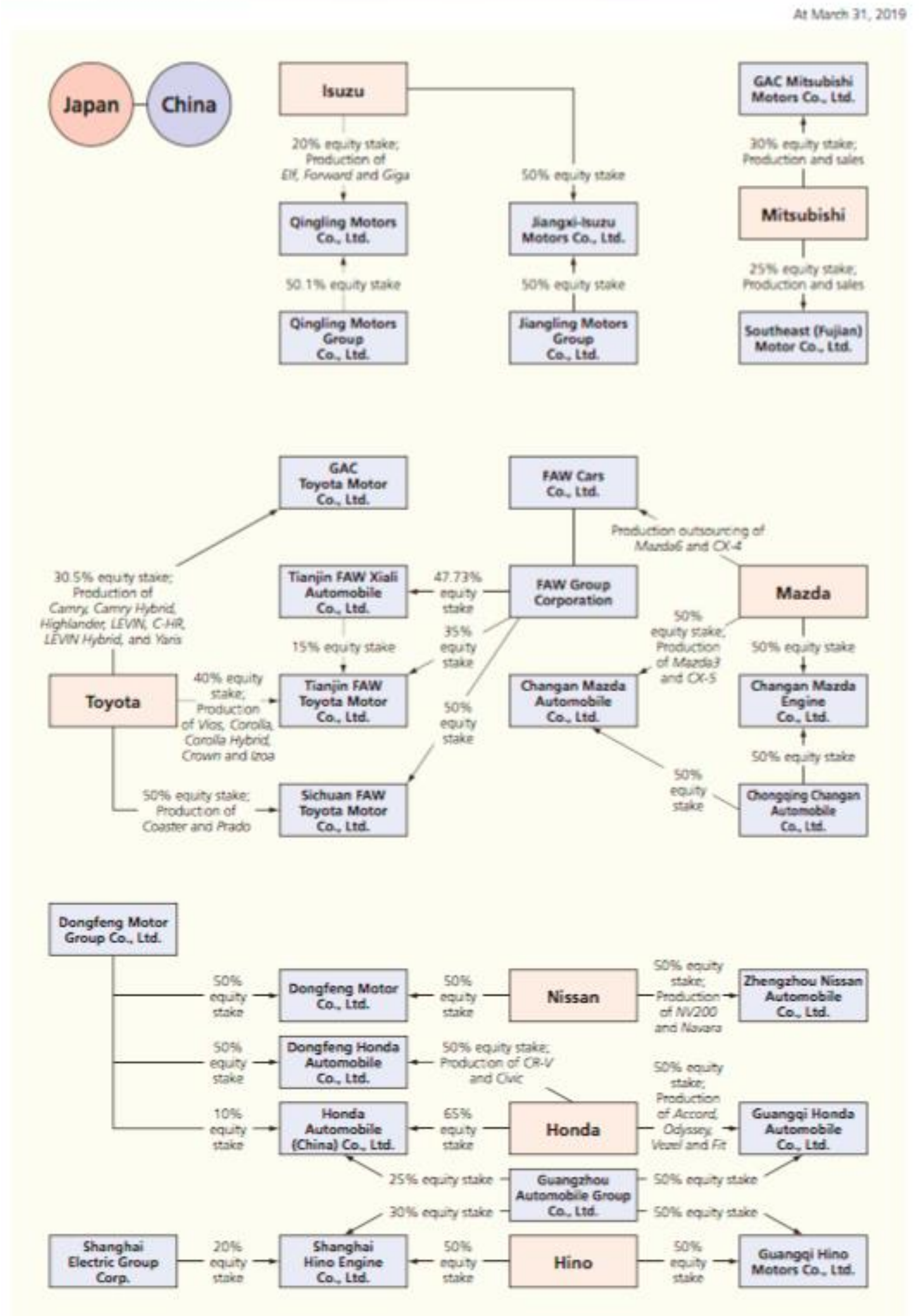
As for Japan, alliances are very much related to the keiretsu-system, which embodies a major economic phenomenon within the Japanese business environment. It literally translates to a system or series, furthermore grouping of enterprises that is linked together in a special order of succession. What it basically means is that domestic companies engaging in the same business field are interacting with each other, but still remaining legally independent from each other. The Japanese automotive industry is a perfect example of how intertwined the domestic landscape is, and how domestic manufacturers have continued to work together, share car platforms, or even trade fully assembled cars with each other in order to save cost. Figure II below illustrates these linkages between domestic OEMs in the Japanese automotive industry.



Source: JAMA, 2019

Figure II. *Domestic Japanese automotive OEM alliances in Japan*

For the most part, Japanese automotive alliances have continued to be focused on these domestic linkages between OEMs, in order to improve efficiency, save cost and keep domestic standards. However, as the Japanese automotive industry, as well as the country's economy itself remains highly dependent on export, Japanese manufacturers started to furthermore reduce cost by outsourcing their production to overseas facilities. In this context, Japanese FDI towards China becomes very relevant. Indeed, Japanese OEMs hold a variety of production facilities, as well as partnerships with local OEMs in a variety of East Asian countries, however the number of partnerships and assembly alliances with Chinese OEMs is far higher. The below figure III illustrates partnerships between Japanese OEMs and Chinese local manufacturers, showing that Japanese FDI towards China's automotive industry is substantially high.



Source: JAMA, 2019

Figure III. *Japanese and Chinese Automotive OEM Alliances*

As Japanese car brands continue to be popular in China, despite the occasionally escalating still unsolved political disputes, Japanese OEMs keep investing in China. More than half of all Japanese FDI expenditure towards China is linked to the automotive industry (JETRO, 2019). In total numbers, outward FDI spending of Japanese companies account for 143 Mio USD in 2018, ranking Japan first amongst all nations, followed by China with almost 130 Mio USD

(JETRO, 2019). Table IV below shows the top 10 countries and regions in the world in terms of FDI as of 2018.

Top 10 countries/regions in the world in terms of FDI (2018)

(Unit: Million USD)

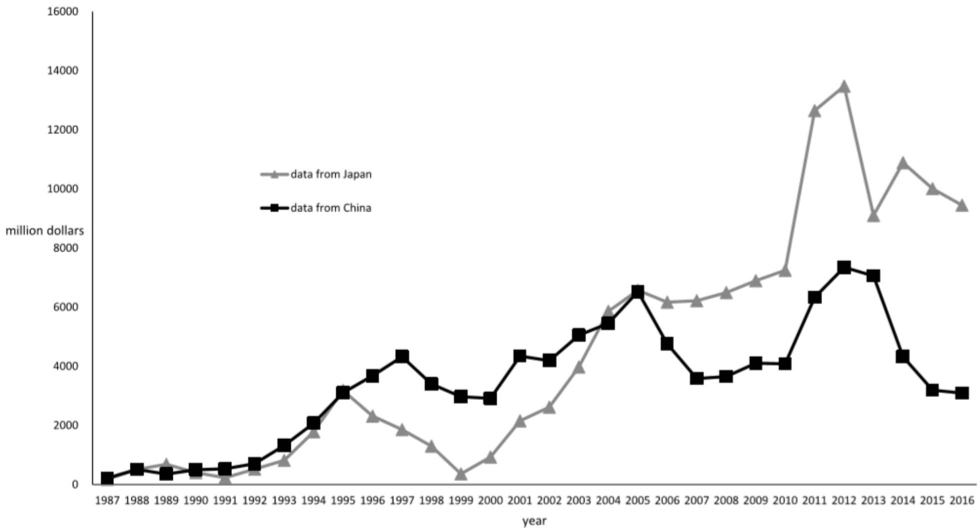
	Inward FDI		Outward FDI	
1	United States	251,814	Japan	143,161
2	China	139,043	China	129,830
3	Hong Kong, China	115,662	France	102,421
4	Singapore	77,646	Hong Kong, China	85,162
5	Netherlands	69,659	Germany	77,076
6	United Kingdom	64,487	Netherlands	58,983
7	Brazil	61,223	Canada	50,455
8	Australia	60,438	United Kingdom	49,880
9	Spain	43,591	Korea, Republic of	38,917
10	India	42,286	Singapore	37,143

Note: Excluding financial centers in the Carribean region
Source: Data of UNCTAD

Source: UNCTAD, 2019

Table IV. Top 10 countries in the world in terms of FDI.

On the recipient's side, Japan is not being mentioned among the top 10 list, as the country spends far more money on FDI as it receives. China on the other hand, as the second largest receiver of FDI in an international context has seen more than 139 Mio USD in inbound FDI in 2018 (FDI). In this context, the FDI imbalance between China and Japan becomes worth looking at. According to a study on the performance of Japanese FDI into China, "compared with the performance of other source country FDI into China as well as the performance of Japanese FDI to the rest of the world show that Japanese FDI towards China is significantly high" (Armstrong, 2009: p. 29). "This was done by creating a counterfactual, and predicting what FDI would be expected to be given the determinants of FDI flows, which shows that Japanese FDI vastly underperformed in China in the early 1980s" (Armstrong, 2009: p. 29). "During this time, risk- averse Japanese companies faced high uncertainty in investing in China and MNEs did not start to enter in any substantial scale until Chinese policy shifted in the late 1980s. China's economic policy shift, the Plaza Accord, had effects on Japanese investment towards China, however the BIT signing between Japan and China had even more. It reduced uncertainty and gave investing Japanese companies a framework, which increased confidence in committing resources in China" (Armstrong, 2009: p. 29). Armstrong further states, "Chinese trade liberalization and domestic reform in the 1990s — which continued China's opening up and was aimed at WTO accession — resulted in Japanese FDI performing highly through most of the 1990s until the Asian financial crisis" (Armstrong, 2009: 29). The Asian financial crisis had implications for all. Japanese FDI shrank, bilateral political tensions between the two countries rose again after 2001. However, the measure of political distance did not widen greatly as China's WTO accession offset negative political sentiment with positive economic sentiment. In this context, it is crucial to look at the differing data both countries publish in regards to Japanese FDI towards China. A study on outward FDI from Japan to China, conducted by Sui (2019), a Chinese scholar from Yokohama City University shows that the respective data on FDI statistics published by China's Ministry of Commerce, as well as from Japan's Ministry of Finance converted from JPY into USD by Japan External Trade Organization (JETRO), differ greatly. Graph VI below shows that while the two series are strongly correlated, the gap between them is also quite extensive. "FDI from Japan reported by the Chinese government is larger than that reported by Japan during 1994 to 2004. However, after 2006, the figures published by the Japanese government are much larger than those, reported by China" (Sui, 2019: 127).



Source: Jetro, 2019; Sui, 2019.

Graph VI. Data Comparison on FDI from Japan towards China (in Mio. USD)

Despite the fact that Japanese automotive manufacturers focused on domestic linkages and partnerships, there is one very remarkable example of international cooperation, namely the Renault-Nissan alliance. Especially in the context of EV-technology, the Renault–Nissan–Mitsubishi Alliance is a crucial aspect to look at. The alliance is a French-Japanese strategic partnership between the automobile manufacturers Renault (based in Boulogne-Billancourt, France), Nissan (based in Yokohama, Japan) and Mitsubishi Motors (based in Tokyo, Japan), which together account for 1 of 9 sold cars worldwide (Marklines, 2020). The alliance group sold 10.6 million vehicles worldwide in 2017, making it the leading light vehicle manufacturing group in the world (Marklines, 2020). The Alliance adopted its current name in September 2017, one year after Nissan acquired a controlling interest in Mitsubishi and subsequently made

Mitsubishi an equal partner in the Alliance. Further, the strategic partnership between Renault, Nissan and Mitsubishi is not a merger or an acquisition, as the three companies are joined together through a cross-sharing agreement that grants them equal rights. Structurally, the alliance was unique within the automotive industry and embodied a model that other OEMs followed in the following years. The alliance itself has broadened its scope substantially, forming additional partnerships with automakers including Germany's Daimler, China's Dongfeng and Russia's AvtoVAZ. Prior to the formation of the triangular partnership, Renault and Nissan became bilateral partners, by forming a strategic partnership in 1999, known as the Renault–Nissan Alliance. From the beginning, Renault and Nissan influenced each other in terms of their respective marketing and product focus. The authorities decided to invest an extensive amount of capital into research and development, especially for BEVs in the beginning of the early 2000s, which at the time did not yet play a major role amongst the world leading OEMs. A major milestone of their partnership was the development of a platform for BEVs that Nissan used for it Leaf model, the first mass-produced BEV, entering the market in 2010. As of December 2019, global sales were at over 450,000 units, making it the world’s best selling BEV model (Marklines, 2020). As of January 2018, the Renault-Nissan-Mitsubishi alliance is the world's PHEV manufacturing group, with global sales since 2010 of over 500,000 electric vehicles (Marklines, 2020).

4.2. Demand Conditions

4.2.1. Domestic

4.2.1.1. Domestic EV sales and growth

China

The Chinese market is characterized by very high sales numbers of passenger vehicles, seeing a drop within recent years. In June 2012, the State Council of China established a plan to develop the domestic energy-saving and NEV industry. The plan set a sales target of 500,000 new energy vehicles by 2015 and 5 million by 2020 (Millikin, 2012). According to a report by McKinsey, EV sales between January 2009 and June 2012 represented less than 0.01% of new car sales in China (Wang, 2012). The China Association of Automobile Manufacturers (CAAM) forecasted that sales of EVs and would reach 60,000 to 80,000 units in 2014, but sales numbers have been significantly lower than previously expected (Xueqing, 2014). As a consequence for the low sales volume, the government bought most of the deployed NEV stock for public fleets, and further issued new monetary incentives by the end of 2014 in order to boost sales

(Marklines, 2020). The new target was set at 160,000 units, but again failed to be met. As of 2014, NEV sales rose up by 324% to 74,763 units compared to 2013 (Marklines, 2020). Experiencing first successful steps, the China Industrial Association of Power Sources expected NEV sales to rise up to over 200,000 units by 2015, and 400,000 units in 2016 (Li, 2015). In the meantime, the growing demand continued in 2015, with a total of 331,092 NEVs sold, rising 343% y/y (CAAM, 2016). As for 2019, nearly 21.5 million cars passenger cars were sold in China, which is a drop by 8.2% compared to 2018 (Marklines, 2020). Taking a closer look at the NEV share shows that the number of BEVs account for over 80% of all NEV-types, or 4.53% of all newly registered passenger cars in 2019. The number of BEVs even grew by 1.2%, which clearly indicates a strong trend towards BEVs, as the share of BEVs was almost 20% lower, ranging at around 62.7% of all newly registered passenger cars. Table V shows the respective shares of NEV (PHEV, BEV) and FCV.

	2019	**Share in percentage (2019)**	**Growth in percentage**	**2018**	**Share in percentage**
Passenger cars	21,444,000	100%	-8.2%	23,710,000	100%
NEV	1,206,000	5.6%	-4.0%	1,256,000	5.3%
PHEV	232,000	1,1% (19.2% of NEV)	-14.5%	265,000	1.1% (21.1% of NEV)
BEV	972,000	4.53% (80.6% of NEV)	1.2%	788,000	3.3% (62.7% of NEV)
FCV	2,737	0.013% (0.23% of NEV)	79.2%	1,995	0.008% (0.16% of NEV)

Table V. China's EV sales 2019 (Marklines, 2020; EV-Volumes, 2020).

Chinese statistics do not count HEV separately as they are considered to be a very small niche market, which is why they could not be evaluated for the below table.

Japan

Japan is a very special case in terms of its domestic automotive market, as there is no other country in the world with similar numbers of HEV sales. As discussed within the previous chapters of this thesis, Japanese OEMs started to focus on HEV technology in the late 1990s over the last two decades, which heavily influenced domestic passenger car sales. As of 2019, the NEV share in Japan was at 40.3%, containing 96.6% HEV (Jada, 2020). HEVs account for

38.9% of all newly registered passenger cars, showing that NEVs are heavily dominated by HEVs. Numbers of PHEVs and BEVs seem slim in comparison, but are still gradually growing. The total number of PHEV sales in 2018 was 22,099, or 0.5% of all sold passenger cars, and 1.5% of all NEVs. As for BEVs, the 2018 number was 22,941, thus even slightly higher compared to the total amount of PHEVs. BEVs accounted for 0.5% of all newly registered passenger cars, and also 1.5% of all NEVs. For the sake of completeness, the below Table VI. also includes the number of newly registered FCV, amounting at 603, also declining due to the fact that there are currently just two models available on the domestic market, namely the Toyota Mirai and the Honda Clarity Fuel Cell. As Toyota is currently developing the successor-model, sales have been slightly declining.

	2018	**Share in percentage (2019)**	**Growth in percentage**	**2017**	**Share in percentage**
Passenger cars	4,391,160	100%	0.1%	4,386,377	100%
NEV	1,495,674	34.1%	3.8%	1,438,530	32.8%
HEV	1,451,031	33% (97% of NEV)	4.9%	1,380,133	31.5% (95.9% of NEV)
PHEV	21,099	0.5% (1.5% of NEV)	-38.1%	34,102	0.8% (2.4% of NEV)
BEV	22,941	0.5% (1.5% of NEV)	-2.9%	23,634	0.5% (1.6% of NEV)
FCV	603	0.014% (0.04% of NEV)	-8.8%	661	0.016% (0.05% of NEV)

Table VI. Japan's EV sales 2019 (Jada, 2020; NeV, 2020; JAMA 2019)

Very remarkably, PHEV sales as well as BEV sales have been declining for 38.1% (PHEV) and 2.9% (BEV) from 2017 to 2018. The 2019 numbers show slight growth, however as a detailed statistic on propulsion has not been published yet, the most recent data analyzed in this thesis is from 2018. As for this period, only HEVs have continued to grow by 4.9%, leading to a overall positive trend.

4.2.1.2. Societal adaption and Costumer sophistication

China

According to Krieger et al. who deal with electric mobility from the perspective of market readiness, comparing supply and demand conditions to each other in order to evaluate the state of market readiness. They develop an electric vehicle index (EVI) reaching from 5 (most developed) to 0 (least developed). As of 2012, China has been given 1.5, whereas Japan ranked highest amongst the compared countries with 2.6 (Krieger et al., 2012). They conclude by stating that China's biggest challenges remain, "government action, building public fleets, recalibrating automaker's strategies, and building local supplier's capabilities" (Krieger et al., 2012). Tyfield conducts a multi-level perspective (MLP) analysis based on Foucault's framework on socio-technical system's transition is applied, in order to analyze China's mobility transition in a global context (Tyfield, 2014: p. 587). He concludes that "a socio-technical perspective such as MLP allows identification of brighter possibilities regarding disruptive innovation around EV and potential redefinition of the car, but problems facing transportation and the full societal implications go beyond" (Tyfield, 2014: p. 601). A similar approach was made by Hao et al. in a study on China's electric vehicle subsidy scheme. They state that, "in order to promote the market penetration of EV, China launched the Electric Vehicle Subsidy Scheme (EVSS) in Jan 2009, followed by an update in Sep 2013, which the authors named phase I and phase II EVSS, and compared them to each other" (Hao et al., 2014: p. 722). They conclude their evaluation on governmental subsidy by stating, "China's EVSS is very necessary for BEVs to be cost competitive compared with CPVs in the short term, especially before 2015" (Hao et al., 2014: 731). A very crucial factor in terms of the sophistication of the domestic market is the affordability of electric vehicles. As China aims for a wide-scale spread of BEVs, there have been efforts to reduce the biggest burden, the price of the car. Referring to McKinsey, "the average price of a Chinese BEV has been reduced drastically over the last couple of years. In 2010 the average price of a BEV in China was around three times the amount of money of an average annual salary, therefor making it quite expensive for middle-class families to purchase a BEV" (McKinsey, 2020). In 2015 the average price dropped to 1.7 times the amount of an average salary. The reason behind this is manifold, but can be broken down to two main factors. "Firstly, the fact that the actual price of BEVs has dropped, thanks to the progress that has been made within the last few years, showing that the financial investment and research and development that has been primarily made by the government, paid off. Secondly, it also implies that wages in China are rising, making costly purchases, such as BEVs a bit more realistic for a broader class of the population. The predictions for 2020 even say that the average price of BEVs will further be reduced to less than 1.5 times the annual wage, making a even greater distribution amongst the population possible" (McKinsey, 2020).

Another important factor upon the sophistication of the market is the amount of vehicles per 1,000 people. In China, the number of cars has been steadily rising over the last years but still remains remarkably low, at around 130 per 1,000. Putting this into perspective, comparable countries in terms of size, such as the USA, are ranging around 850 vehicles per 1,000 (McKinsey, 2020). The Chinese government is further aware of its power in controlling and steering the market with financial incentives. “There have so far been two major tax cuts regarding the purchase of vehicles in 2009 and 2015” (McKinsey, 2020). Tax-policy intervention is likely to remain an important tool for the government to achieve its high goals regarding the EV shift. Governmental policies are further being discussed in chapter **4.4.1.3.** of this analysis. In 2018, the amount of plug-in vehicles in use (including BEVs and PHEVs) was by far the highest in the world, counting 2,243,772 vehicles IEA, 2019). The remarkable fact concerning this number is twofold. Firstly, it shows a tremendous growth rate. As of 2017, there were 1,227,770 registered plug-in vehicles in China, showing that the number of these vehicle types is rapidly growing. Secondly, as of 2018, the Chinese fleet of plug-in vehicles account for 43.8% of all plug-in vehicles in use worldwide (IEA, 2019). In relation to the number of registered vehicles in China, the share of BEVs and PHEVs is already at around 2.31 million units, accounting for already 1% of the whole fleet of automobiles in use in China (Statista, 2020; IEA, 2020).

Japan

As already mentioned above, the Japanese automotive industry is influenced greatly by the so-called herd-effect, meaning that the seven big domestic OEMs are constantly observing each other, are even in an interdependent relationship with each other, and thus operate along the same lines. In terms of electrification of the automotive industry, this means that the trend of HEV mass-production, medium PHEV and growing BEV consumption affects the whole domestic market. Japan is further a quite interesting case, as it has a very large domestic demand of vehicles compared to their medium population and quite small land-size. The amount of cars per 100 households in Japan lies at 105.8 cars, which is quite high for a highly urbanized country like Japan, with an urbanization rate of over 90% (JAMA, 2019).

NEXT-GENERATION PASSENGER CAR NEW REGISTRATIONS, 2008-2018

In vehicle units

Year	Hybrid vehicles	Plug-in hybrid vehicles	Electric vehicles	Fuel cell vehicles	Clean diesel vehicles	Total
2008	108,518	0	0	0	0	108,518
2009	347,999	0	1,078	0	4,364	353,441
2010	481,221	0	2,442	0	8,927	492,590
2011	451,308	15	12,607	0	8,797	472,727
2012	887,863	10,968	13,469	0	40,201	952,501
2013	921,045	14,122	14,756	0	75,430	1,025,353
2014	1,058,402	16,178	16,110	7	78,822	1,169,519
2015	1,074,926	14,188	10,467	411	153,768	1,253,760
2016	1,275,560	9,390	15,299	1,054	143,468	1,444,771
2017	1,385,343	36,004	18,092	849	154,803	1,595,091
2018	1,431,980	23,230	26,533	612	176,725	1,659,080

Source: Japan Automobile Manufacturers Association

Source: JAMA, 2019.

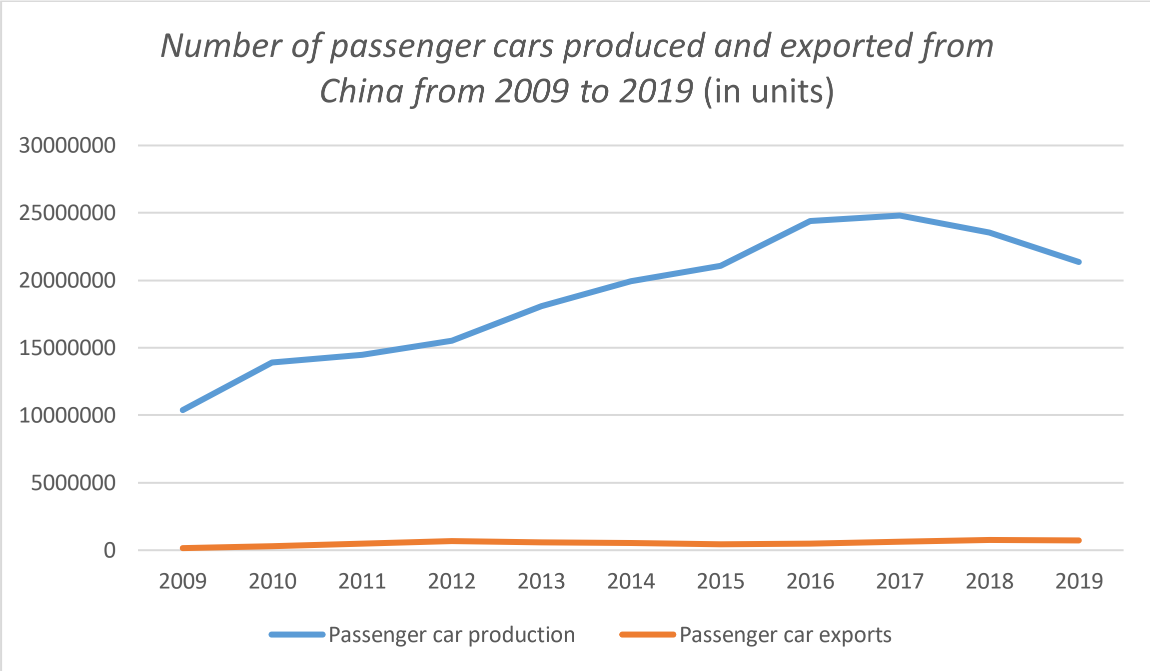
Table VII. *NEV passenger car registrations in Japan 2008-2018*

According to numbers from the IEA, as of 2018 there are more than 257,000 PHEV and BEV vehicles in use in Japan, accounting for 0.4% of the 62,025,916 passenger cars registered in 2018 (IEA, 2019; JAMA, 2019). This ranks Japan 4th behind China, the USA and Norway amongst the countries with the largest fleet of plug-in vehicles. These numbers do not include HEVs, which do account for almost 40% of new passenger car sales in Japan. Out of 62,025,916 registered passenger cars in use in Japan in 2018, there were 7,539,094 registered HEVs, accounting for already 12.2% of all registered passenger cars in Japan. The share is rapidly rising, as in 2019, the number of registered HEVs rose by already one million vehicles (AIRIA, 2020).

4.2.2. International - EV export volume and development

China

The Chinese automotive industry is heavily relying on the domestic market, as it is dominated by domestic brands, joint-venture alliances and local manufacturing. Exports have traditionally been fairly low, with a slight increase over the last decade in absolute numbers. As production capacities of Chinese OEMs have been increasing even more drastically, the export share is still comparatively low. Graph VII below shows the number of exports, compared to the total units of produced passenger cars from 2009 to 2019.



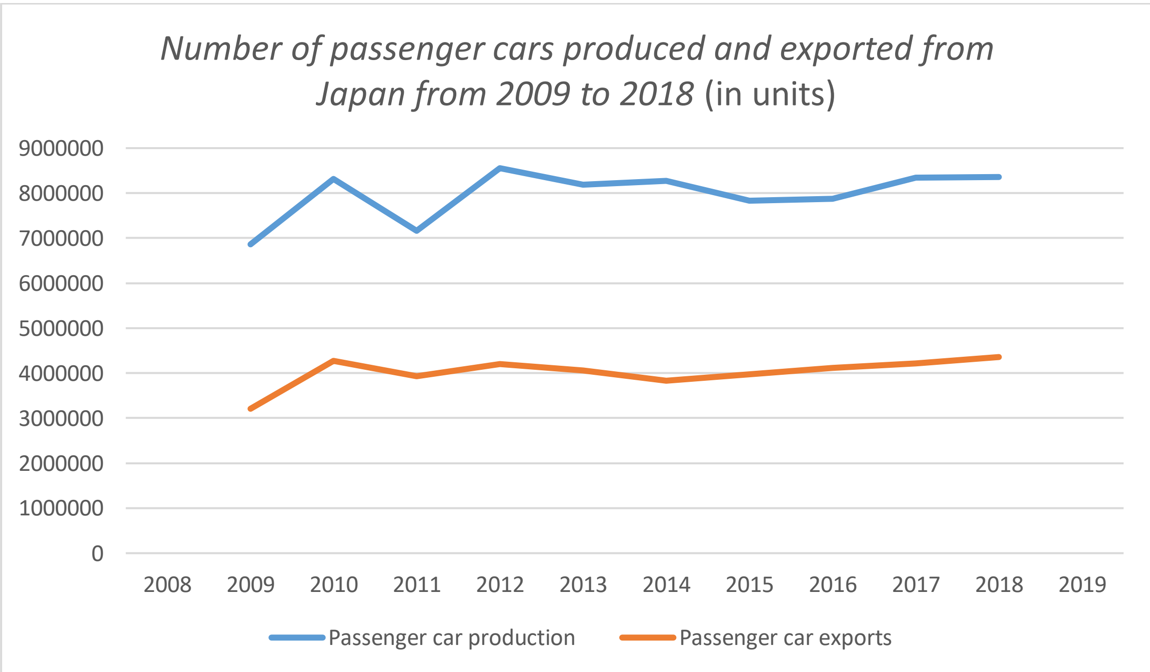
Source: Statista, 2020

Graph VII. *Number of passenger cars produced and exported from China from 2009 to 2019*

The number of exports was at 217,000 units in 2009, accounting for not even 1.5% of the total manufactured amount of passenger cars (Statista, 2020). Export numbers rose very quickly to 661,200 units in 2012, representing 4.6% of the total produced amount of passenger cars, thus China's highest number so far. As production capacities rose very quickly from 2012 onwards and export did not, the export share shrank again. As for 2019, China exported 725,000 units of its produced passenger cars, accounting for 3.4% of the overall production. The latest data for the EV share that could be found for this analysis is for 2018. In 2018, China exported 702,100 passenger vehicle units, among which 4,570 BEVs were exported (MOFCOM, 2019; WKO AC Shanghai, 2020). Given the extensively high numbers of produced and sold car units in China, the export number is substantially smaller. Compared to these numbers, the even smaller number of NEV exports appear quite high. As of 2018, NEV exports account thus for only 0.65% off all passenger car exports. As for commercial vehicles, the export units are even smaller, amounting in 306,800 units, among which 4,561 NEV were exported (MOFCOM, 2019; WKO AC Shanghai, 2020). The number of exported commercial NEVs within the same year account for 1.5% of all exported commercial vehicle units, making it a bit higher than the exported NEV share of passenger car units. At this point data discrepancy becomes an issue again, as the export trade statistic indicates quite high numbers for the following year of 2019. According to HKTSC, in 2019 Chinese exports of Electric vehicles for transport of persons amounted in 254,545 units, a growth of 40.4% (HKTSC, 2020). Breaking down into subcategories, the numbers are as follows: Battery electric saloon car and cross-country car, 240,326 units, growth of 29.6%, 12,401 units, growing by 389.4%, and non-plug-in hybrid electric saloon car and cross-country cars, amounting in 23,016 units, a growth by 400% (HKTSC, 2020). In terms of overall export value of automobiles, China ranks 19th worldwide in 2019 (USD 8,637,814,000), increasing by 0.1% (World's Top Exports, 2020).

Japan

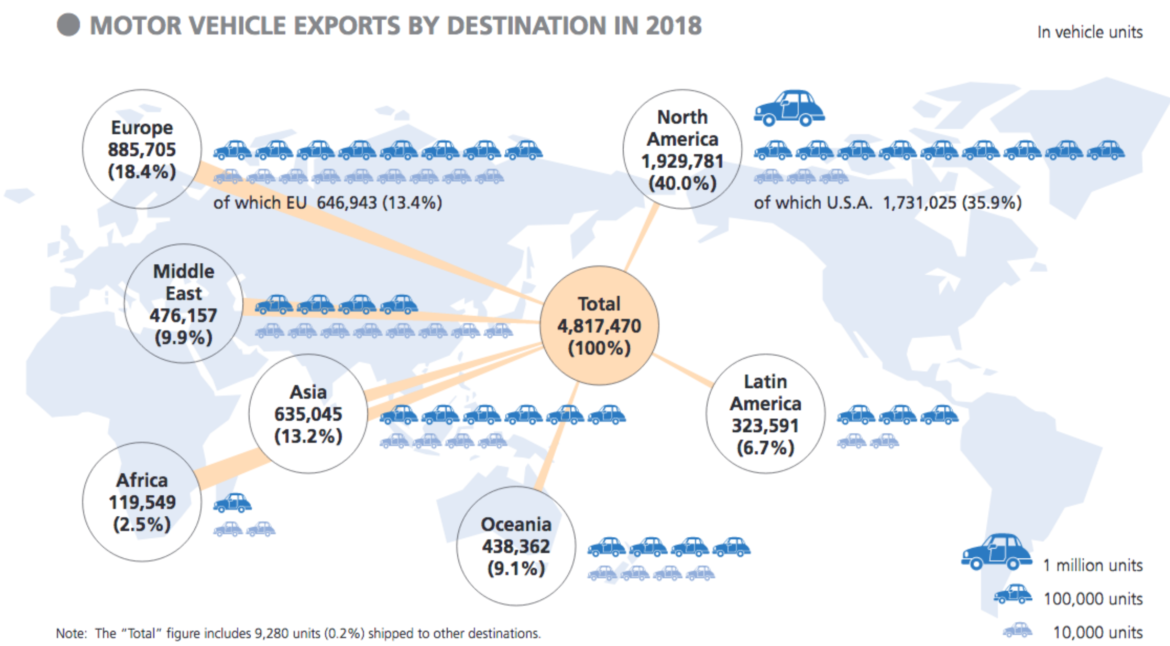
As of 2018, Japan exported 4,817,470 motor vehicles, of which 4,357,782 (90.4%) were passenger cars (JAMA, 2019). Both car production, and car exports have been rather stable in Japan, with a significant peak in 2011, due to the Eastern Japan Earthquake and Tsunami that caused production difficulties in domestic OEM facilities. Graph VIII below shows the export numbers in relation to toal production of passenger cars from 2009 to 2018.



Source: JAMA, 2019

Graph VIII. *Number of passenger cars produced and exported from Japan from 2009 to 2018*

Apart from the mentioned peak in 2011, both lines appear to be quite stable with slight growth in both areas from 2012 onwards. Total passenger car production in 2011 shrank by 13.86% compared to the previous year (JAMA, 2019). However, as the domestic market decreased heavily in 2011 as well, the lowered production capabilities could be shifted towards production of export vehicles, in order to compensate the deficit. From 2011 to 2012 the exports shrank by 8.1%, which is far more moderate than production capabilities themselves shrank. The export share of produced passenger cars is constantly around half fluctuating slightly. In 2011, due to weak domestic demand, the export share reached 55%, the highest number in the analyzed period. As of 2018, the export share was 52.1% (JAMA, 2019). Motor vehicle exports from Japan to all destinations increased compared to the previous year. The graph below illustrated the export volume of Japanese OEMs to overseas markets.



Source: JAMA, 2019

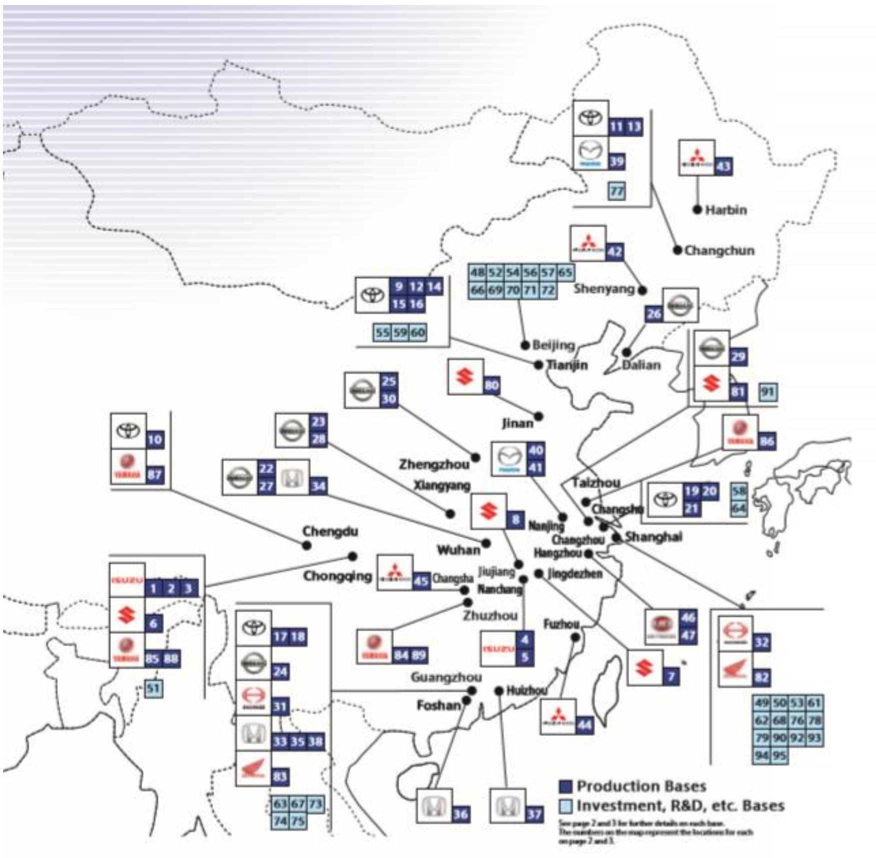
Graph IX. *Japanese Motor vehicle exports by destination in 2018*

The most important overseas market for Japanese car exports is North America, where exports climbed to 1.93 million units, which accounts for 40% of the total Japanese car exports in 2018 (JAMA, 2019). Europe embodies the second most important market for Japanese OEMs, as they exported 886,000 units, accounting for 18.4%. The other markets include 635,000 units, or 13.2% to Asia, 476,000, or 9.9% to the Middle East, 438,000 units, or 9.1% to Oceania, 324,000 units, or 6.7% to Latin America, and 120,000 units, or 2.5% to Africa (JAMA, 2019). Car units produced by Japanese OEMs in overseas facilities are not counted in. As for export value of automobiles, Japan ranks 2nd worldwide (after Germany) with USD 98,043,242,000 (World's Top Exports, 2020).

Taking a look at BEV-shares of exported vehicles in 2019, Japan's export share appears very slim, ranking 10th amongst all BEV exporting countries with 431.5 Mio USD of value, accounting for only 1.7% of all exported BEV units worldwide (World's Top Exports, 2020).

China ranks 9th with 438.1 Mio USD of export value, accounting for 1.7% of global BEV exports as well (World's Top Exports, 2020). Interestingly, amongst the top 10 BEV exporters are countries that do not even include global OEMs but still export significant numbers of BEVs, including Austria, ranked 5th with 1.3 billion USD in export value, accounting for 4.9% of global BEV exports in 2019 (World's Top Exports, 2020).

A significant phenomenon in terms of Japanese OEMs overseas activity is local production of Japanese branded cars, partly in cooperation with local manufacturers (joint-ventures), and partly independently under the Japanese brand. Especially in China, where Japanese outbound FDI is substantially large, overseas production density is very high. The figure below shows Japanese OEMs plant and factory operations in China. The most recent data that could be evaluated, are from 2015, will be the reference point for the sake of completeness of this thesis.



Source: JAMA, 2015

Figure IV. *Japanese OEMs Operations in China*

According to the respective data published by JAMA, Japanese OEMs have 95 production and other bases for passenger cars, trucks, buses and motorcycles, including automotive parts that are operating in China (JAMA, 2015). Especially interesting, out of 79 bases aimed in relation to passenger vehicles, 47 are solely used for production, whereas 32 are for other purpose, first and foremost, R&D (JAMA, 2015). All together, the automobiles related facilities hold approximately 166,000 employees, 158,900 of them working directly at the plants, and 7,100 of them working at other facilities, including research facilities (JAMA, 2015).

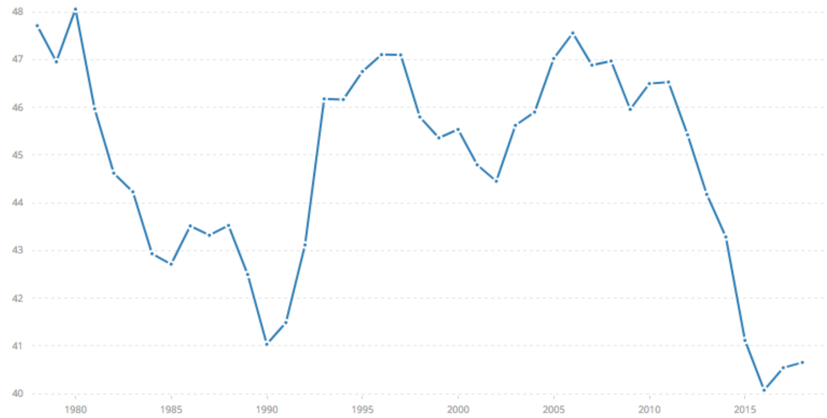
4.3. Related and Supporting Industries

4.3.1. Domestic

4.3.1.1. Overall Industrial Production Growth Rate, Suppliers

China

Concerning the related and supporting industries. The academic discourse on EV technology in China contains variety diverging approaches. In their analysis of the strategic importance of the EV industry for China, Li and Zhang pointed out that the optimization of overall benefits for all stakeholders should be the prime principle in the design of business models for E-mobility services (Li and Zhang, 2012). They provided a set of metrics for evaluating the overall benefits for all stakeholders in the EV industry, including the following four points: (1) the whole market scale of EV industry: battery, EV, E-mobility services, and etc., (2) the industrial core competencies: key technologies, international standards, and etc., (3) social benefits: pollution and emission reduction, energy saving, and etc., (4) Risk levels: investment recovery, pollution of used batteries, and etc. And an analysis model is developed for evaluation of the overall benefits for all stakeholders in the EV industry (Li and Zhang, 2012: p. 1, 2) They argue that “EV development is of strategic interest in China, because of the rising numbers of car owners, the aimed independence of oil by realization of the electrification of the power train. Therefore, BEVs will play as an important strategic role for securing the future energy safety of China” (Li and Zhang, 2012: p. 1, 2) In order to reach these goals, most importantly, “China has to find a way to catch up in international competition, gain future competitive advantages” (Li and Zhang, 2012: 2). The overall industrial situation in China is key in order to understand how the country can position itself on a global scale.



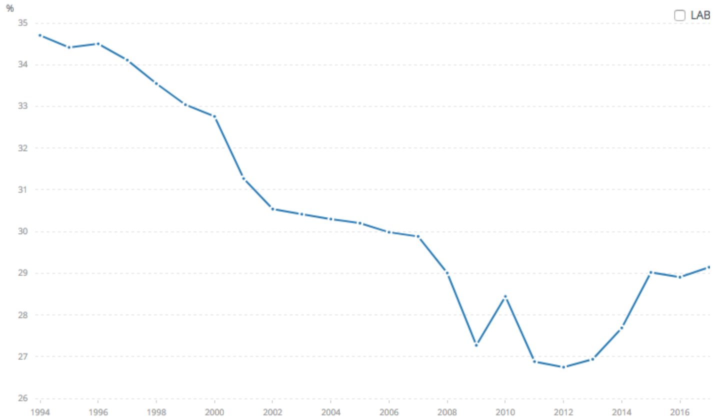
Source: World Bank

Graph X. *Industry (including construction), value added (% of GDP) in China*

Graph X above shows China's industry share of the GDP from 1978 to 2019. The data shows that the industrial sector has always been the major source of Chinese GDP, ever since the country has economically opened up itself in 1978. The share of the industrial sector has constantly been over 40%, currently ranging at 40.7% of the country's GDP (World Bank, 2020). In terms of automotive suppliers, China embodies a global player. China is not just the biggest domestic market for automobiles per se, but also the biggest market for automotive components, parts and supply. As there is no official data on the entire amounts, values and size of the domestic automotive supply-market, this thesis refers to official estimates done by the Austrian Chamber of Commerce – AußenwirtschaftsCenter Shanghai in 2020. Estimates say that there might be over 100,000 automotive supplier firms in China, out of which just half are officially covered by data reports. The reason for this might be their small size and the fact that they are intertwined with other bigger companies that do not report them. Officially available data state that just 10% of the registered firms generate more than RMB 20 Mio. (approx. EUR 2.6 Mio.) of revenue (MIIT, 2018; WKÖ AC Shanghai, 2020). There are even more than 160 registered major startups in China that are intertwined with EV technology, and the numbers remain growing (WKÖ AC Shanghai, 2020; Crunchbase, 2020), indicating that EV technology remains the top priority within the sector.

Japan

The industry sector in Japan has been undergoing substantial change ever since the countries' economic peak in the 1970s. As developed nation, Japan has shifted more and more from the secondary to the tertiary sector, making goods and services more profitable, than the actual construction and manufacturing. These trends do certainly affect the automotive sector as well, as many OEMs have started rationalizing and outsourcing production to overseas. The below graph reflects these developments, showing the continuous decline of the industrial sector's GDP share from the mid 1990 onwards until it reached a slight increase after the Asian financial crisis in 2008, dropping again in 2011 after the Fukushima Daiichi Nuclear accident, and eventually re-rising in recent years.



Source: World Bank, 2020

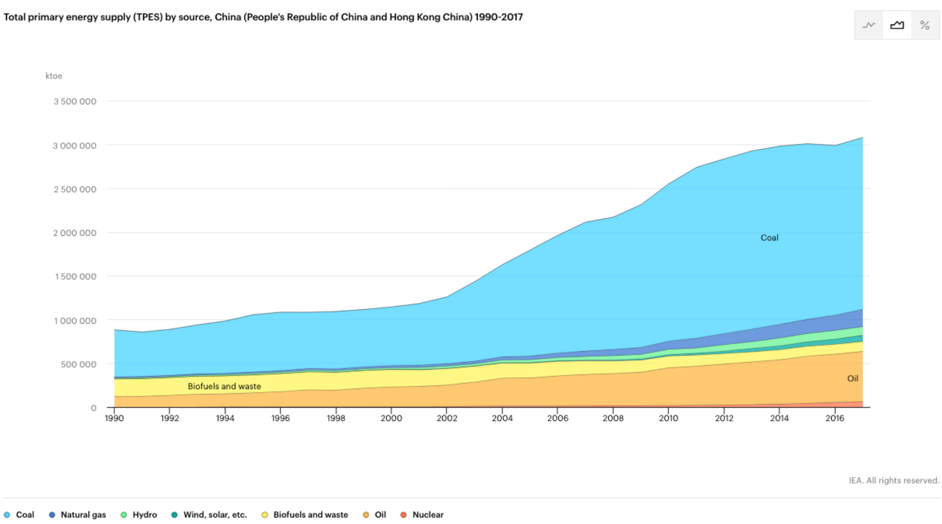
Graph. *Industry (including construction), value added (% of GDP) in Japan*

In Japan, the share of industry in relation to the whole GDP has been continuously dropping from the mid-1990s onwards. Experiencing the bubble-economy and its burst in the late 1990s, the country has seen a very strong trend towards consumer goods and services, decreasing the GDP-share for its industrial sector. Nevertheless, industrial production and manufacturing remains a major pillar of the Japanese economy, as by 2017 nearly 28% of Japan's GDP was covered by the industry (World Bank, 2020). Historically, Japanese OEMs have kept close ties with their suppliers, and some of them have even been operating as parts of larger diversified conglomerates. The principle of keiretsu, an expansive network of companies with separate competencies aligned through cross-shareholding, traditionally working tightly to maintain strategic relationships that are mutually beneficial, is still very common amongst Japanese OEMs. Others have built their own extensive networks with suppliers along their value chain. The largest amongst the so-called vertical keiretsu belongs to the world's leading car company Toyota. Japan's automotive component industry contains great diversity, including various fields, such as chemicals, electronics, textiles, and mechanical components. Many car parts makers, often also called tier-1 suppliers, are very specialized in their product offerings. "They exist as a means for vehicle manufacturers to outsource the development and production of car parts" (Neely, 2016). He further states, "other companies are more diversified, producing automotive goods in addition to products for other industries within their competencies. As a result, many companies manufacturing goods for various industries are nevertheless heavily reliant on the automotive industry" (Neely, 2016). The largest Japanese automotive suppliers are thus clustered nearby major OEMs. The best example of an automotive cluster in Japan is Aichi-prefecture, mostly the city of Nagoya and its surroundings, as this area is home to the Toyota Motor Corporation and many of its suppliers. Denso is the largest automotive parts manufacturer in Japan, and consistently a global leader as well. Their specialty is in electronic systems and powertrain control modules. Other notable Japanese tier-1 suppliers holding top spots globally include major companies such as Aisin Seiki, Yazaki, JTEKT and Hitachi Automotive System. A detailed analysis on suppliers is conducted in chapter 4.3.2.2. Import and export value of EV components.

4.3.1.2. Power situation, generation

China

China, as a very energy demanding country has a quite distinct power generation and energy consumption situation. According to World Bank data for 2014, energy use in kg of oil equivalent per capita reached a level of 2,236.73 kg. This amount is still comparatively low in international comparison. However, as the most recent reliable data that could be found for this analysis is from 2014, and given the fact that the amount has been growing ever since the 1970s, it is assumed that China has by now already reached comparable consumption levels of fully developed countries.



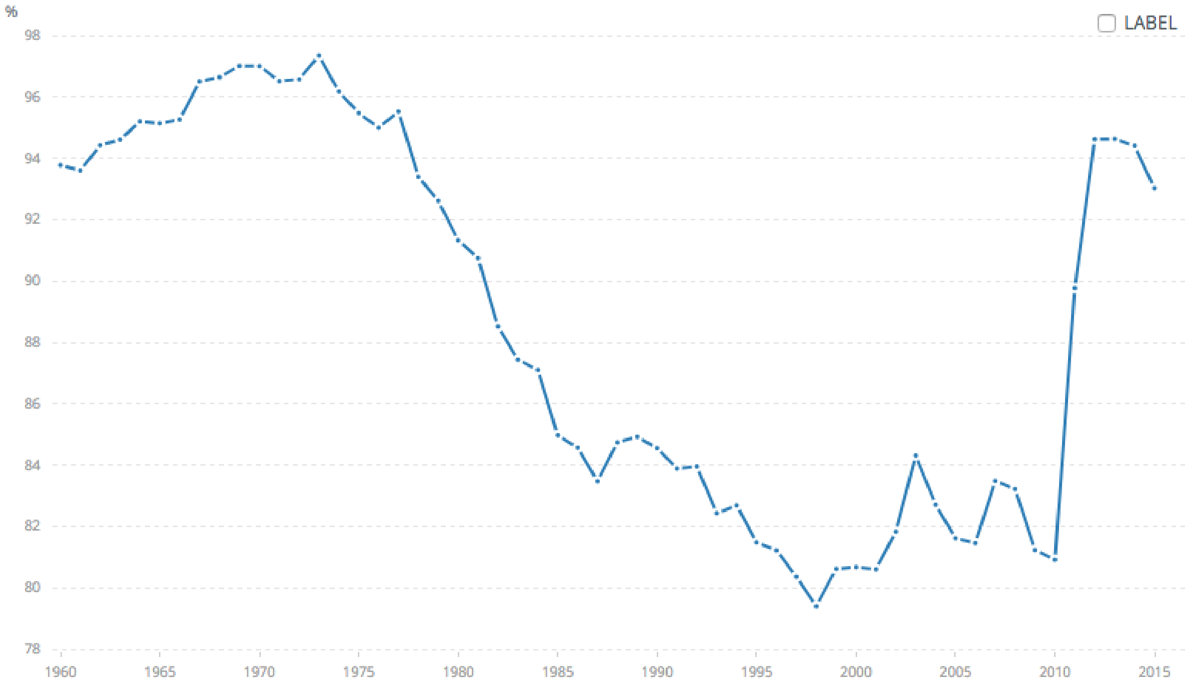
Source: IEA, 2020

Graph XII. *Total primary energy supply (TPES) by source, China (People's Republic of China and Hong Kong China) 1990-2017*

As China's president Xi Jinping announced, the country will be undergoing an "energy revolution", tackling the still high pollution levels of major cities along the East coast and south of the country. "As the country is still facing a phase of rather extensive economic growth and development, China's growing energy needs are increasingly met by renewables, natural gas and electricity" (IEA, 2020). It is forecasted that between 2019 and 2024, China will account for 40% of global renewable capacity expansion, driven by improved system integration, lower curtailment rates and enhanced competitiveness of both solar PV and onshore wind, contributing to the enormously growing demand for electricity, also due to infrastructural changes and the ongoing shift towards EV-technology as mainstream propulsion (IEA, 2020). China is also believed to lead global growth in terms of biofuel production, as ethanol blending is being conducted in a growing number of areas, increasing investments in production capacity. That being said, China's coal demand and production capacity remain rather high. Currently, one of every four tons of coal used globally, is burnt in order to generate electricity in China (IEA, 2020). "The Chinese government is continuously pushing for reduction of emissions and has already improved air quality by switching to gas in industrial and residential areas. However, China's coal fleet is comparatively young, highly efficient and still ten times larger than its gas-fired fleet" (IEA, 2020). Taking a look at the current costs of gas, new onshore wind and solar photovoltaic facilities appear to be much more inexpensive options to generate electricity. The difficulty in terms of policy formulation here is to ensure sufficient investment towards electricity networks, without sacrificing the immense electricity needs of a growing economy (IEA, 2020).

Japan

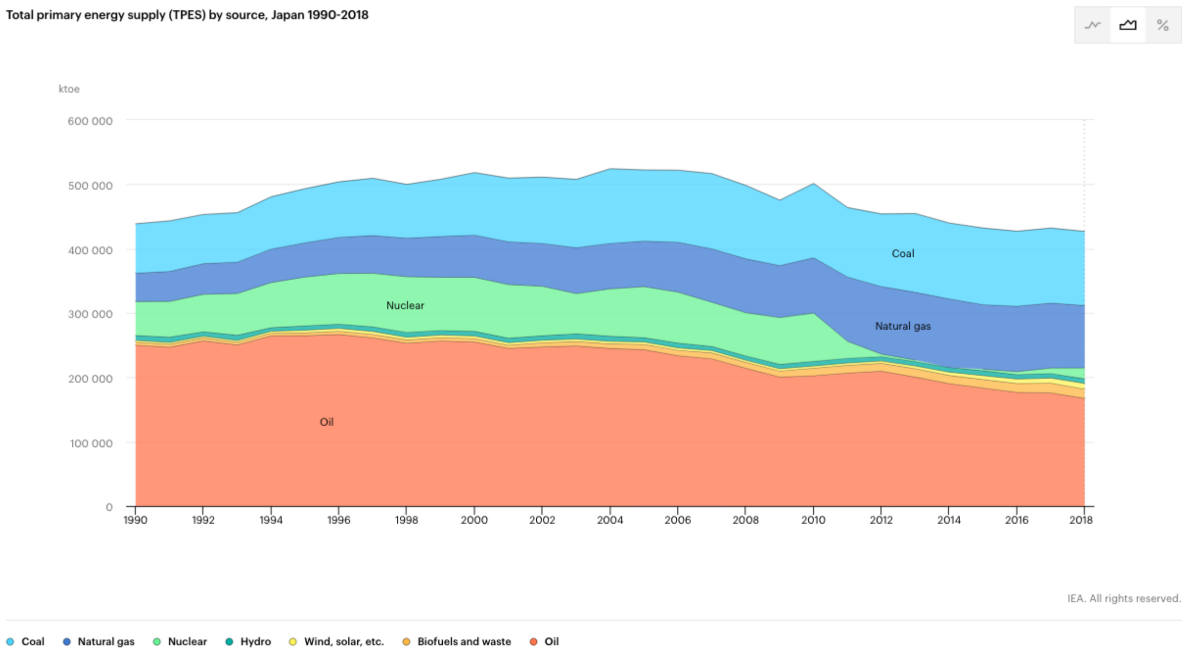
Japan has a relatively high demand of energy, as its economy has reached a fully developed stage already in the 1980s. Energy use in kg of oil equivalent per capita as of 2015, lies at 3,429 kg (World Bank, 2020). The interesting fact about Japan in this regard is the continuous drop that the country has seen from the late 1990s onwards. However, in 2004 Japan reached its highest amount of oil consumption so far with over 4000 kg, experiencing a steady decline again, reaching levels from the 1990s in 2015. Fossil fuel consumption in an energy generating context is a very crucial topic for Japan. As the country is a volcanic archipelago without any natural resources is heavily depending on fossil fuels, the Japanese government started to invest heavily in nuclear energy that dominated the energy sector throughout the bubble economy until the 2011 Fukushima-Daiichi nuclear accident.



Source: Worldbank, 2020.

Graph XIII. *Fossil fuel energy consumption (% of total) – Japan from 1960 to 2015*

Graph XIII above shows the fossil energy consumption in % of total energy consumption from 1960 until 2015. It becomes clear that the country is heavily relying on fossil fuel imports for energy generating purpose, with initially very high levels of almost 98% in the 1970s, then gradually changing the objective with the switch towards nuclear energy reaching levels below 80% in the late 1990s. The most significant rise in consumption can be spotted in 2011, as the Fukushima-Daiichi accident triggered a temporary shut-down of the country's large number of nuclear power plants. Energy loss had to be compensated by generating energy from coal and other fossil fuels, triggering an increase from slightly over 80% prior to Fukushima, towards over 94% immediately after (World Bank, 2020).



Source: IEA, 2020

Graph XIV. *Total primary energy supply (TPES) by source, Japan 1990-2018*

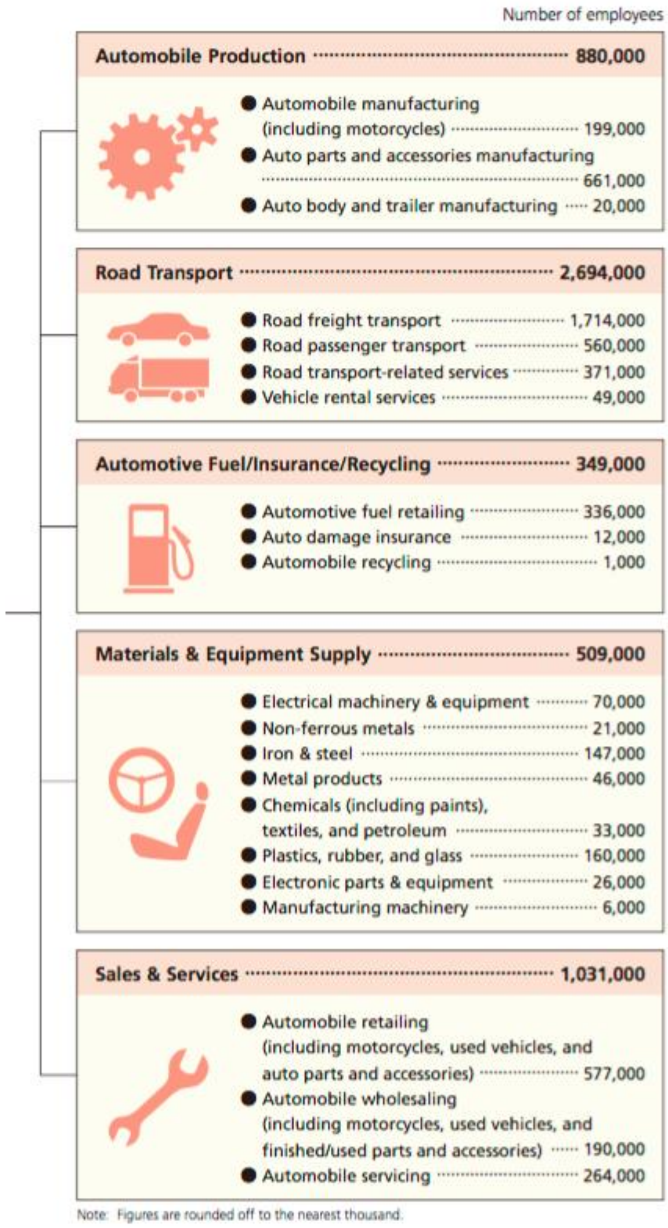
4.3.1.3. Employment numbers in automotive industry

China

Employment data from China is very complex to analyze, due to rather restricted access. According to World Bank data, 28.27 % of the whole Chinese workforce was employed in the industrial sector (World Bank, 2020). Employment within the automotive sector itself is also extensively high, showing China's reliance on it. As of 2019, the total share of people working in or related to the automotive industry in China was slightly over 1/6 of the total Chinese workforce. In total numbers this translates to approximately 130 Mio employed people within the sector of a 774,710,000 people containing workforce by the end of 2019 (MOFCOM, 2019; WKO AC Shanghai, 2020).

Japan

The automotive industry is a major employment provider in Japan. "Automobiles are the focus of an extremely wide range of industrial and related activity, from materials supply and vehicle production to sales, servicing, freight shipping and other auto-centred operations" (JAMA, 2019). Automobile--related employment in Japan at present totals 5.46 million people (JAMA, 2019). The graph below shows the number of employees in each related sector.



Source: JAMA, 2019

Figure V. *Employment in the automobile manufacturing and related industries*

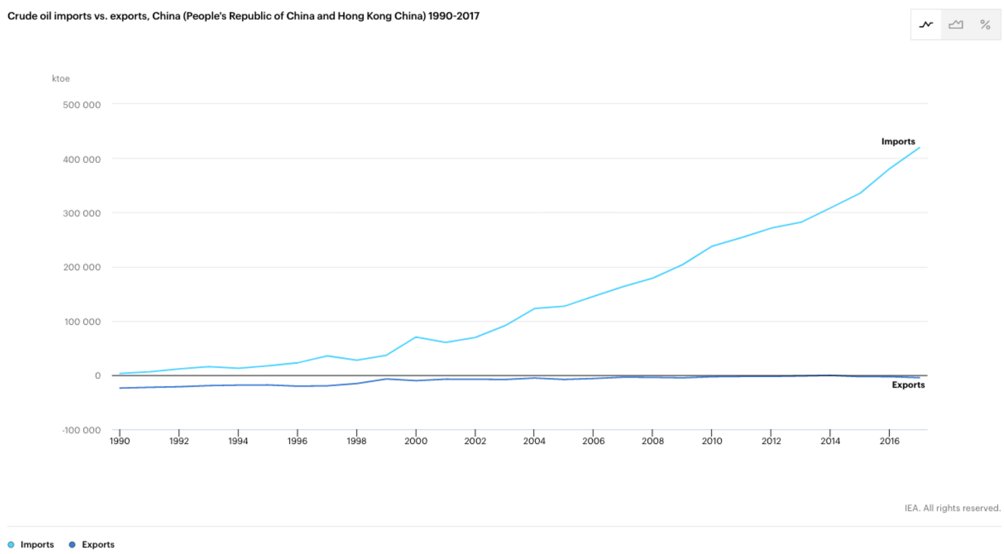
In direct relation to the total workforce of currently 66.64 million people, the number of automobile-related employment is 5.46 million people, which accounts for 8.2% (JAMA, 2019). The production of vehicles alone provides jobs for around 880,000 people in Japan, representing 16% of all jobs within the automotive industry, and 1.3% of the total Japanese workforce (JAMA, 2019). Even more than that is related to sales and services, offering 1,031,000 jobs, accounting for almost 19% of all automotive related employment, as well as 1.5% of the total workforce (JAMA, 2019). The biggest sector within the automotive industry however is transportation, comprising 2,694,000 jobs, accounting for almost 50% of automotive related employment, covering over 4% of the total Japanese workforce (JAMA, 2019). In other words, over 8% percent of the Japanese workforce is directly depending on the automotive industry.

4.3.2. International

4.3.2.1. Oil imports and exports

China

China is one of the world's largest consumer of crude oil, receiving oil from forty-three countries in 2019. Roughly half (44.8%) of Chinese imported crude oil originates from nine Middle Eastern nations ranging from USD 386 million from Egypt up to USD 40.1 billion for Saudi Arabia (World's Top Exports, 2020). The weaker Chinese currency makes China's imported crude oil usually paid for in USD. The top 15 countries that supplied 90.1% of the crude oil imported into China during 2019 are, Saudi Arabia: USD 40.1 billion (16.8% of China's total imported crude oil), Russia: USD 36.5 billion (15.3%), Iraq: USD 23.7 billion (9.9%), Angola: USD 22.7 billion (9.5%), Brazil: USD 18.5 billion (7.8%), Oman: USD 16.4 billion (6.9%), Kuwait: USD 10.8 billion (4.5%), United Arab Emirates: USD 7.3 billion (3.1%), Iran: USD 7.1 billion (3%), United Kingdom: USD 6.3 (2.7%), Congo: USD 5.54 billion (2.3%), Malaysia: USD 5.5 billion (2.3%), Colombia: USD 5.4 billion (2.3%), Libya: USD 4.8 billion (2%), Venezuela: USD 4.4 billion with s share of 1.9% (World's Top Exports, 2020). Graph XV below shows that China's imports and exports of crude oil in kilotons from 1990 until 2016.



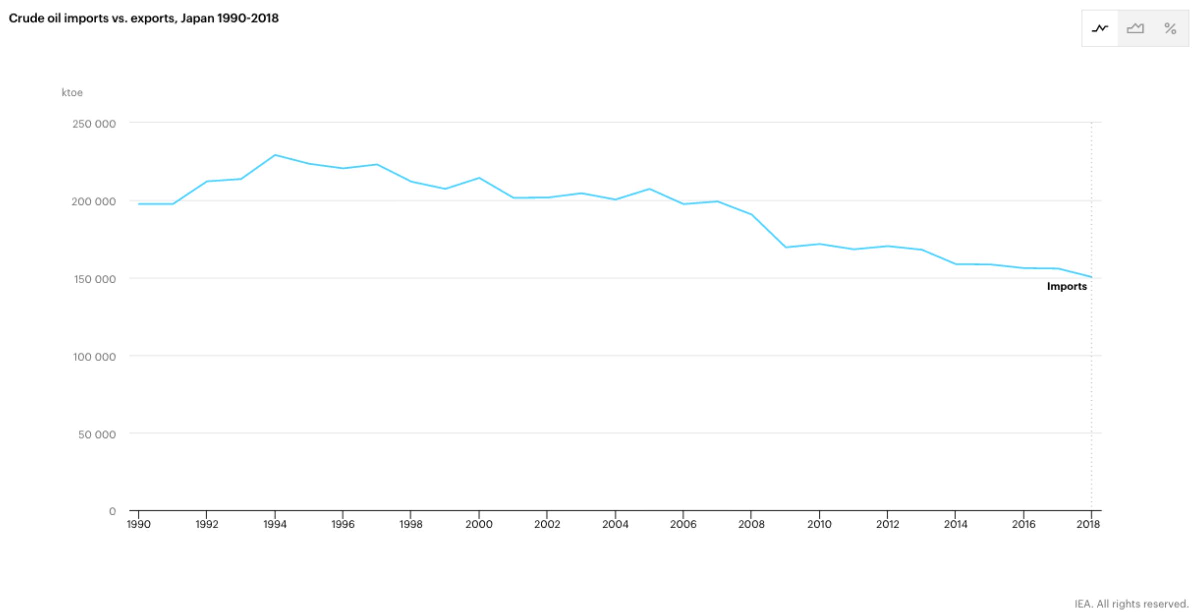
Source: IEA, 2020.

Graph XV. *Crude oil imports vs. exports, China (People's Republic of China and Hong Kong China) 1990-2017 (in kilotons).*

It can be observed that China's export capacity is very low and did not significantly change until the 1990s, whereas its imports have risen drastically from almost zero in the 1990s to more than 400,000 kilotons in 2016 (Worldbank, 2020).

Japan

As a highly industrialized country scarce of resources, Japan has to import all its needed oil. The top 15 suppliers from which Japan imported the highest dollar value worth of crude oil during 2019 are, Saudi Arabia: USUSD 26.1 billion (up 16.4% from 2015), United Arab Emirates: USD 21.9 billion (up 24.9%), Qatar: USD 6.3 billion (up 14.8%), Kuwait: USD 6.1 billion (up 22.4%), Russia: USD 4 billion (down -33.3%), United States: USD 1.6 billion (up 3,273%), Oman: USD 1.3 billion (up 193.4%), Iran: USD 1.1 billion (down -65.1%), Iraq: USD 959.6 million (down -0.6%), Ecuador: USD 882.5 million (up 66.4%), Bahrain: USD 728.4 million (no 2015 data), Kazakhstan: USD 528.5 million (up 98.6%), Malaysia: USD 279.1 million (down -8.5%), Vietnam: USD 242.7 million (down -62.1%), Algeria: USD 223 million (World's Top Exports, 2020). As Japan does not export oil, as it does not have any resources, Graph XVI below just shows how Japan's oil imports have changed from 1990 until 2016.



Source: IEA, 2020

Graph XVI. *Crude oil imports vs. exports, Japan 1990-2018 (in kilotons).*

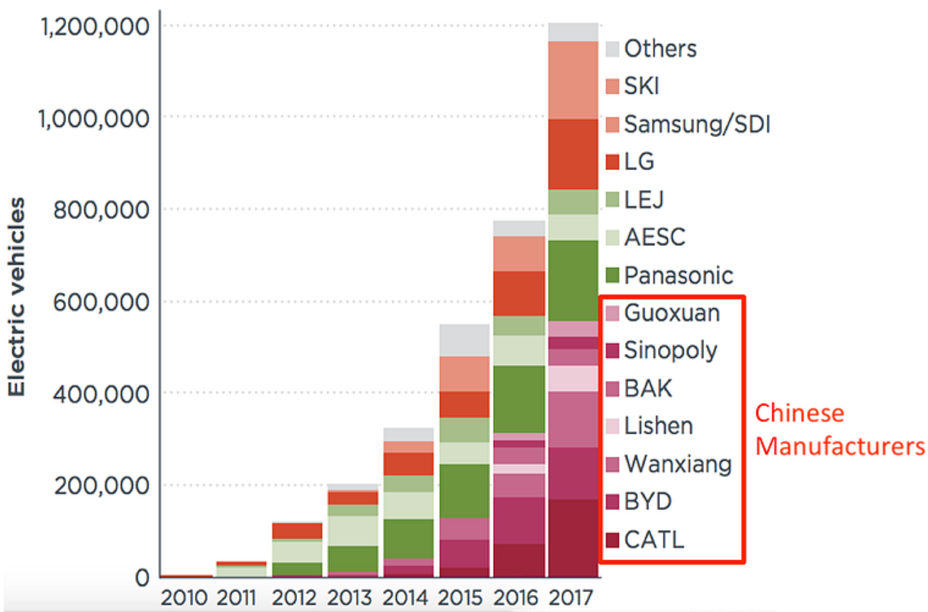
In 1990, Japan has imported around 200,000 kilotons of crude oil, whereas the number continued to grow until the mid 1990s from where they started to shrink again, returning to 200,000 kilotons a year. The early 2000s were significantly dominated by nuclear energy, which made oil imports shrink significantly in 2009. From 2009 onwards the number declined a little, and stagnates between 170,000 und 150,000 kilotons per year (Worldbank, 2020).

4.3.2.2. Import and export value of EV components

China

As of 2019 China exported automotive parts and components translating to more than 53 billion USD of value (HKTDC, 2020). Compared to 2018, the value was growing by 3.1% from 47 billion in 2018 (HKTDC, 2020). Unfortunately, Chinese export statistics do not categorize auto-parts based on propulsion, which makes it rather difficult to evaluate the share of exported EV-related auto-parts.

Dealing with EV-related automotive supply, the battery supply situation might even give more insight in the current domestic situation. According to Liu (2018) the China's EV battery market has recently undergone a rapid consolidation, emerging with two major producers, namely CATL and BYD. In 2017, five firms controlled 62% of the domestic Chinese market, led by BYD and CATL (29% and 16% respectively, as the below figure indicates.



Source: ICCT, 2018

Graph XVII. *Global EV production by battery cell suppliers from 2010 to 2017.*

According to Liu (2018) China's approach towards promoting the development of domestic EV battery industry is quite similar to the approach the country took more than a decade ago in developing its solar panel industry, tuning itself into a global leader (Liu, 2018). “Domestic companies drastically lowered their production costs so that the cost of solar power today is about one-eighth as much as a decade ago, and China embodies the center of a globally developed supply chain” (Liu, 2018). Looking back at this successful example, “Chinese government shows clear ambitions of repeating this already seen success by applying a similar strategy to the EV battery industry” (Liu, 2018).

Within the last couple of years, Chinese companies have been intensively securing overseas resources. However, when it comes to cobalt, Chinese companies do not control it solely for the purpose of reversing their position as price-taker, but rather in order to control the global supply chain of a state-chosen industry (Liu, 2018). Especially the situation of cobalt, as it is said to be the core-material of batteries, becomes a crucial element in this context. It is a rare-earth mineral and an essential input for the production of high-energy density, low-weight lithium-ion batteries. Today, most cobalt is being used in order to produce batteries for portable electronic devices, like smartphones, but the EV-shift is generating extensive demands. “EV batteries require nearly 1,000 times more cobalt than a battery for a typical smartphone” (Liu, 2018). According to Bloomberg New Energy Finance, by 2030, global demand for cobalt is estimated to be 47 greater than it is now (BNEF, 2020).

“At this point, industrial sector adjustment and structural changes to its economy will continue to drive changes to China’s demand for commodities. The key to meeting the rising demand will be large overseas acquisitions of strategic resources” (Liu, 2018). The continuous uprising of China’s EV battery industry together with an increasing number of acquisitions aimed at securing access to cobalt shows that China is following its dedicated path towards controlling the global battery supply chain, and thus potentially influencing the entire global electric vehicle market. As for now, there are roughly 100,000 Chinese firms that are operating within the automotive supplier business (WKÖ AC Shanghai, 2020). According to the Austrian Chamber of Commerce’s Business Center Shanghai, there are no publicly available lists of Chinese automotive supplier companies, which makes it very difficult to tell how large their actual number, as well as the EV-share of their production commodities is. Based on a 2018 study conducted by the Chinese Ministry for Industry and Information (MIIT) shows that the number of officially registered automotive suppliers in China might be less than 50% (MIIT, 2018; WKO AC Shanghai, 2020). Officially available data state that just 10% of the registered firms generate more than RMB 20 Mio. (approx. EUR 2.6 Mio.) of revenue (MIIT, 2018; WKÖ

AC Shanghai, 2020). When it comes to the actual amount and value of exports, as well as the degree of internationalization, it might be helpful to refer to the current "Top Suppliers" list of Automotive News regarding the global position of the most important exporting Chinese suppliers and their shares. The 2018 list of the top 100 OEM suppliers list only seven Chinese companies, namely Yanfeng (15th), BHAP (61st), CITIC Dicastal Co. (65th), Johnson Electric Group (80th), Minth Group (86th), Wuling Industry (89th), and Anhui Zhongding Sealing Parts Co. ranked 92nd (AutoNews, 2019). Interestingly, the respective top 100 rankings for North America and Europe do not contain all of the listed in the worldwide ranking, indicating that most of the mentioned manufacturers operate specificly in China, thus do not export as much. The top 100 lost for Europe only lists one Chinese supplier, namely Yangfeng, ranked 37th, whereas the North American list does not contain any Chinese supplier (AutoNews, 2019). This shows that although the Chinese automotive supplier market is the biggest in the world, the country relies on its strong and continuously increasing domestic demand, as export volumes and value continues to be rather limited.

Japan

The situation of Japanese automotive suppliers differs greatly from the Chinese reality. As the Japanese automotive OEMs are amongst the most successful in the world, supplier firms that have always been developing alongside the big OEMs are too. EV components are thus intertwined with EV activities conducted by the major Japanese OEMs. As for now, major manufacturers have been focusing on HEV technology, not requiring as much new parts than already used so far. Nissan as currently biggest contributor to BEV sales in Japan, has so far been concentrating on its alliance partner Renault, using similar parts as Renault’s BEV model ZOE. Considering export value of Japanese suppliers, there are 23 of them listed amongst the top 100 suppliers worldwide: Denso Corporation (2nd), Yazaki Corp. (11th), Panasonic Automotive Systems Co. (12th), Sumitomo Electric Industries (14th), JTEKT Corp. (18th), Toyota Boshoku Corp. (23rd), Hitachi Automotive Systems (30th), Calsonic Kansei Corp. (32nd), Koito Manufacturing (35th), Toyoda Gosei Co. (37th), JATCO (41st), NSK (49th), NTN Corp. (51st), TS Tech Co. (53rd), Tokai Rika Co. (55th), NHK Spring Co. (67th), Mitsuba Corp. (70th), Asahi Glass Co. (75th), Sumitomo Riko Co. (79th), F-Tech Inc. (83rd), Ryobi (88th), and Omron Corp. ranked 98th (AutoNews, 2019). As for the main Japanese suppliers to Europe, the biggest amongst them is Denso Corp. (14th), followed by Aisin Seiki Co. (25th) and JTEKT Corp. ranked 34th (AutoNews, 2019). Surprisingly, amongst the top 100 suppliers in North America, no Japanese company has been listed-up amongst them. However, the EV-shift has already started to exert great impact on suppliers that have been developing alongside mainstream-technology of combustion engines. The system of just-in-time supply that has dominated the Japanese automotive industry for decades, is apparently not working as well for EV-supply, as battery manufacturers are rather limited in their number, and did not yet grow alongside their dedicated OEMs, so that transport distances, time and cost differ greatly. The supply-chain of EV batteries basically consists of three main parts: (1) cell manufacturing, (2) module manufacturing, and (3) pack assembly (Coffin and Horowitz, 2018). These three stages can theoretically all be conducted in the same place, but in a Japanese context tend to be broken up into mostly two, sometimes even three different locations. Pack assembly tends to occur near the vehicle assembly location because of the cost of transporting battery packs, which are larger and heavier than cells or modules (Coffin and Horowitz, 2018). Considering leading battery-manufacturing firms, Japan still ranks on the top of the scale. As of 2017, amongst the five biggest lithium-ion battery makers, Panasonic has the biggest global market-share (19.63%), including lithium-ion batteries for electronic devices and electric vehicles (Statista, 2020). Especially in terms of supply to international OEMs, Japanese battery manufacturers are situated very well. A prominent example is the US-American EV-OEM Tesla, known for using Japanese-batteries for its EV models (Coffin and Horowitz, 2018).

4.4. Business Context

4.4.1. Domestic

4.4.1.1. Variety of domestic EV producers

China

As of 2019, there was a total amount of 486 EV manufacturers in China. At an earlier stage, HEVs have been one of the focus points of the new energy vehicle project since 2001. After years of research and development have passed, China has managed to eventually grasp the key concepts for parts and motive systems of this technology, started manufacturing HEVs, but now merely focusses on BEV-technology as mass propulsion. The development started with early joint-venture companies such as FAW-Toyota. Table VIII below shows Chinese domestic sales numbers of PHEV and BEVs by OEMs. HEVs without plug-in system, as well as imported vehicles are not counted-in.

Name of OEM	Total Sales	EV sales	EV share	EV models
BYD	507,127	235,701	47%	11
BAIC	1,079,300	165,367	15.3%	2
SAIC	2,946,000	123,092	4.2%	> 5 (different brands: Maxus, MG, Roewe, and Yuejin)
Geely	1,523,119	69,725	4.6%	4
Chery	669,300	65,798	9.8%	4
Hawtai	120,640	52,826	43.8%	3
JAC	185.259	49,849	27%	1
JMC	56.193	49,326	87.8%	1
Dongfeng	1,212,213	40,445	3.3%	2
Changan	1,499,700	35,307	2.4%	4
Zotye	232.409	31,616	13.6%	5

Source: Statista, 2020, Marklines, 2020.

Table VIII. *Domestic EV sales of Chinese OEMs in 2018 (China)*

The numbers point out that out of the big Chinese mass-producers, BYD has the highest share of NEVs with already ranging at 47% of total sales in China. As for smaller brands, the statistics show that especially JMC has nearly focused solely on NEV models, with a share of 87.8%. Also Hawtai, with almost half (43.8%) and JAC with 27% NEV share show already a major focus on NEV models. When it comes to the big domestic OEMs portfolio of EVs, there are however significant differences amongst the producers. BYD, as China's biggest EV manufacturer with almost 50% of its sales being NEV based, has a rather vast portfolio of EV models. The line-up contains 11 EV models. Zotye and SAIC have 5 EV models in their portfolio. SAIC is a very interesting case, as it contains four different brands, including 5 EV models in total. The SAIC group introduced its first EV models via its luxury brand Roewe, emerged from Rover, the former British manufacturer, and subsequently released two more EV brands, Maxus and MG. It also manufacturers two more models through the JV with GM, Buick and Baojun. Geely, Chery and Changan respectively having 4 EV models in their portfolio, Hawtai has 3, Dongfeng and BAIC 2, JAC and JMC respectively 1.

Japan

In recent days, all of the big seven Japanese OEMs, Toyota, Nissan, Honda, Mazda, Suzuki, Subaru and Mitsubishi produce and offer EV-models. Not all of them have focused on BEV production yet, as HEVs continue to dominate the Japanese automotive landscape heavily. For a better understanding of the market situation of plug-in vehicles (BEVs and PHEVs) the Table XI below will not contain sales figures of HEVs.

Name of OEM	Total Sales	BEV sales	PHEV sales	Plug-in EV sales (BEVs and PHEVs)	EV share (excluding HEV)	Plug-in EV models (BEVs and PHEVs)
Toyota	1,508,295	0	9,569	9,569	0.6%	2
Nissan	358,520	19,786	0	19,786	5.5%	2
Honda	348,061	0	64	64	0.02%	3
Mazda	166,563	0	0	0	0	0
Suzuki	117,284	0	0	0	0	0
Subaru	105,075	0	0	0	0	1
Mitsubishi	43,745	105	5,286	5,391	12.3%	3

Source: Marklines, 2020; JADA, 2020)

***Table* IX .** *Domestic EV sales of Japanese OEMs in 2019 (Japan)*

Most interestingly, Japan's top manufacturer Toyota does not have any BEV sales as of 2019. The same fact applies to Honda, Mazda, Suzuki and Subaru as well. Counting together BEVs and PHEVs, Nissan has the biggest sales numbers for 2019 (19,786), accounting for 5.5% of its total passenger car sales. Surprisingly, Mitsubishi has also very strong focus on plug-in vehicles, and sold 5,391 units, representing 12.3% of its total passenger car sales in 2019 (JADA, 2020). The most interesting model in terms of BEVs is the Nissan Leaf, which by mid 2018 was sold over 100,000 times in Japan since its launch in 2010 (Marklines, 2020). Domestic OEMs have been focusing on HEVs rather than BEVs so far. A major exception has been Nissan, following a rather different approach towards the EV-shift, nonetheless influenced by its close alliance with French OEM Renault. The Nissan Leaf was Japan's first mass-produced passenger vehicles that reached significant sales-numbers. The second generation of the model has already surpassed 100,000 sold units in Japan and continues to be a major global BEV model, sold all around the world. There are thus manufacturers that do not offer BEV or PHEV models in Japan. However, every OEM offers at least ¼ of their models as HEV version, except for Mazda, who is focusing rather on its own developed *Skyactive-technology* trying to downsize and foster the full potential of combustion engines to the limits. Japanese OEMs started tackling electrification at a very early stage, setting up joint ventures to manufacture lithium-ion batteries with domestic electronics companies. Toyota paired with Panasonic, while Nissan Motor set up a joint venture with NEC called Automotive Energy Supply Corp., or AESC (Nikkei Asian Review, 2018). The Japanese ventures tried to control big shares of the EV market through exclusive use of sophisticated domestic battery technology, with Nissan becoming the leader in the global EV market in 2010 by launching the Leaf, the world's all-time best-selling EV (Nikkei Asian Review, 2018). “As new competitors entered the market, AESC was losing the fierce price competition, and Nissan sold the battery venture to a Chinese renewable energy company. At the current stage, Japanese companies are trying to get out in front of their rivals once again, with Toyota leading research on so-called solid-state battery technology” (Nikkei Asian Review, 2018). “Especially Toyota intends to spend JPY 1.5 trillion (USD 13.2 billion) by 2030 on R&D programs for next-generation batteries. The company has so far been remarkably reluctant to invest into BEV technology, as it has been heavily contributing to the HEV development as well as to R&D of FCEV. Toyota is also leading a JPY 10 billion national project launched by the New Energy and Industrial Technology Development Organization to develop basic technologies for solid-state batteries, which includes 23 OEM and battery manufacturers, including Panasonic, Nissan and Honda” (Nikkei Asian Review, 2018).

4.4.1.2. Governmental policies

China

In 2009, the Chinese government introduced a profound plan to revolutionize China’s automotive technology, and seize the growing new energy vehicle (NEV) market to become a powerful world leader in manufacturing of BEVs. The government's political support for the adoption of electric vehicles has four goals, (1) creating a world-leading industry that would produce jobs and exports, (2) creating energy security to reduce its oil dependence, which comes from the Middle East, (3) reducing urban air pollution, and (4) reducing its carbon emissions (Lee et al., 2014). The Chinese government uses the term new energy vehicles (NEVs) to designate PHEVs and BEVs, which are subject to purchase incentives. Initially, conventional hybrids were also included, but excluded later on (PRTM, 2011).

The most common tool to increase EV adoption are consumer subsidy programs. With the announcement of the ‘New Energy Vehicle Demonstration and Promotion Notice’ in the beginning of 2009, the Chinese government paved the legal way for implementing financial subsidies for the purchase of public vehicles. Following this notice, in June 2010, the Chinese government introduced the first pilot project for private consumer subsidies in the five cities of Shanghai, Shenzhen, Hangzhou, Changchun and Hefei (Tagscherer, 2012). Depending on the efficiency of the technology, buyers received up to EUR 7,700 per vehicle for BEVs and up to EUR 6,300 for PHEVs, covering about 40 to 60% of the costs of the new vehicle. In addition, local authorities often provided a subsidy of the same amount, which added up to as much as EUR 15,400 in some cities (Growth Analysis, 2013; Hall & Lutsey, 2017). In the years following, the government added new cities to the program, mainly developed cities in the southeast, and eventually extended the subsidy range from the promotion city groups to the entire country in 2016 (Tagscherer, 2012; Zhang et al., 2017). Moreover, in 2016, the subsidy program was renewed again with subsidies of EUR 7,100 for BEVs and EUR 3,900 for PHEVs and with the goal to slowly decrease the amount of funding. Based on the 2016’s standard, financial support was decreased by 20% in 2017 and 2018 and it will decrease by 40% in 2019 and 2020. China plans to phase out the subsidy entirely by 2020 (Hall & Lutsey, 2017; Lu, 2018).

Another policy measure introduced by the Chinese government is the exemption of registration plate fees for buyers of environmental friendly vehicles. Registration plates in China must be won in auctions or lotteries, depending on the city, and are a big barrier for people that want to drive a car. The average auction price for registrations plates in 2015 was EUR 10,000, with a bidding success rate of only 5%. EV buyers can bypass this controlled auction or lottery systems, thus saving up to EUR 10,000 and a long waiting time (Wang et al., 2017). On top of these monetary benefits, in most provinces and cities in China, the government allows EVs to use bus lanes, they can park for free at publicly funded places and they are not restricted by traffic control Beijing for instance, the system is based on a vehicle's license plate. Odd numbers will be allowed on the roads one day, even numbers the next. Adding to that, these policies allow cities to include taking half of the city's private cars off the roads on days when there are serious levels of pollution (Lu, 2018). For manufacturers, the government has introduced a strategy that could be described as production encouragement, the ‘dual-credit policy’. This policy has taken effect in April 2018 and assesses vehicle manufacturers in terms of fuel consumption and EV production in order to qualify for new energy credits. To obtain these new energy credits, manufacturers will need to produce a minimum number of EVs, and the amount of credits they receive will be based on factors such as driving range and EV weight. The policy requires that 10% of a vehicle manufacturer's total credits must consist of new energy credits in 2019 and 12% in 2020. Manufacturers failing to meet the requirements will be fined or must buy credits from other manufacturers (Lu, 2018).

In addition to consumer subsidies, the government pursues two major tax strategies. The first strategy attempts to make EVs more attractive by eliminating car related taxes. In 2012, the Chinese government exempted them from the annual vehicle and vessel tax. Two years later, further tax incentives were implemented by introducing tax exemptions for the 10% purchase tax. These measures will continue at least through 2020 (Lu, 2018). The second strategy targets traditional passenger cars and attempts to make them unattractive by raising taxes. Already in 2008, the tax was raised for cars with an engine capacity of three liters. In 2012, additional taxes were added for cars with an engine capacity of 2-2.5 liters, as well as for vehicles with even bigger engines (Growth Analysis, 2013).

In her analysis on governmental policies towards EV development and production in China, Tagscherer argues that, "exactly this embodies a huge development potential, which makes analysts believe that China will become the largest market for electric vehicles in the future" (Tagscherer, 2012: p. 1). She furthermore argues, "this belief is shared by the government, which led them to implement and draft several different policies and rules to support and speed up the development of electric vehicles" (Tagscherer, 2012: p. 2). "At the highest policy-making level, the Chinese government adopted the development of electric vehicles in its highest priority national plan, the 12th Five-Year Plan" (Tagscherer, 2012: p. 2). "At the same time, the electric vehicle industry has been selected as one of the seven strategic emerging industries by the National Development and Reform Commission (NDRC), which underlines its believed future importance for China" (Tagscherer, 2012: p. 1). She evaluates, that the current strategy of the Chinese government concerning the development of electric vehicles is supported mainly by three major policy fields: (1) support for R&D, (2) support for the related industry, and (3) support for private and public consumption (Tagscherer, 2012: p. 1). She concludes by stating that "unless China's systemic weaknesses are addressed, the development of new energy vehicles seems to be quite separate from energy policies and from policies to mitigate climate change. Therefore, the benefit for the environment may be less than currently expected by many scholars and politicians” (Tagscherer, 2012: p. 16).

Heiden and Taube agree with Tagscherer on the importance of the government and state that “since government support for the development and commercialization of EVs in China has commenced, substantial resources were allocated to promote R&D, demonstration projects or the construction of related infrastructure. Especially since EVs have been recognized as strategy emerging industry in the 12th FYP, state intervention has been substantial, albeit with modest results” (Heiden and Taube, 2013: p. 497). However, “without blue-prints for the popularization of green vehicles available from other countries, Chinese transition strategies centered on exploration and experimentation” (Heiden and Taube, 2013: p. 498). The Chinese government reaffirmed their prioritized goal to promote NEVs, especially BEVs in its 13th Five-Year Plan (2016-2020). The Central Committee of the Communist Party of China approved the document that emphasizes boosting technological innovations in the manufacturing of new energy vehicles and promoting the use of electric cars, PHEVs and FCVs, included in its latest Five-Year Plan. In April 2016, the Traffic Management Bureau under the Ministry of Public Security introduced a new system new green license plates to identify NEVs, as opposed to the country's standard blue plates. These NEV plates include a Chinese character abbreviation for the provincial region where the car belongs to, and seven numbers and letters, compared to the usual six on standard number plates. The main objective of these plates is to facilitate police enforcement of the preferential policies that some local authorities apply to cleaner cars to help cut emissions and ease traffic. An illustrative example is central Beijing, where a road space rationing scheme is in place, enabling for a driving restriction regulation that bans conventional vehicles from entering the city for one day a week, but new energy vehicles are exempted from the restriction, thus are allowed to enter the central city area at any time (Xinhua, 2016).

Beijing also introduced a vehicle quota system in 2011, awarding new car licenses through a lottery, with a ceiling of 6 million units for 2017. NEV were placed in a special category where the odds of winning a license plate are much higher than they are for conventional combustion engine vehicles. Most recently, Chinese policy developments include the restriction of investment in new ICE vehicle manufacturing plants and a proposal to tighten average fuel economy for the passenger light-duty vehicle (PLDV) fleet in 2025, thus updating the 2015 limits (IEA, 2020). Further the government uses differentiated incentives for automobiles based on their battery characteristics, such as zero-emissions vehicle credits and subsidies under the New Energy Vehicle mandate (IEA, 2020).

Japan

Besides the industry itself, also the respective ministry of economy, trade and industry (METI) got involved in the whole development process, and developed a roadmap which aims at becoming more capable in terms of performance of lithium-ion batteries (Horak and Pascha, 2013: p. 486). Pohl and Yarime argue that "Japanese national policy has so far had a limited direct role in the electrification of vehicles" (Pohl and Yarime, 2012: p. 1431). Before the global shift towards BEVs started, Japan introduced policies to further strengthen its domestic HEV sales. In 2009, the Japanese government implemented a set of policies and incentives that included a program of tax breaks on hybrid vehicles and other low emission cars. At the same time, levy on gasoline prices were raised, which raised end consumer prices for gasoline. The consequence was a significant rise in HEV sales for 2009 that almost tripled those for 2008 (Marklines, 2020). This can be considered another major reason for the domestic HEV focus, and the main reason, why governmental policies have not be appointed directly towards HEV anymore ever since. Yamazaki argues that the main reasons why BEV sales in Japan are still very little, despite the fact that Nissan and Mitsubishi already offer quite competitive models, are the expensive prices, as well as the not yet sufficient mile range (Yamazaki, 2014: p. 156). The Ministry of Economy Trade and Industry of Japan (METI) announced its *Next Generation Vehicle Strategy* in 2010. This strategy is targeted at spreading the market share of BEVs to 20–30% (METI, 2010). This strategy in the Japanese context led to the wide range of new policies implementation aiming at building a low carbon society and at promoting next generation vehicles to promote the development of 'smart communities'. One of the first model cases in terms of becoming a smart-city was Toyota City, which received governmental support for its infrastructural development towards an PHEV-friendly community (Ando et al., 2014). In May 2009, the Japanese diet passed the 'Green Vehicle Purchasing Promotion Measures' to promote the purchase of new, eco-friendly vehicles. For this program, the government allocated approximately EUR 2.8 billion and sponsored consumers of energy friendly vehicles through March 2010. The program was split into two parts, one trying to attract buyers with older passenger cars, and one targeting people that purchase a new car without having an older car to be replaced. In the replacement program, the consumer was eligible for a EUR 2,000 subsidy when purchasing a standard car and EUR 950 when buying a mini-vehicle. In the non-replacement program, the government supported buyers with EUR 800 for a standard car and EUR 400 for a mini- vehicle (JAMA, 2009). After the program ended in 2010, it took the government almost two years to initiate a new consumer subsidy program. From April 2012 to March 2013, the government allocated funds of EUR 2.1 billion to support the EV market

(Growth Analysis, 2013). Continuing this proactive approach, another program was launched in April 2015 continuing through March 2017 with the government subsidizing buyers with EUR 3,500 per vehicle (JAMA, 2017).

Currently, the automobile tax structure of Japan consists of nine different taxes, four taxes on automobiles and five taxes on fuel consumption. This creates a heavy tax burden for Japanese car owners and therefore tax incentives provide an efficient way to promote the wider use of eco-friendly vehicles in Japan (JAMA, 2017). Since April 2009, the Japanese government has applied several tax incentives for consumers of new energy cars. The first program they had initiated was executed from April 2009 to March 2012. Since then, tax incentives have been introduced in two-year steps all the way through 2019, including the vehicle-purchase tax, the motor-vehicle tax, the tonnage tax and the mini-vehicle tax. The purchase tax accounts for 3% of the purchase price for private passenger cars and 2% for commercial vehicles and mini-vehicles and has been exempted as part of these tax measures. The motor-vehicle tax is a fixed amount that is assessed on the owner every year and can cost up to EUR 850, depending on the car's engine power. Due to the government's policies, consumer of next-generation electric vehicles benefited from a 50% reduction and since 2016, the reduction of the motor-vehicle tax accounts for as much as 75% (JAMA, 2017). The tonnage tax is assessed according to the vehicle's weight at each mandatory inspection. A normal car for instance, costs EUR 31/0,5 t per year. EVs however, are exempted from the tonnage tax at the first and second inspection. The mini-vehicle tax is a fixed amount of EUR 85 per year. Owners of battery powered vehicles are given a 75% reduction on this tax (JAMA, 2016 & 2017).

In a nutshell, Japan's automotive strategy through a co-operative approach across industrial stakeholders, aims to reduce 80% of greenhouse gas emissions from vehicles produced by domestic automakers (90% for passenger vehicles) – including exported vehicles – to be achieved by 2050 with a combination of hybrid electric vehicles (HEVs), BEVs, PHEVs and FCEVs (IEA, 2020).

4.4.2. International

4.4.2.1. Specialization

China

Chinese manufacturers rely heavily on technical knowhow and engineering advantages that their joint-venture partners provide to them. The Chinese market is extensively vast, characterized by an enormous amount of local manufacturers and joint-ventures that oftentimes offer a very diffuse range of models. Ever since the EV-shift has been claimed as a nationwide achievement to be reached, nearly all manufacturers already offer EV models, and are in the stage of further development. According to McKinsey, there are currently five major trends characterizing the Chinese EV market, (1) “Made in China for China turns to ‘innovate in China for the world', meaning that there is a substantial opportunity for multinational carmakers to position China as an auto innovation hub. The domestic market is the largest and most diversified market for EVs, and the government is interfering heavily to foster global leadership in smart car development and production” (McKinsey, 2019: p. 18). (2) “The ‘one-size-fits-all’ evolved to ‘tailored for China’, meaning that global automakers operating in China could by leveraging both digital and data analytics to suit the relatively fluid regulatory environment in China. create a retail business model tailored to Chinese consumers' needs’ (McKinsey, 2019: p. 19). (3) “The single Chinese market developed to multiple sub-markets. As China is vast country with many regional differences, demanding regional specialization by global OEMs who can no longer treat China as a single and conform domestic market” (McKinsey, 2019: p. 19). (4) “Cost-plus to market-back, ensuring that cost competitiveness does not suffer in the event of Chinese rivals launching high-quality, lower-priced challenger models onto the market” (McKinsey, 2019: p. 19). (5) “Joint venture to wholly owned enterprise, meaning that in 2022, China will eliminate its caps on foreign ownership of car companies, allowing automakers to own their Chinese operations outright instead of partnering with domestic companies. Foreign auto companies should review their existing collaborations and modify their joint ventures in accordance with their strategic goals” (McKinsey, 2019: p. 19).

Japan

As already mentioned, the Japanese automotive industry is strongly characterized by the herd-effect of its keiretsu-driven OEMs that have been focusing very distinctly on HEV propulsion technology. By highlighting the fact that the Japanese HEVs embody the first and yet only unconventional technology that hit the market with mass production, Pohl and Yarime develop a framework to evaluate the technological paradigm shift within the Japanese automotive industry. They elaborate on firm– internal and firm–external factors, and define six dimensions of innovation: (1) knowledge, (2) expectations, (3) entrepreneurship, (4) growth, (5) institutions, and (6) externalities (Pohl and Yarime, 2012: p. 1442).

As for **knowledge, "**the development in basic and generic technologies such as batteries and fuel cells has been the main activity stimulated by the government. There was also a national project addressing the development of BEVs in the 1970s. However, it was judged as potentially counterproductive by one of the participants" (Pohl and Yarime, 2012: p. 1441). Interestingly, their study also confirms the close relationship to the suppliers, which is believed to be typical for Japanese manufacturers (Yamazaki, 2014), but at the same time highlights Toyota's and Honda's ambitions to stay independent regarding their knowledge (Pohl and Yarime, 2012: p. 1441). As for the **expectations**, they state that during the phase of commercial HEV development in Japan, governmental policy was targeting BEVs, and not HEVs. Thus HEVs were not included in governmental policies until the year Toyota launched its first mainstream mass production HEV, the Prius. Despite Åhman and other scholars opposing this, they argue that at least until 2009, the government's role regarding HEV development has been rather remote (Pohl and Yarime, 2012: p. 1441). In terms of **entrepreneurship**, the authors argue that Toyota and Honda were the first two manufacturers, who focused on the development of HEVs, whereas Nissan was primarily focusing on FCEVs (Pohl and Yarime, 2012: p. 1441). They agree with Horak and Pascha on the fact that intensive patenting was one method used by Toyota to protect the uniqueness of the new HEV solution (Pohl and Yarime, 2012: p. 1443). In terms of **growth**, they agree with Yamazaki, Horak and Pascha and argue that "one key factor contributing to this capability accumulation was the intense competition between the Japanese automakers" (Pohl and Yarime, 2012: 1442). Further, Toyota rapidly emerged as technologically superior because of its early formation of joint ventures with electronic companies, such as Panasonic. Toyota has allowed for a broader use of the new technologies through licensing and deliveries of batteries to almost all HEV makers from its joint venture with Panasonic (Pohl and Yarime, 2012: p. 1442). The academic discourse on the Japanese automotive industry appears to be in a broad consensus on the Japanese automakers generally applying longer-term strategies, which is in line with the findings of Pohl's and Yarime's study. As for **institutions**, it can be said that despite the government focusing on the development of FCEVs at the time, the Japanese manufacturers have managed to establish the concept of an HEV among buyers and users of cars (Pohl and Yarime, 2012: 1442). Lastly, regarding the

externalities, Pohl and Yarime agree on what has already been stated by Reingold (1999), namely "*Toyota Hybrid Synergy Drive* (HSD) technology initially not meant to become mainstream and going into mass production, but attracting people to the brand again, which made not just Toyota but also the Japanese manufacturers in general acquire a new image that successfully contributed to the emergence of the technology" (Reingold 1999; Pohl and Yarime 2012: p. 1443). At the very end of their study Pohl and Yarime raise a very interesting question on the linkage between governmental policy and new-technology vehicles, namely whether policy measures have created sufficient diversity. "Another implication linked to the long duration of the process is that there might be opportunities for intermediate solutions to be of commercial interest. The relative success of HEVs on the market is an example of one such potentially intermediate solution" (Pohl and Yarime, 2012: p. 1442). Eventually, they conclude by extracting three policy implications: (1) "The limited direct role of national policy calls for realistic and probably modest expectations relating to national policymakers possibilities to direct the technological development in a mature industry", (2) "the case illustrates the inherently international nature of the mature automotive industry, which in turn must be reflected in national policy", and (3) "the indirect role of maintaining a highly competitive national market nurturing a strong and efficient product development capability appears to be crucial" (Pohl and Yarime, 2012: p. 1443). Pohl and Yarime state that "without the HEV commercialization, other electrification technologies such as BEVs or plug-in HEVs would not have developed to their current status" (Pohl and Yarime, 2012: p. 1444).

Yabe et al. add onto this by stating, "EVs seemed to take longer time to become widespread because of their higher initial cost and inconvenience of frequent charges. However, large-scale production of EV/PHEVs has recently begun, and the possibility has arisen that adoption will proceed faster than our forecasts had predicted" (Yabe et al., 2012: p. 530). Furthermore, there is "great uncertainty in augmenting zero emission power supplies in Japan, particularly after the huge tsunami followed by the severe accident in Fukushima 1 nuclear power plant" (Yabe et al., 2012: p. 530). Yabe et al.'s study was conducted by following a *computational model*, which the authors developed. This model can assess the amount of CO2 emitted as well as the total cost of the private-use passenger vehicle sector and the power supply sector throughout Japan (passenger vehicle model and power supply model), and can optimize the vehicle type composition, power generation mix, and power supply operation which minimizes the sum total of annual fixed cost and fuel cost during the assessment period of 40 years from 2010 to 2050 (Yabe et al., 2012: p. 531). Eventually the authors concluded the following: (1) "Though the large-scale introduction of PHEVs/EVs has the potential to significantly reduce CO2 emissions, the penetration speed is not so fast considering the economical viewpoint of vehicle owners and the learning curve of Li-ion batteries”. (2) It will be particularly difficult to realize the target set by Japan’s government of ‘‘having one in every two new vehicles be a new model environmentally friendly vehicle in 2020’’ unless there is a framework for subsidies and technological innovation over the long term. (3) “Though Japan’s CO2 reduction policy may be reconstructed considering the severe accident in nuclear power plants, the introduction of PHEV/EVs continues to be an effective and reasonable measure to reduce total CO2 emissions in Japan considering their energy efficiency” (Yabe et al., 2012: p. 537). A quite recent contribution to the discourse was made by Zhang et al. Their study was based on the three following profound research questions: (1) “Which factors mainly affect the adoption potential of BEVs?” (2) “What are the sensitivities and interaction of such factors to the adoption potential of BEVs?” (3) “What effective policies should be put forward by the government to respond to the proposed target?” (Zhang et al., 2018: p. 528). Based on three years of GPS data of 1.6 million people, Zhang et al. estimated the travel and adoption demands of BEVs in Japan. “Under the current construction conditions for public charging systems and charging technologies, the adoption potential of battery electric vehicles may not be as promising as previously expected, and the government still faces great pressure to respond to the market share target. Given the current level of battery technology, technical and policy improvements such as fast charging, reducing the production cost, perfecting the public charging infrastructure, and increasing purchasing subsidies were found to be more effective than improving the battery capacity at increasing the adoption potential of battery electric vehicles” (Zhang et al., 2018: p. 528).

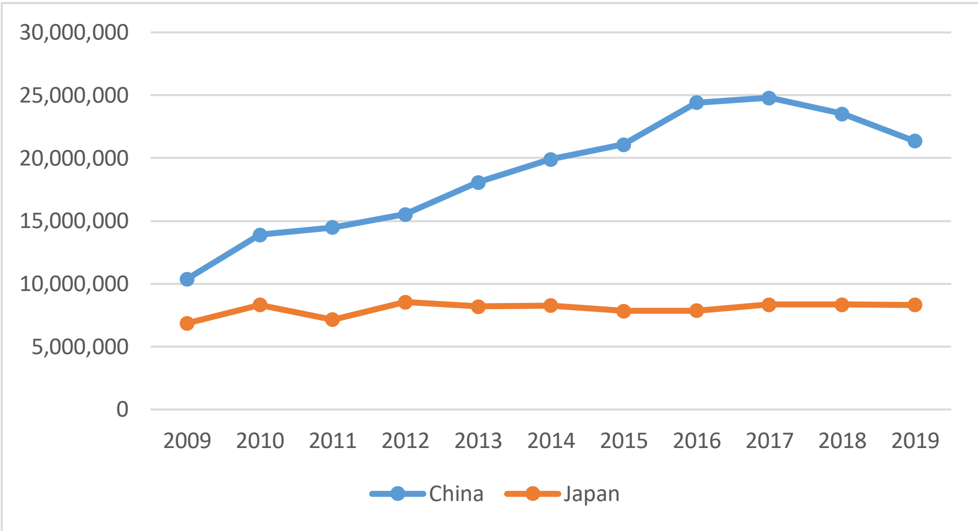
After the Fukushima Daiichi nuclear crisis, Japan increased imports of natural gas and crude oil in the short term to make up for the power shortage. Due to these tendencies, Zhang et al. could already evaluate this impact on power generation and consumption in his study, which Yabe et al., six years earlier on, could not. Although the production and sales of EVs have steadily increased, the annual demand for primary energy increased to 445.3 million tons of oil equivalent, and transportation accounts for 24.1% of the total energy consumption (Zhang et al., 2018: p. 527). As Yabe et al. have already identified the importance of further infrastructure development, Zhang et al. state that the key technologies restricting the marketization of BEVs are those for efficient battery energy storage and quick charging at a low temperature (Zhang et al., 2018: 528). In addition, “the high prices of electric motors, batteries, and motor control systems increase the production cost of BEVs compared to ICEVs, which limits the market potential of BEVs to a certain extent, and can thus only be overcome by sufficing governmental support and subvention" (Zhang et al., 2018: p. 528). They state that "sophistication of these support service systems will directly affect the demand for BEVs, and are thus strongly related to the of governmental policies towards CO2 reduction, and environmental friendly mobility" (Zhang et al., 2018: p. 528). Further, "the promotion of BEVs will impact the development and operational efficiency of urban areas, which will further enhance EV sales, thus the development of BEVs is a challenging sociotechnical issue of both economic, as well as social importance" (Zhang et al., 2018: p. 528). The authors follow Yamazaki's footprints and conclude in terms of the charging intervals analysis that compared to increasing the battery capacity, "improving the public charging infrastructure and developing fast-charging technology are much more efficient at increasing the adoption potential of BEVs" (Zhang et al., 2018: p. 532).

5. Analysis

5.1. Factor Conditions

Production capabilities

As for the production capabilities, both countries showed very differing realities. China on the one hand produces the highest amount of passenger car units in the world. Its focus lies on serving the domestic market. Export numbers are fairly small, EV production quite heavily focused on BEVs that account for more than 4.5% of all produced passenger cars. Japan on the other hand shows a different focus, embodying the third biggest automotive manufacturing country in the world. The share of produced and sold HEVs in relation to the overall production and sales in Japan is still the highest in the world. In direct comparison to that, the numbers of BEVs are fairly low. The Japanese focus has traditionally been exporting a large amount of its produced units. Within the last decades, Japanese OEMs have been more and more focusing on outsourcing their production facilities for export units overseas. Therefore, the amount of Japanese cars manufactured overseas is remarkably high. In direct comparison to China, the huge importance of export for the Japanese automotive industry becomes visible.



Source: Statista, 2020; JAMA, 2019; Marklines, 2020

Graph XVIII. *Passenger car production in China and Japan 2009-2019*

Research and Development

Ever since the announcements of their respective strategies, China and Japan have promoted the development of EV development at different stages of the implementation process. Both China and Japan have established and funded major R&D projects and cooperated with key players from the automotive industry, research institutions, universities and other relevant organizations. In terms of R&D, both countries share the common fact that the government is hugely in favour of spending resources on the technological development and therefor has an interest to enhance competitiveness and domestic capabilities in terms of production. In the case of China, the government has announced these intentions in their recent five-year plans and therefor provided a baseline for domestic OEMs and the whole industry itself to follow this approach. In Japan on the other hand, HEVs have been the main focus of the automotive industry from the late 1990s onwards, which already provided the industry, first and foremost the big domestic players, with basic knowledge of electric vehicle technology. Although HEVs, as they just embody a bridge or symbiosis of combustion engine technology and electric vehicle technology, and therefor still relying on fossil fuels, have never been focused by the government in any strategic campaign or R&D program. As for BEVs, both countries appear to be supportive in terms of governmental incentives to enhance research and development. Given these fundamentally diverging approaches in terms of governmental power, the Chinese case appears to be more drastic. Japanese OEMs have a very high reputation when it comes to end quality, technological knowhow and car reliability. The country is highly depending on its exports, which made Japanese OEMs outsource their facilities for oversea production to other countries on nearly every other continent in the world. Given this fact, their OEMs had to adapt to many diverging local standards in terms of quality, technology, manufacturing processes, which made them allocate their R&D resources. Therefor, Japanese OEMs have been gathering knowhow in many different fields from many different facilities all over the world. This comes in very handy, as they know hold access to a large number of data that can be used for R&D of electric vehicles. On the other hand, China finds itself in a totally different stage of automotive manufacturing. Chinese OEMs have not had the opportunity to collect as much data and knowhow on automotive manufacturing that the country had to open up in the late 1990s to foreign investment, joint-ventures with foreign manufacturers, in order to compensate this gap. As these joint-venture partners did not happen to share their latest technology, but rather shared technological platforms and engineering of previous models, the Chinese government is aware of the fact that financial resources hast o be allocated towards the R&D of electric vehicles, in order to make the countries OEMs more competitive.

Infrastructure

Concerning infrastructure, the governments in Beijing and Tokyo have been active in launching and funding projects in major cities and along major traffic routes. In China, the funding of 88 designated pilot cities was crucial for the expansion of the charging network. In order to receive funding, cooperating cities were required to provide one charging point for every eighth vehicle, and charging stations were designed to be within one kilometer distance of any potential spot within the center area of the city (OAV, 2018). In Japan, the ‘next generation vehicle charging infrastructure deployment’ was one of the major undertakings to expand the number of charging stations. The incentive was to get local governments, highway operators and other players to cooperate in this program. As for charging-equipment, two-thirds of the installation costs were subsidized by the Japanese government (OAV, 2018). In terms of infrastructural development, China is not just the largest producer of BEVs, but also the country with the biggest infrastructure network. In 2017, 213,900 charging points (130,500 slow and 83,400 fast charging stations) existed in China, compared to 28,800 charging points (21,500 slow and 7,300 fast charging stations) in Japan (IEA, 2020). These numbers suggest that China is far ahead of Japan, but taking a look at the ratio of cars to charging stations, it becomes apparent that China and Japan are almost on equal terms. On average, one public charging point serves six cars in China, while there is one charging point for every seventh BEV in Japan (OAV, 2018). China appears to tackle both infrastructural development, as well as the actual distribution of BEVs amongst society in equal terms. Japan on the other hand has put a lot of effort into the development of its BEV-friendly infrastructure that the number of charging stations is remarkably high, given the rather small amount of BEVs and PHEVs, as the focus on HEVs continues be very predominant.

FDI and Alliances

For Japan, domestic alliances amongst fellow OEMs have been a very essential part of the Japanese economic model, not just for the automotive industry, but throughout the 21st century. Japanese automotive manufacturers appear to continue these strategic activities in order to reduce cost and raise efficiency. Almost all of the seven major OEMs (Toyota, Nissan, Honda, Suzuki, Mazda, Mitsubishi, Subaru) obtain partnerships, which is very unique to Japan. There have been made some international alliances within the past decades as well, first and foremost the strategic partnership between Renault and Nissan that now also includes Mitsubishi-Motors and contribute strongly to the ongoing EV-shift with its shared focus on mass-production of BEV-models. In China, domestic partnerships do exist as well, but not in a comparable coherent form throughout the whole automotive sectors. Ever since the economic opening of the country in the late 1970s, international partnerships in form of joint-venture programs have been a major strategic pillar of the Chinese automotive industry. Nearly all of the multinational global players in the automotive industry formed at least one, oftentimes even two joint-venture programs with Chinese OEMs in order to enter the promising Chinese domestic market.

5.2. Demand Conditions

Domestic EV sales, growth

Both China and Japan feature very distinct domestic market situations. The Chinese domestic sales are characterized by the highest vehicle sales numbers in the world, relatively low HEV and PHEV shares, but a massively growing BEV share, ranging at already 5% of total sales. For a domestic market, as huge as the Chinese one, these numbers are very high, showing the country's ambitious plans for the ongoing EV shift. Japan offers a very different reality. Shares for PHEVs and EVs are rather low, but almost 40% of all passenger car sales are HEVs. There is no other market in the world with a similar share of HEV. These high numbers of HEV are closely connected to the expertise of Japanese OEMs in terms of HEV technology. The very interesting fact here is that China is already tackling BEVs, thus is moving completely away from dependence towards fossil fuels, whereas Japan is still relying on its symbiosis of combustion engines, supported by non-chargeable electric motors. Although PHEVs were originally developed by Japanese manufacturers, their share appears to fairly slim. Both countries seem to contribute their domestic shift towards electrification of mobility by their own pace. The Chinese market has already large capacities of BEV production, resulting in very high numbers of BEV sales, whereas Japan is still focusing on expertise of their own manufacturers that are emphasizing HEV technology.

Societal adaption, and Costumer sophistication

Both countries countries face different EV realities when it comes to the societal adaptation of EV technologies and the domestic consumption of it. China has seen governmental support in terms of consumer oriented policies towards lifting financial burdens on BEVs. The country has huge potential concerning the adaptation of NEVs as the total number of cars amongst the population remains fairly low, wages are rising, the costs of BEVs are lowering, and financial incentives are a frequent tool used by the government to channel the demand. In Japan, HEVs remain the most attractive choice for costumers, as the technology has proven its upsides, and do not cause any infrastructural troubles. The overall sophistication of the market is very high, as the number of cars compared to the total population and land-size remains remarkably high. Except for the large cities, the amount of cars per 100 households ranges from 80 to over 100 for most of the Japanese prefectures (JAMA, 2019).

EV export volume, EV export growth development

Both countries show relatively stable export numbers, China's overall production capabilities both in terms of passenger vehicles in total, as well as NEVs specifically have shown drastic growth over the last decade, seeing a recent drop. The export numbers on the other hand have been rather stable, ranging between 2-3% of the total production of passenger cars. Japan has not seen an extensive rise in production capabilities, rather continues to slowly grow, defending its position as global automobile superpower. Its export numbers have been stable at around 50% of its total production capacities. In this regard, China and Japan's position could not be more different, as China's low export numbers allow the country to primarily focus on its domestic needs, thus can directly react to domestic changes and adapt faster, which makes it a lot easier to generate growth. Directly compared to that, Japan is rather static and not as capable to quick adaptations, as it relies heavily on export, thus has to balance domestic and international interests and standards in order to keep its position.

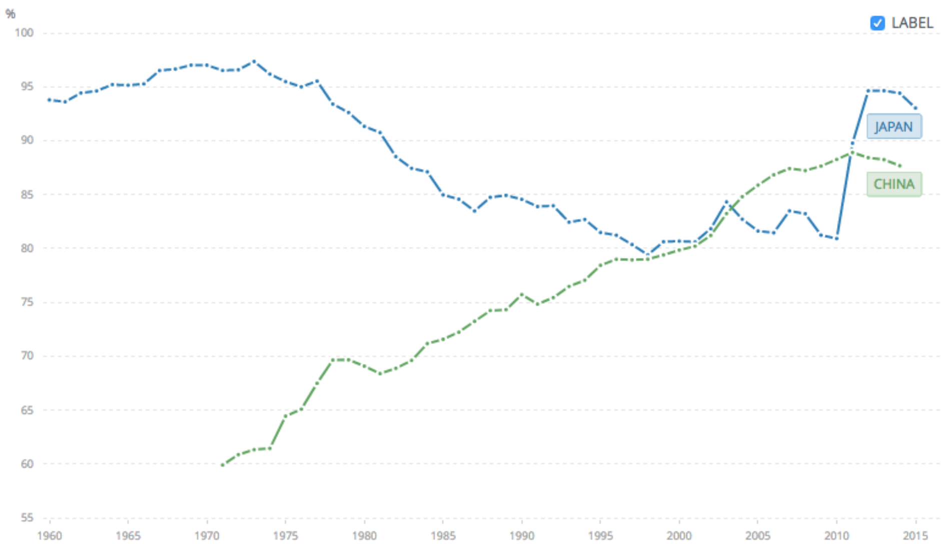
5.3. Related and Supporting Industries

Overall Industrial Production Growth Rate, Suppliers

In terms of automotive suppliers, China embodies a global player. Estimates say that there might be over 100,000 automotive supplier firms in China, out of which just half are officially covered by data reports. The vast size and regional differences are a very unique factor that characterize the Chinese automotive sector in many aspects. As for the supply-chain, the regionalism is very important, indicating rather strong ties between regional players. In Japan, the share of industry in relation to the whole GDP has been continuously dropping from the mid-1990s onwards. Experiencing the bubble-economy and its burst in the late 1990s, the country has seen a very strong trend towards consumer goods and services, decreasing the GDP-share for its industrial sector. Differing from China, in Japan regionalism doe not really play an essential role. The keiretsu system predetermines where the suppliers working with the respective OEMs should locate, as OEMs want their suppliers to be close by. This system did not allow as much for regional differences, as the main economic relevant regions have developed alongside the keiretsu-system.

Oil imports and exports

In terms of fossil fuel consumption, the developmental difference between China and Japan regarding their current state could not be more obvious. The graph below indicates both countries' respective fossil fuel energy consumption in %.



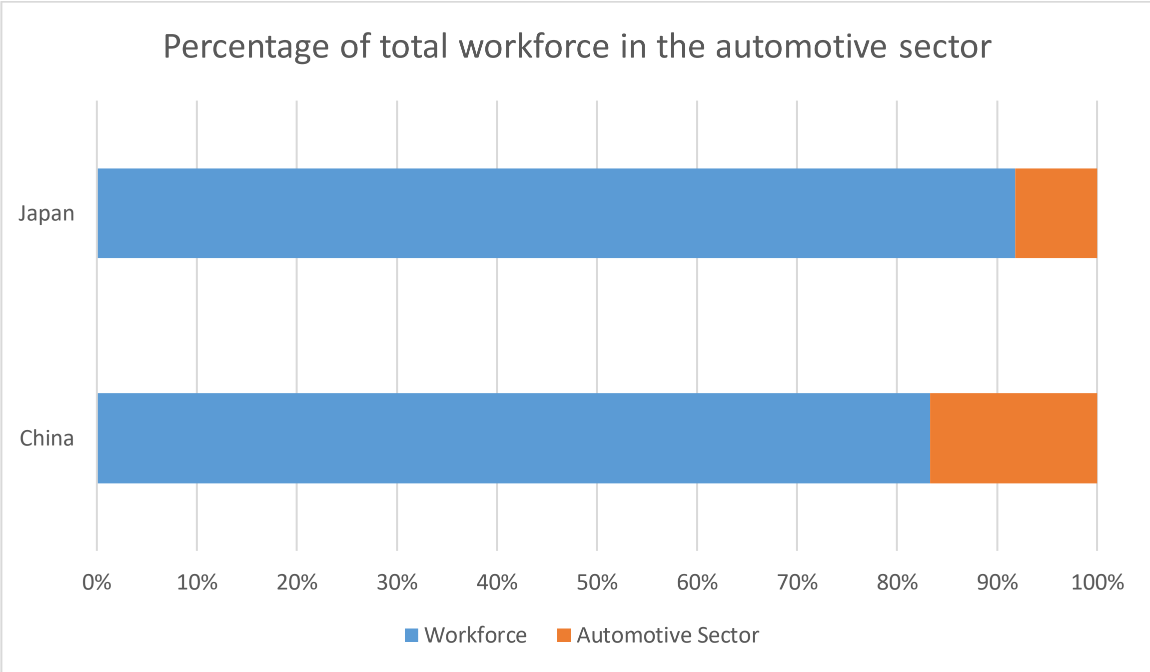
Source: World Bank, 2020

Graph XIX. *Fossil fuel energy consumption (% of total) - Japan, China*

It shows that China has been continuously rising from the countries' economical reforms in the first half of the 1970s from over 60% to recent numbers between 85 to 90% (Worldbank, 2020). Given these numbers, the further development of EVs is an essential counter-measure, as the Chinese government realizes its stated goals of reducing hydrocarbon intensity, fighting air pollution, and improving the quality of the environment. This might be the most important reason for the government deciding that the EV-shift, including the actual development of the technology, the production of EVs, as well as the further development of more competitive battery-systems are strategic industries with great potential to impact not just the domestic situation, but also gaining global significance. Furthermore, the Chinese economy has recently entered a new phase of slower growth, facing new challenges. "The government can no longer rely upon breakneck economic growth as the source of its political legitimacy and authority. Instead, the way for the Party to continue to demonstrate its strong leadership is to solve the serious environmental problems facing China through revolutionizing China's energy consumption structure" (Liu, 2018). Japan on the other hand has been facing even higher numbers of fossil fuel consumption in it economic peak throughout the 1960s and early 1970s, reaching numbers over 95% (Worldbank, 2020). As the nation soon started to foster nuclear energy for energy generation, the numbers went down significantly, coming close to 80% in 2010. The year after, when the Fukushima-Daiichi nuclear power-plant accident happened, the numbers went up rapidly, as Japan had to temporarily shut down all reactors, making the country once more dependent on fossil fuels. In 2012 and 2013, the numbers went up to 95%, close to the all-time high from the 1960s. Given these numbers, one might assume that the EV-shift is far more evolved in Japan, as it actually is. Japanese OEMs seem to collectively agree on the importance of its domestically developed HEV technology, but beyond this are apparently focusing on different economic goals, thus leading to diverging technological approaches.

Employment numbers in automotive industry

As of 2019, the total share of people working in or related to the automotive industry in China was slightly over 1/6 of the total Chinese workforce. In total numbers this translates to approximately 130 Mio people, thus higher than Japan's total population. Graph XX below shows the respective automotive share of China's and Japan's workforce. Interestingly, China's share is double the Japanese share.



Source: MOFCOM, 2019; WKO AC Shanghai, 2020; JAMA, 2019)

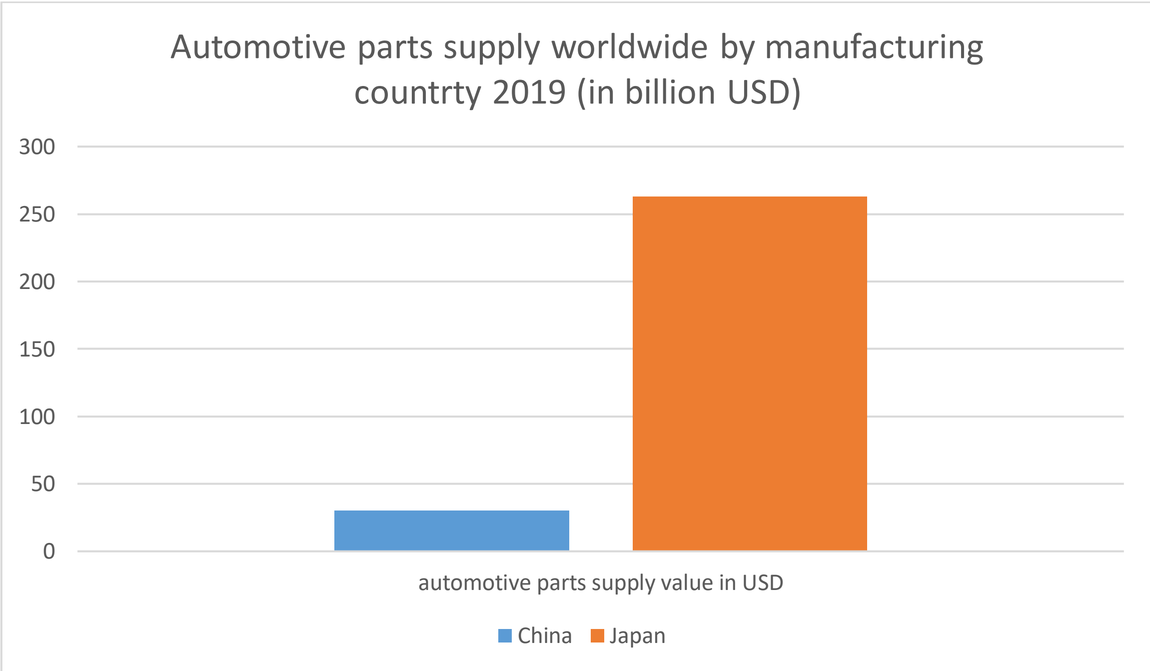
Graph XX. *Share of employees in automotive industry (in percentage)*

Both countries are automotive superpowers, generating a significant share of the GDP through this sector. This shows that both countries are very depending on their automotive sector, China even more so than Japan, as Japan has outsourced a lot of its domestic OEMs export production to overseas markets. In this regard, Japan might be a few developmental steps ahead of China, which will at some point face similar issues.

Import and Export value of EV components

Among global automotive parts supplier, China and Japan face very different realities. Following their OEMs business strategies, domestic supplier are very much focusing on the domestic market. Regionalism in China contributes further to a very diverging landscape, making it rather difficult for one big supplier cover the whole county. Instead, Chinese supplier are very large in numbers but rather cover limited areas. In total, estimates assume that there are more than 100,000 automotive supplier firms in China. Unfortunately, Chinese export statistics do not categorize auto-parts based on propulsion, which makes it rather difficult to evaluate the share of exported EV-related auto-parts.

Japan on the other hand has developed a rather different model at a very early stage in its developmental process, namely the keiretsu system, triggering both the OEM and their subordinate suppliers to settle in the same region, forming long lasting partnerships. Thus, the situation of Japanese automotive suppliers differs greatly from the Chinese reality. Japanese automotive OEMs are amongst the most successful in the world, supplier firms that have always been developing alongside the big OEMs are too. EV components are thus intertwined with EV activities conducted by the major Japanese OEMs. The graph below shows the total value of both countries automotive parts supplier amongst the global top 100.



Source: AutoNews,, 2019.

Graph XXI. *Automotive parts supply worldwide by manufacturing countrty 2019 (in billion USD)*

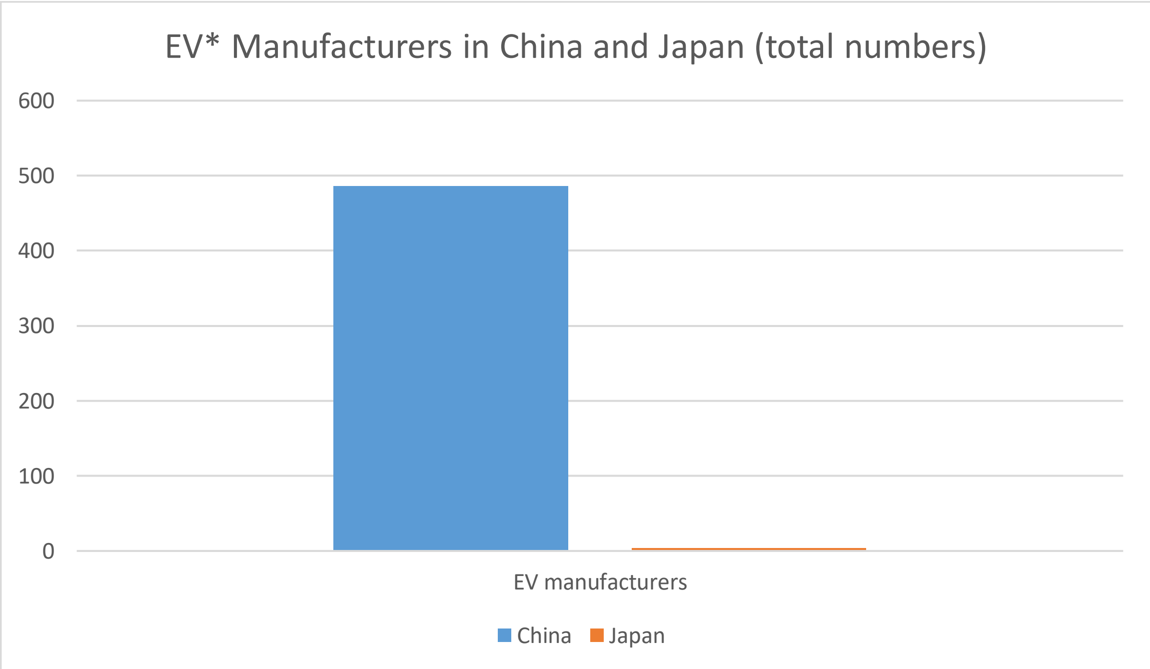
China's 7 top suppliers generated a bit less than USD 30 billion value, whereas Japan's top 23 suppliers among the global top 100 generate almost ten times that amount. In terms of imports, China remains very restricted, not allowing for high import value. Japan on the other hand appeared to be a tough market for foreign suppliers throughout the last few decades, but is more and more opening up.

Especially in terms of EVs, battery supply becomes crucial and shows that China is making a lot of effort to catch up, already now embodying the most important market for lithium-ion batteries. China already holds 7 of the worlds 13 biggest battery-makers, showing remarkable growth. Japan is trying to focus on its domestic partnerships, investing heavily in R&D in order to promote its image as knowhow superpower.

5.4. Business Context

Variety of domestic EV producers

Regionalism continues to be a very characteristic attribute of China's automotive landscape. The country holds 486 EV manufacturers. Many of them are part of bigger conglomerates or JVs. The analysis of the biggest automotive groups showed that all of them offer EVs, mostly BEVs, more than half of them offer PHEVs, only HEVs appear not be a major area of interest, as the Chinese definition of NEV does not include them, thus they are not covered by the government's incentives. In Japan on the other hand, surprisingly BEVs are not the main focus in terms of EVs. Only three of the major 7 domestic OEMs offer BEV models, and five offer PHEVs. As HEVs still have a large market share of almost 40% in Japan, all OEMs offer HEV models, most of them 50% of their model lineup with HEV solutions, some of them even 2/3, including a variety of HEV-only models, such as the Toyota Prius series.



*BEV and PHEV manufacturers, not including HEV

Graph XXII. *EV manufacturers in China and Japan (total numbers)*

Gfaph XXII above shows the variety of domestic EV manufacturers in both countries. China has 486 EV-manufacturers in total, including various regional brands. Japan on the other hand has 4 producers among their major OEMs, namely Toyota, Honda, Nissan and Mitsubishi.

Governmental policies

Both countries' governments have been setting their respective goals for the ongoing EV-shift, and are approaching it according to it, supported by various governmental support programs that help to achieve these goals. China is heavily relying on its influential governmental position that enables it to define goals and allocate resources according to it. Remarkably, the domestic EV sales did not rise all of a sudden out of nowhere as oftentimes expected, but gradually followed governmental set incentives. In 2009, the government firstly introduced its goal to tackle NEV development and sales in China, and set the first measures in form of financial support for research. Still, it took the country five years to reach a decent level of sales numbers. It was not until 2015 that the governmentally introduced measures became effective and sales numbers rose significantly, increasing sales by 3-digit percentages until recently. The ongoing governmental incentives have all been eliminated so far, as the market is considered to be stable, but future support is always an immanent option for the Chinese government, in order to to facilitate future growth. In Japan on the other hand, governmental incentives have been rather limited to infrastructural projects, and occasional financial support for NEVs. The Japanese automotive market is a very strong and sophisticated on, heavily relying on already existing expertise of domestic manufacturers. As the customers interest has been shifted towards HEVs already without any special policy initiated by the government, governmental policies have been exclusively focusing on BEV-based incentives, first and foremost to provide the needed infrastructure for further development. Besides funding R&D and expanding the charging infrastructure, another key measure to increase the adoption rate of EVs is the cutting of high purchasing and maintenance costs. Therefore, both governments have provided financial incentives such as purchase grants, tax cuts and exemptions from registration and license fees. In China, for instance, buyers of electric cars were released from the obligation to pay vehicle purchase tax and the vehicle and vessel tax. At the same time, tax rates on traditional passenger cars were raised to make the purchase of conventional cars unappealing. The Japanese government, on the other hand, did not increase taxes on solely combustion engine powered cars. However, it created incentives by reducing or eliminating the vehicle purchase tax, the motor vehicle tax, the tonnage tax, and the light-vehicle tax. Considering the heavy tax burden for Japanese car owners, a very attractive measure and an effective incentive.

Specialization

The Japanese automotive industry and all the technological trends have previously been described as example of the so called herd-effect. As Japanese OEMs hold close relations to each other, as well as to their subordinate suppliers, the whole industry is very intertwined. Figuratively, there is barely any OEM or supplier that does not have any partnership with Toyota, Nissan or Honda. The three major OEMs contributed to the early shift towards HEV technology in the late 1990s, which was started by Toyota's first Prius model in 1997, and then later followed by Honda. As far as BEVs go, Nissan was the first OEM to make a move towards mass production, thus commercialization of the already previously existing technology in 2009. In China, specialization used to be primarily focused on affordability of the cars. The consumers demanded cars that are cheap and easy to run. Chinese manufacturers therefore made use of their JVs, acquiring technology from experienced foreign OEMs, even though the international partners would usually not give them access to the latest model platforms, but rather predecessor models which are not produced anymore in western countries or Japan. Recently, China has seen a huge shift towards costumer needs. The domestic market has become far more divergent and partly as demanding as other more sophisticated domestic markets. Chinese OEMs have previously been very much focused on having low prices by using cheap domestic labor cost. As for now, the EV/shift has influenced the status-quo, as China is currently trying to generate its own expertise and knowhow, focusing on EV-technology. Design, technology and image are becoming increasingly important for Chinese customers as well, so that the current model lineup of Chinese OEMs appear to be far more diverse than it used to be a few years ago.

6. Discussion

6.1. Similarities and differences between China and Japan

The analysis has shown that even though both countries have announced ambitions to strengthen its position within the ongoing global EV-shift, the taken approaches are differing very much. Both countries find themselves in completely different stages of economic development, leading to strongly differing automotive industries as well. Japan has been a major automotive manufacturing nation since the 1960s, even reached higher production volumes than the USA in the 1970s and 1980s, and nevertheless can be regarded as a technological hub for automotive manufacturing. Production volumes are high, exports shares are as well, symbolizing international recognition as sophisticated manufacturing country. China on the other hand has started quite late with automotive manufacturing. The country opened op its economy in the early 1970s, which was the actual start of broader automotive manufacturing. The weakest point in international comparison has been the technological disadvantage, due to the absence of experience, knowhow and research and development on the

Chinese side. The government was aware of this strategic disadvantage and allowed for joint ventures with more experienced OEMs, mainly from Europe and Japan in order to close this gap. Throughout the 1980s and 1990s, China and Japan emerged into diverging directions, as China needed to establish its automotive infrastructure, supply-chain management and foster domestic demand. Japan already had these steps done several decades before, therefore could heavily focus on export. Japan even partly surpassed the USA in terms of economic power, embodying the world’s powerful economy in that period. As China continued its promising policy of promoting inbound foreign direct investment towards their thriving domestic OEMs, production capabilities rose significantly in the early 2000s. Japan had by the time already entered its phase of stagnation and partial recession. High labor costs, a shrinking society and partial recession made Japanese OEMs furthermore relocate production to overseas markets, primarily Europe, North America, the Middle East and South-East Asia, showing the country’s enormous dependency on export. The 2010s were primarily characterized by China eventually becoming the world’s biggest automotive manufacturing country, as well as the biggest domestic market for cars. Japan’s domestic market is still stagnating, its exports are stable, partly growing, thanks to their strategic partnerships in economically growing regions such as ASEAN or the middle East.

The below table summarizes the findings of this thesis once again by attaching one of five attributes to the respective category, → for stagnation, moderate standard, ↗ for growth or relatively high standard, ↘ for decline or relatively low standard, ↑ for rapid growth or extraordinarity high standard, and ↓ for rapid decline, or extraordinarily low standard.

		China		Japan	
		Automotive Sector	EV	Automotive Sector	EV
Factor Conditions	Production capabilities	↑	↑	↑	→
	R&D	→	↑	↑	↗
	Infrastructure	↘	↗	↑	↑
	FDI Outbound	↘		↗	
	FDI Inbound	↑		↗	
	Alliances	↑		↑	
Demand Conditions	Domestic sales	↑	↑	↗	→
	Societal adaption, and Costumer sophistication	↑	↑	↑	↘
	exports	↓	↓	↑	→
Related and Supporting Industries	Suppliers	↑	↗	↑	→
	Power generation	↑		↑	
	Employment	↑		↗	
	Oil imports	↑		↑	
	Oil exports	↓		↓	
	Import automobile components	↘	↘	→	↗
	Export value of automobile components	↘	↘	↑	↑
Business Context	Variety of domestic producers	↑	↑	↗	↘
	Governmental policies	↑	↑	↗	→
	Specialization	↗		↑	

Table X. *Results on Similarities and Differences between China and Japan*

6.2. Differing capabilities in terms of EV competitiveness

The different developmental stages of both countries' automotive sectors trigger huge differences between the two countries. China has for a long time fulfilled the cliché of a low-technology mass-manufacturer, showing very strong tendencies of change. The EV-shift has shown its potential for China already. The government is investing heavily in the further development of EV capabilities, lithium-ion battery manufacturing, infrastructure, and incentives for consumers. Japan has for a long time been surprisingly quiet in this regard, as the domestic manufacturers have been heavily relying on its HEV technology that has been seen as a bridge between keeping the system of combustion engines and combining it with partial electrification. A very famous business concept, by Toyota is kaizen (改善), meaning to continuously improve the current situation and processes by setting minor changes, such as further improve efficiency or replacing minor parts for smoother processes, etc. The current situation on the Japanese market perfectly fits this concept, as the herd-effect has not yet led to a collective approach towards BEVs, compared to the situation where this had happened towards HEVs.

7. Conclusion

The analysis has shown that although China and Japan are two very opposing countries in many ways, analysis in terms of EV-shift within their automotive industries is possible. The analysis that has been conducted by applying and further modifying Porter's diamond model has shown both countries' differences and similarities towards the approach of the ongoing global EV-shift. China has been severely tackling the ongoing EV-shift, the powerful government taking on active initiatives. The country's high oil dependency, weak automobile exports, technological improvement through thriving joint/venture activities lead into a positive direction. So far, the Japanese government has not to the same extent promoted the EV-shift towards BEVs. The county's numbers of oil imports remain very high, especially in a post-Fukushima-period. Japanese OEMs follow their own strategic agendas, thus make it difficult for the government to interfere. In terms of infrastructure, the Japanese government has shown enormous commitment, showing that there is much more potential for further BEV use. A very severe problem, faced during the stage of analysis for this thesis is data availability. As for Japan, mostly every aspect included in his analysis has been covered by officially available statistics. The only downside is that Japanese statistics tend to be updated quite late, so that for this analysis 2019 data was not always available yet. As for China, official statistics are very difficult to get access to, especially without profound knowledge of the Chinese language. Another issue is reliability. In some cases, statistics would differ immensely depending on the source, making it almost impossible to get reliable information. Especially in terms of EVs, China has apparently great interest in promoting and advertising its figures, so that accessibility was not major issue, but the differing numbers were. As the EV-shift is continuously expanding, statistical figures are constantly changing, creating the need for follow-up research in this field. Especially as Japanese OEMs are showing more initiative to tackle to approach BEV technology more intensively, a future comparison with China, or South Korea would be needed to evaluate the current situation even further. Another potential field of interest is FCEVs, as Japanese OEMs, first and foremost Toyota and Honda, but also Chinese conglomerates showing great interest in.

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Appendix

Abstract (English Version)

With China and Japan, two major economies have announced ambitious goals to become leading players in the emerging car- and batteries markets. Both countries have shown tendencies to adapt to the ongoing shift in terms of mainstream mobility, but appear to follow different incentives that are leading them to diverging approaches. This thesis aims to discover differences and similarities in terms of electric mobility development within both countries' automotive sectors in order to evaluate their respective competitive capabilities concerning the ongoing global EV shift. An essential research objective of this thesis is to challenge the common assumptions of Japan being the technological leader, heavily investing in R&D, whereas China simply being the mass-producer of relatively uncompetitive EVs for domestic use. The thesis clarifies what the respective stages of the Chinese and Japanese e-mobility development are, and how these presumably greatly differing positions contribute to the respective state of the domestic automotive sector. Both Asian countries stand for automotive superpowers, as they embody the top of global automotive production. Given their role as global players, it is crucial to understand China's and Japan's differing status and intentions in terms of EV development. Hence, this comparison aims at clarifying China's and Japan's differing approaches towards EVs in order to understand how and to which extent both countries are contributing to the ongoing global EV shift. The basis for analysis is determined by Porter's "the Diamond Model" which enables to explain country-, or more specifically, industry-competitiveness. In this model Porter defines four determinants of industry competitiveness: (1) Factor conditions such as the nation's or industry's position in factors of production, such as skilled labor and infrastructure, (2) demand conditions such as sophistication of customers in the home country or market, (3) related and supporting industries, and (4) business context such as conditions for organization of companies and the nature of their domestic rivalry (Porter, 1990). The methodology of the thesis is characterized by an eclectic approach that builds upon Porter's four pillars and extends them by adding sector-specific factors in order to evaluate the developmental state of both countries' automotive industries in terms of electrification. The results show that despite its developmental and technological deficits, China has so far approached the EV-shift more sustainably.

Abstract (German Version)

Mit China und Japan haben die beiden größten Volkswirtschaften Asiens ehrgeizige Ziele angekündigt, um Führungspositionen im Bereich der Elektromobilität zu erreichen. Beide Länder zeigen Tendenzen, sich an die Elektrifizierung der Mobilität anzupassen, scheinen jedoch unterschiedliche Ziele zu verfolgen, die sie zu unterschiedlichen Ansätzen führen. Diese Arbeit zielt darauf ab, Unterschiede und Ähnlichkeiten in Bezug auf die Entwicklung der Elektromobilität in den Automobilsektoren beider Länder herauszuarbeiten, um ihre jeweiligen Wettbewerbsfähigkeiten in Bezug auf die anhaltende globale EV-Verlagerung zu bewerten. Ein wesentliches Forschungsziel dieser Arbeit ist es, gängige Stereotypen dieser Branche Frage zu stellen: (1) Japan sei der Technologieführer ist und stark in Forschung und Entwicklung investiert, während (2) China lediglich der Massenproduzent von international nicht wettbewerbsfähigen Elektrofahrzeugen für den chinesischen Markt sei. Die Arbeit erarbeitet die jeweiligen Stadien der chinesischen und japanischen Entwicklung der Elektromobilität und wie diese unterschiedlichen Realitäten zum jeweiligen Stand des heimischen Automobilsektors beitragen. Angesichts ihrer Rolle als Global Player ist es wichtig, den unterschiedlichen Status und die unterschiedlichen Absichten Chinas und Japans in Bezug auf die Entwicklung von Elektrofahrzeugen zu verstehen. Daher zielt dieser Vergleich darauf ab, die unterschiedlichen Ansätze Chinas und Japans in Bezug auf Elektrofahrzeuge zu klären, um zu verstehen, wie und in welchem Umfang beide Länder zur anhaltenden globalen Mobilitätselektrifizierung beitragen. Die Basis der Analyse wird durch Porters „Diamond Model“ bestimmt, da dieses ermöglicht, die Wettbewerbsfähigkeit einer Volkswirtschaft oder einer bestimmten Branche zu analysieren. In diesem Modell definiert Porter vier Determinanten der Wettbewerbsfähigkeit der Industrie: (1) Faktorenbedingungen wie die Position des Landes oder der Industrie in Bezug auf Produktionsfaktoren wie Fachkräfte und Infrastruktur, (2) Nachfragebedingungen im Heimatmarkt, (3) verknüpfte und unterstützende Branchen und (4) Geschäftskontext wie die Bedingungen für die Organisation von Unternehmen und Inlandskonkurrenz (Porter, 1990). Die Methodik der der Arbeit baut primär der auf den vier Säulen von Porter auf und erweitert diese durch branchenspezifische Faktoren, um den Entwicklungsstand der Automobilindustrie beider Länder im Hinblick auf die Elektrifizierung zu bewerten. Die Ergebnisse zeigen, dass China trotz seiner Entwicklungs- und Technologiedefizite die die automobile Elektrifizierung bisher nachhaltiger angegangen ist.