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The Chinese automotive industry at a turning point. An Overview

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The Chinese automotive industry at a turning point. An Overview [§]

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ABSTRACT

China is by far the largest car manufacturing country and the world's biggest auto market. Despite this, Chinese brands and companies are almost unknown in Europe and other advanced markets. The international car oligopoly is still dominated by a group of legacy companies and brands.

The recent development of the electric car and the growing emphasis on sustainable mobility represent a great opportunity for China. Backed by the government, Chinese companies can exploit the new technology and follow a leapfrogging strategy by investing in research and development, developing new products, and proposing new business models in order to enter international markets with their own brands.

Will the Chinese auto industry be able to achieve this? Will it be able to compete on a level playing field with the powerful foreign multinationals in the global markets? This work tries to offer an answer to these questions by reviewing the Chinese car industry, the main characteristics of its development and its future prospects in the context of the great changes promised by sustainable mobility.

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* Information and data have been updated in October 2022.

1. Introduction

In August 1958, the luxury sedan Hongqi CA72, the first passenger car produced domestically in China after the foundation of People's Republic of China in 1949, left the assembly line of the First Automotive Works (FAW) (Harwit 1992). The foundation stone of the factory had been autographed by Mao Zedong three years earlier, in 1953[1]. The factory had been completed in 1956 under the assistance and technical support of Soviet advisors. Most of the technology and machinery came from the Soviet Union. The design of the Hongqi was based on a 1955 Chrysler.

At that time, no one thought that cars could become a consumer good for the Chinese people, as was the case in the US and Europe. Vehicle factories were designed to produce trucks and heavy vehicles to support economic development or for use in the army. Automobiles were considered a "bourgeois" luxury item, and the few models that were produced, like the open-top limousine version of the Hongqi CA72, were used by party leaders and government officials during parades. Until 1984, private individuals were not even allowed to own vehicles (Chu 2011).

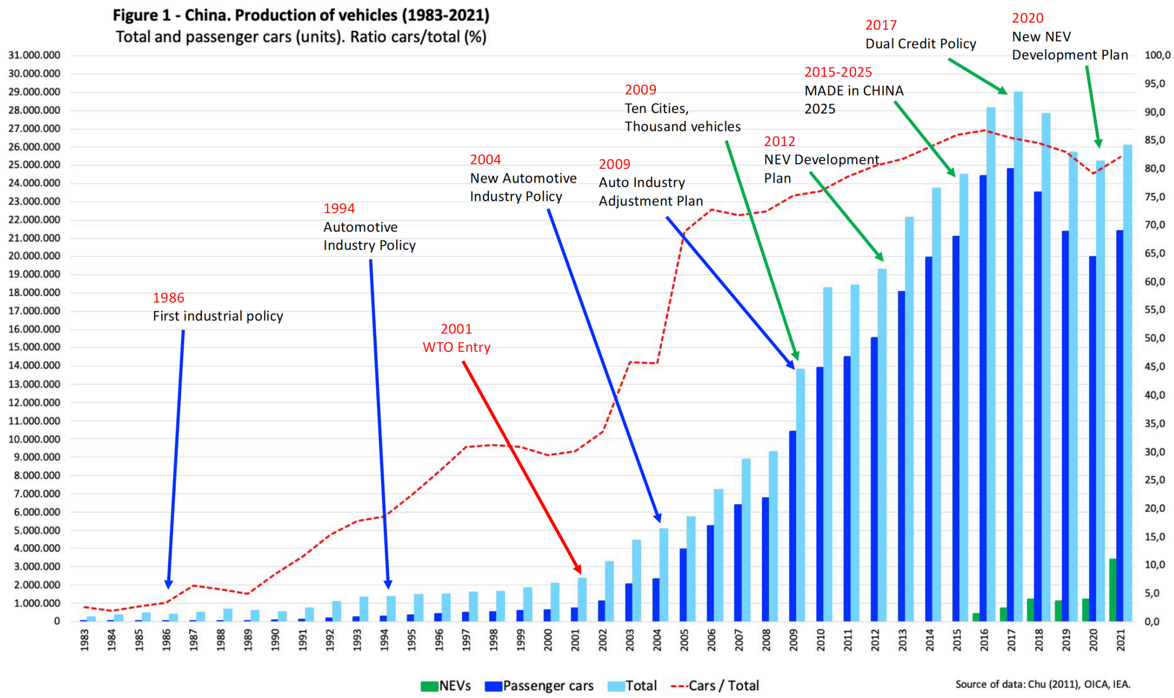
In 2021, after 63 years from the first Hongqi, FAW, in joint venture with Silk, an international automotive engineering and design company, announced an investment of one billion euros for the construction of a new manufacturing plant in the Motor Valley of the Emilia Romagna region in Italy for the production of the ultra-luxury, high-performance, new energy, fully electric sport vehicle Hongqi S9[2]. The goal is to challenge the best luxury sports car brands such as Ferrari, Lamborghini, Pagani and Maserati. Hongqi means "red flag". With this ambitious move, the first auto manufacturer of modern China wants to plant the red flag in the top segment of the world market.

Is this a sign that the technological dependence of the Chinese automobile industry is about to wane? Is this going to happen in the near future? Will Chinese car makers compete on a level playing field with the powerful foreign multinationals in the global markets? Can the development of the electric car in the upcoming era of sustainable mobility trigger this process? This paper tries to offer an answer to these questions by reviewing the Chinese car industry, its development and its future prospects in the context of the great changes promised by sustainable mobility.

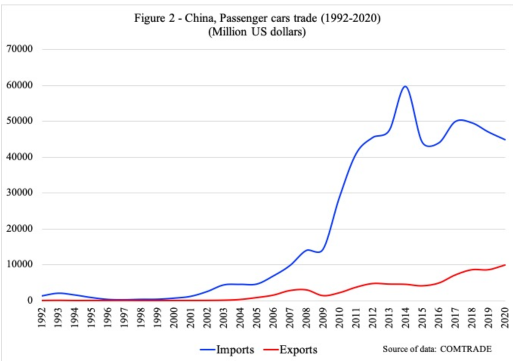
2. Industry shaped by the State and the joint ventures

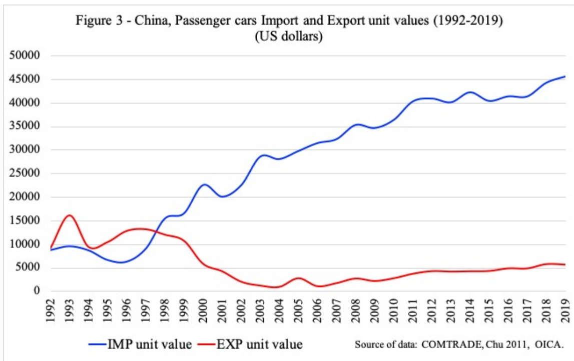
Figure 1 illustrates the trend of vehicle production in China over the past 38 years. From a few hundred thousand units at the beginning of the eighties, mostly heavy vehicles, to over 26 million vehicles produced in recent years, 82% of which are passenger cars. An impressive growth, and a great success for China.

[1] FAW web page. http://www.faw.com/fawen/gyjt36/fzlc/index.html
[2] FAW web page. https://www.silkfaw.com/app/uploads/2021/12/20200202_Silk-FAW_Joint-Venture.pdf



The development of the Chinese sector has occurred almost in isolation from global markets. As Figure 2 shows, for a long time trade with foreign countries was negligible. Only in the last decade there has been a substantial increase in the value of imports and a moderate growth of exports. In quantity terms, however, exports accounted on average for less than 1% of domestic car production in the 1990s and less than 6% during the last decade. Imports, on the other hand, were on average one quarter of the estimated domestic market in the 1990s and less than 6.5% in the last decade. The increase in the value of imports is basically due to the increase of unit values of imported passenger cars (Figure 3).





The state played a vital role in the formation and development of the industry. This took place, firstly, through the ownership of the main companies (SOE, State-owned enterprises), and secondly, through a long series of industrial policies and policy measures at central and provincial level, in relation to the different development phases of the country and its economic policy (Thun 2004, Holweg et al 2009, Chu 2011).

Two main phases characterized the history of state intervention in the automotive industry. The first lasted from the mid-1980s to the end of the first decade of the 2000s and is mainly based on the promotion of joint ventures between Chinese companies and foreign

OEMs (Original Equipment Manufacturers). The start of the second phase can conventionally be placed with the rollout of the 2009 car industry adjustment plan. The turning point was the development of electric cars and the promotion of sustainable mobility. As we will see, the consequences of this policy change on the structure of the industry and the prospects of Chinese companies have been significant.

The first phase

Industrial policy, as a tool to promote and strengthen the country's industrialization process, is mentioned for the first time in an official document in the Seventh Five-Year Plan 1986-90 (Jigang 2020). In 1988, an Industrial Policy Division was created in the State Planning Commission (Heilmann and Shih 2013).

At that time, the automotive industry was characterized by fragmentation and deep technological backwardness. According to some estimates, before the reform and opening up policies, the technological level of the Chinese car manufacturers was about 30/40 times lower than in advanced countries (CATARC report 2001, cited in Chin 2010). Labour productivity was particularly low compared to international standards. In 1981, 0.19 vehicles per worker were produced (0.3 in 1990), compared to 16 vehicles per worker in Japan (Zhang 2015, Gao 2002). The car market was underdeveloped, especially private demand, and heavily protected from imports and competition. In the eighties, car import tariffs were around 200%, reduced to 80-100% in the following decade (Gao 2002).

For a quarter of the last century, the main tool used by the government to build a competitive industry, promote demand growth and reduce the technological gap with foreign producers, was the **promotion of joint ventures** between a selected number of Chinese state-owned groups (SOEs) and foreign multinationals (FOEMs). Especially in the first decade, the government played a central role in the promotion and negotiation of the agreements. Citing Evans' study of Brazil (Evans 1979), Thun interpreted this policy as a “new form of a triple alliance between central government, foreign firms, and their local partners” (Thun 2004, p.455).

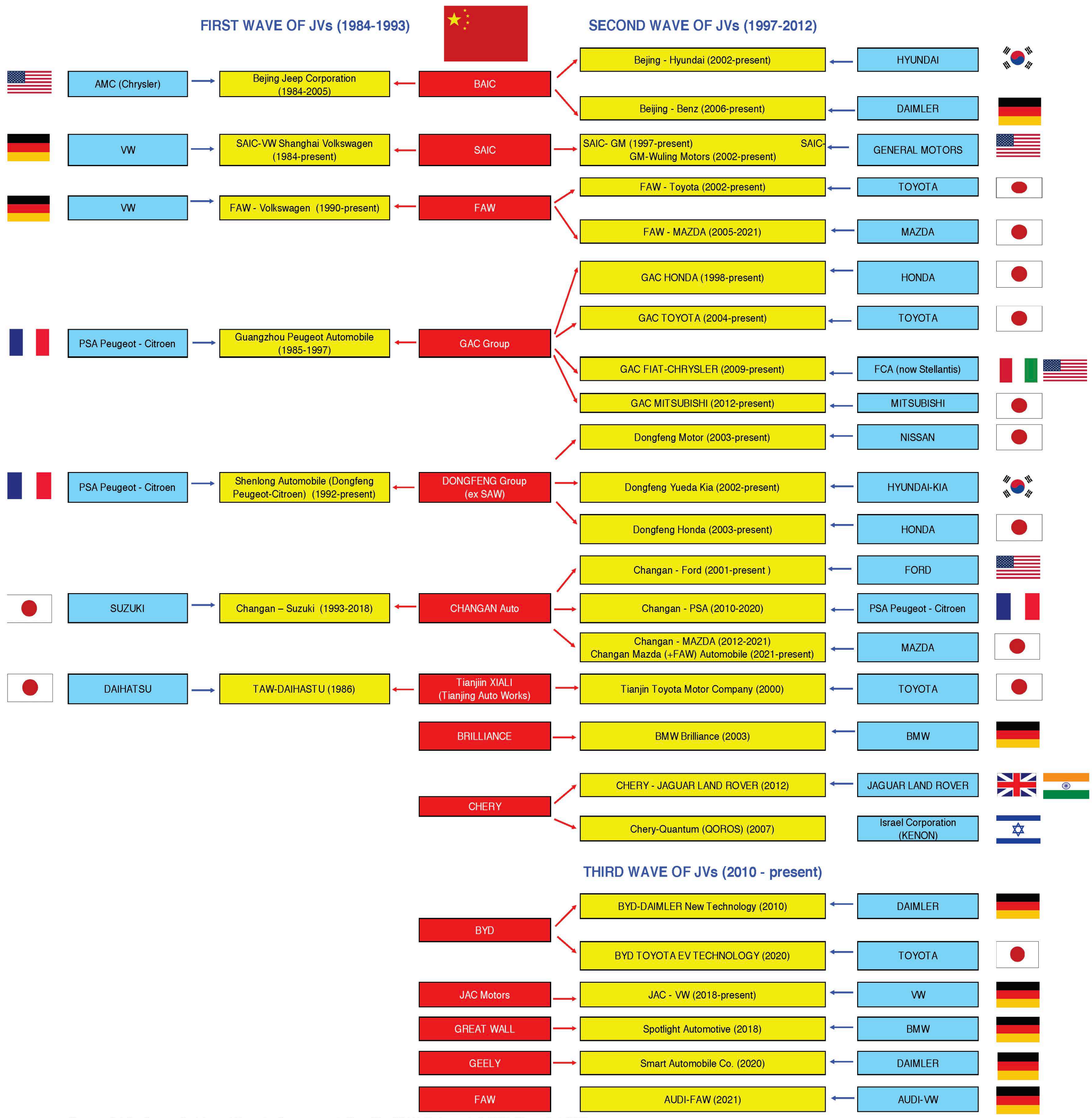
The purpose of joint ventures was to prevent foreign companies from dominating the development of the domestic auto market, to the detriment of the fragile and fragmented Chinese producers. A simple import substitution policy, based on trade restrictions and greenfield investment by large car multinationals -a policy followed by Brazil or Argentina in the past- would have developed the domestic industry but at the price of technological dependence (Chu 2011).

On the contrary, China chose to adopt its own industrialization path through a *JV-based import substitution policy* (Chu 2011). The basic idea was to trade *market access and market protection in exchange for technology transfer* (Thun 2004). Foreign companies were welcomed into the domestic market, protected from imports and the entry of other competitors, but at the same time they were expected to transfer technology to Chinese firms. The hope was that, through the JVs partnership, Chinese companies would accumulate the experience, knowledge and skills necessary to build over time an independent and competitive industry, with innovation capabilities and own brands.

The **first wave** of joint ventures occurred in the decade 1984-1993 (Figure 4). The Chinese companies involved were the so-called "Big three" (FAW, SAW-Dongfeng, SAIC), "Small three" (BAW-BAIC, Guangzhou-GAC, Tianjing Automotive Industry TAIC), and "Mini Two" (Changan, Guizhou Aviation Industry), all owned by the State through the SASAC

(State-owned Assets Supervision and Administration Commission) at central and provincial level (Lee et al 2002, Lo and Wu 2014, Warburton et al 2013, Holweg et al. 2009). The first agreement was between BAW-BAIC and the American Motor Corporation-Chrysler in 1984. Then followed the joint ventures of SAIC and FAW with VW, GAC and Dongfeng with the French group PSA-Peugeot-Citroen, Changan with the Japanese Suzuki, and the license agreements between Daihatsu and TAW and Subaru-Fuji Heavy Industries with GAIC.

Figure 4 - CHINA - MAIN JOINT VENTURES IN THE PASSENGER CAR INDUSTRY (1984-2021)



Source of data: Companies' Annual Reports, Company websites, Chu (2011), Holweg et al. 2005, Chen et al. 2020.

However, at the end of this period, the outcome was not what the government expected (Chu 2011). Protected from competition, foreign partners had no incentives to improve efficiency, transfer advanced technology, and innovate models (Wang 2003). Products were obsolete, production plants inefficient, and prices high (demand came essentially from the State apparatus). This guaranteed substantial profits to foreign multinationals (Gao 2002) but did not give Chinese groups the hoped-for benefits in terms of efficiency and technology transfer. For example, in the second half of the 1990s, the estimate of minimum efficient scale (MES) for car assembly plants was 200,000 units. In 1996, 391,000 passenger cars (PVs) were produced in China by 13 factories. SAIC-VW alone produced 200,000 units, Tianjin Xiali – Daihatsu less than 100,000, and all the others less than 50,000 (Francois and Spinanger 2004).

The government reacted with the first specific policy for the automotive industry, "a pillar industry of the national economy", which was adopted in **1994** (*Formal Policy for the Development of the Automobile Industry*, MOFCOM 1994). The aim was to substantially strengthen the efficiency and technological level of the industry.

The plan aimed at the formation, by the turn of the century, of 2-3 large and efficient producers and, by 2010, of 3-4 globally competitive domestic companies, with their own production and marketing strategies. At that time, passenger cars accounted for about 20% of vehicle production (Figure 1), and the goal was to reach more than 50% by 2000 driven by the expected growth of private demand.

In order to consolidate the industry through the closure of inefficient small-scale plants and the improvement of product quality, the government encouraged the formation of additional JVs with foreign companies, this time subject to more stringent constraints (MOFCOM 1994, Lee et al. 2002). First, foreign multinationals were asked to develop updated models consistent with the technology of the nineties and to set up local R&D centers to stimulate innovation activity. Based on the assimilation of foreign technology, the state supported the R&D activities carried out by Chinese companies. Second, the plan required that the Chinese stake in the JVs could not be less than 50% and foreign companies could not set up more than two JVs to produce similar models of cars (*50% + 2 rule*). Chinese groups were allowed the possibility of signing agreements with more foreign automakers, despite these companies being competitors. There were several reasons behind this choice. First, multiple deals avoid dependence on a single foreign group. Second, the potential competition between the partners can play in favor of the Chinese company, increasing its bargaining power. Third, multiple partnerships give access to different technologies, enriching the learning process of the Chinese company. Lastly, more JVs mean a more differentiated product range in the domestic market.

This plan promoted a **second wave** of JVs, from the end of the 1990s to the first decade of the new millennium (Figure 4). New international partners were involved, previously excluded from the agreements. Between 1994 and 2005 alone, foreign OEMs invested about twenty billion dollars in joint ventures (Chin 2010). The international partners involved were the large global players previously excluded from the agreements. These were the main Japanese companies (Toyota, Honda, Nissan, Mitsubishi and Mazda), the German Daimler-Benz and BMW, the American General Motors and Ford, the Korean group Hyundai-KIA, which was beginning its rise in international markets, and lastly Fiat-Chrysler and the Indo-British Jaguar-Land Rover. On the Chinese side, the second wave involved the same large State-owned enterprises of the first wave, joined by the two previously independent companies Brilliance and, at the end of the period, Chery.

At the end of the 1990s, passenger cars represented 30% of the total vehicles produced, a marked increase compared to fifteen years earlier, but still below what the government hoped for in 1994 (50%). With few exceptions, the industry was still inefficient, and only three joint ventures had assembly plants producing more than 100,000 cars: SAIC-VW, SAIC-GM, and FAW-VW (Francois and Spinanger 2004). According to some estimates, models produced in China were 150% more expensive than equivalent ones in Europe or the USA. Profitability levels of JVs were still much higher than elsewhere, due two high prices and lack of competition (Gao 2002, Zhang 2015).

The situation changed radically when China joined the WTO in 2001. Import tariffs were progressively reduced from 100% to 25% (Chen et al 2020), projecting Chinese economy and manufacturing into the global market. This meant the threat of increasing import volumes that would put Chinese companies and technologically backward joint ventures at risk. The opening up of the Chinese market to international trade demanded a strong and competitive automotive industry. The structural adjustment and upgrading of the industry became a priority.

Increasingly aware of the shortcomings of joint ventures, which dominated the domestic market and stifled the emergence of a strong indigenous industry by limiting the capacity for an autonomous technological development, the government changed course in **2004** with a new policy for the automotive sector (*Policy on Development of Automotive Industry*, NDCR 2004), now considered the "supporting industry of the national economy". Building on the technology introduced by foreign companies, the development of products with "self-owned intellectual property rights" and the promotion of Chinese brands, heavily penalized in the previous period, were now strongly emphasized[3].

The plan encouraged the autonomous development of models and technologies consistent with international standards and the promotion of Chinese brands capable of selling both locally and globally. Again, the aim was to make the Chinese industry internationally competitive through structural adjustment and a general up-grading of production. However, the JV policy -still subject to the 50% + 2 rule- was not abandoned, and after 2004 eight new JV agreements with foreign multinationals were signed by Chinese companies (Figure 4). The policy of promoting both indigenous technologies and JVs was conveniently labeled "walking with two legs" by Chen and Zhang (2004), quoted by Chu (2011).

The 2004 *Policy on Development of Automotive Industry* contained an important innovation, which had significant consequences for the future development of the Chinese auto industry. For the first time, the promotion of research and industrialization of battery electric, hybrid and other energy-saving vehicles is part of a government's program[4]. This policy actually follows the commitment of the Ministry of Science and Technology (MOST) in 2001 to support research on HEV (hybrid electric vehicle), EV (electric vehicle) and FCV (fuel cell vehicle) under the national high-tech 863 program (Li and Ouyang 2011, ICCT 2021), in accordance with the 10th Five-year plan. The 863 program, approved by Deng Xiaoping in 1986 with the aim of accelerating China's high-tech development in key areas, was implemented during successive five-years plans and was

[3] "The auto production enterprises shall be encouraged to improve the research and development ability and technological innovation ability, and positively develop products with self-owned intellectual property rights, and pursue the strategy of famous-brand operation. In 2010, the auto production enterprises shall form some famous-brand products of automobiles." NDCR (2004), Art. 3.

[4] "The automotive industry shall, in combination with the requirements of the strategy of state energy source structural adjustment and emission standards, positively carry out research and industrialization of such new types of power as the electric cars, batteries used as vehicles power, etc., and focus on the development of hybrid vehicle technology and diesel motor technology for cars." NDCR (2004), Art. 8.

ended in 2016. In the case of automobile, research focused on the so called “three rows” and “three columns”. The “three rows” are electronic control system of powertrain, electric motor and engine technology, power battery and fuel cell technology. The “three columns” are internal combustion engine (ICE) based hybrid powertrain, pure electric vehicle, and the new generation electric vehicle with two/four wheel motor drive (Li and Oulang 2011).

The second phase

The real turning point in the government’s policies was in **2009**, with the *Auto Industry Adjustment and Revitalization Plan* (State Council, 2009). With a clear indication to “take new energy vehicles as a breakthrough, strengthen independent innovation, cultivate independent brands” (State Council 2009, p.2), the plan marks a radical change from the past and inaugurates a **new season of industrial policies**. The promotion of Chinese brands, with the aim of serving more than 40% of the domestic market, became a strategic priority. However, the most important novelty is related to New Energy Vehicles (NEVs) (Li 2020, Kennedy 2018, Jin et al. 2021). With this term, the Chinese Government refers to plug-in electric vehicles (battery powered electric vehicles, BEVs, and plug-in hybrid electric vehicles, PHEVs) and fuel cell electric vehicles (FCEVs) powered by hydrogen. The government began to see in the development of NEVs not only the possibility of curbing pollution and achieving the decarbonisation goals but also the opportunity to free Chinese industry from technological dependence on foreign multinationals. The plan set production and sale targets for NEVs (500,000 units and 5% of total sales of passenger vehicles) and promoted pilot projects for the diffusion of this type of vehicle in a selected number of large municipalities (a program called *Ten Cities, Thousand vehicles*) (Gong et al. 2013).

In **2012**, the government launched the first specific plan for electric and energy-saving cars (*Energy-saving and new energy automobile industry development plan 2012-2020,* State Council 2012). The main point was to enhance China's automobile industry overall level of technology by supporting the development, industrialization and innovation of NEVs. The target was the sale of 500,000 NEVs by 2015 and 5 million by 2020, with a production capacity of 2 million per year, facilitated by infrastructure policies for charging or swapping stations (State Council 2012). The plan also included support for ICE vehicles with energy-saving technologies (hybrids).

Made in China 2025, the ambitious program that aims to transform China from a world factory to a leading global manufacturing power, launched in 2015, records this fundamental change of direction towards sustainable mobility (State Council 2015, Yeung 2018). The "energy-saving and new energy vehicles with independent brands to match advanced international levels"[5] is listed as one of the ten industries considered strategic for the country, and the development of electric technology is considered a priority. The program has a number of objectives to be achieved, including the improvement of engineering and industrial skills in core technologies such as batteries, motors, intelligent control systems, and lightweight materials.

[5] “3.3.6 Energy Efficient and New Energy Automobiles. We will: (a) Continue to support electric automobiles and fuel cell vehicles. (b) Master core automobile technologies for low carbon, informatization and intelligence. (c) Improve engineering and industrialization capability of core technology like batteries, driving motors, efficient combustion engines, advanced derailleurs, lightweight materials and intelligent controls. (d) Build a complete industrial system and an innovation system ranging from essential spare parts to complete automobiles. (e) Promote energy-savings and new energy automobiles with independent brands to match advanced international levels.” (State Council, 2015, p.25).

Alongside the actions aimed at firms and industry, the government implemented a wide set of policies at central, provincial and municipal level, to encourage the development of the electric vehicle market. These include substantial purchase subsidies, facilities for those who own electric cars, and support for the construction of an extensive network of infrastructures necessary for the circulation of new vehicles, mainly charging stations. From 2009 to 2021, the government spent almost 148 billion RMB (roughly 21 billion euros) in subsidies to the NEV sector, covering more than 1,9 million NEV vehicles[6]. According to Kennedy (2018 and 2020), the government support was even higher, totaling 390 billion RMB (approximately $55 billion) in the period 2009-2017, 81% of which for purchase subsidies and tax exemptions. NEV vehicles were not the only policy target. A recent study by IEA (IEA 2021) estimated that in 2020 the world stock of public vehicle-charging infrastructures was 1.3 million units, of which 70% are slow charging stations and 30% fast-charging ones. China accounts for 55% of the world total of slow-chargers and 79% of fast-chargers for a total of 810,000 stations (from 50,000 in 2015).

In September 2017, the Chinese government rolled out a policy that will probably have the greatest impact on the future development of sustainable mobility. This is the so-called "dual-credit policy" ("Parallel Administrative Measures for Passenger Vehicle Corporate Average Fuel Consumption and New Energy Vehicle Credits"), a market-based regulation scheme inspired by the experience of California's Zero Emission Vehicle Mandate program (ZEVM) and European Union Emission Trading Scheme (EUETS) (ICCT 2018, ICCT 2021, FitchRatings 2021).

The government set two specific targets that each large-scale carmaker (>30,000 units) must meet. The first is a Corporate Average Fuel Consumption (CAFC) target, defined according to the existing regulation on fuel consumption. The second is a NEV credit target, defined as a percentage of energy-saving vehicles (NEVs) over the total annual conventional-fuel passenger car production or import in each year[7]. This percentage target has been revised upwards each year, from 10% in 2019, 16% in 2022, up to18% that should be reached in 2023. The Ministry of Industry and Information Technology recently proposed very high targets for 2024 (28%) and 2025 (38%) (FitchRatings 2022). If accepted, the transition of the automotive industry towards sustainable mobility would be significantly accelerated.

In order to offset a NEV or CAFC deficit and meet the requirements, carmakers can gain credits in four different ways: (i) by producing more NEVs (electric cars, plug-in hybrids and fuel cell vehicles), (ii) by producing conventional ICE vehicles with less emissions than the country's standard (CAFC target), (iii) by using banked CAFC credits from own company or by transferring CAFC credits accumulated by affiliated companies, or (iv) by purchasing NEV credits from other companies.

The aim of this policy is to incentivize companies to produce more NEVs and to improve the fuel efficiency of conventional vehicles, while providing them with relative autonomy in choosing their approach to comply with the regulation.

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[6] "Further cut on subsidies won't hit China's NEV industry", *Global Times,* by Zhang Hongpei, December 20, 2021.

[7] See Ministry of Industry and Information Technology (2017), "Measures for the Parallel Administration of the Average Fuel Consumption and New Energy Vehicle Credits of Passenger Vehicle Enterprises". Note that the production of a NEV vehicle can generate multiple credits. For example, one PHEV car is equivalent to two NEV credits, while the number of credits for BEV vehicles depends on the electric range.

At the same time, the policy of financial and fiscal subsidies for purchases of NEVs began to be phased out from mid-2019, and the program will be terminated by the end of 2022. The reason is the ineffectiveness of financial incentives in promoting NEVs demand. As argued by Liu et al. (2021), while financial subsidies promoted the adoption of electric buses, convenience measures, such as non-purchase restrictions and the construction of charging facilities, were more effective in increasing the demand of electric commercial vehicles and private passenger cars. Financial incentives also caused some distortions in the industry. Encouraged by subsidies, many new players, with little experience in the industry, started producing low-cost, low-tech small vehicles, often at a price higher than the value of the cars. The result is a fragmented industry. According to some estimates, more than one hundred NEV carmakers were active in 2020, most of them with a very small size (Kennedy 2020). Chinese players are dominant in the low-end market, while the most promising segments are the mid-to-high and premium segments where most of the foreign competitors are located. Therefore, the shift from a policy-driven to a market-driven industry is welcomed in order to consolidate the industry and promote technological upgrading and innovation.

The last measure worth mentioning is a new regulation on inward FDI that formally ended the long era of industrial policy for the auto industry based on the promotion of JVs. This policy came into force in 2018 ("2018 Negative List")[8] and changed the rules of JVs in the automotive industry. According to the measure, all restrictions on the share ownership of JVs by foreign OEMs will be phased out over a five-year transition period. The shareholding cap for NEVs was the first to be eliminated in 2018. In 2020, the liberalization affected commercial vehicles, while, for all vehicles, the complete removal of the constraints is scheduled for 2022.

This new regulation is partly a consequence of improved technological, production and marketing skills of the main Chinese groups, thanks also to the experience gained with the JVs, which can now implement autonomous strategies of growth. Second, and more likely, it reflects the shift in focus on the development of NEVs, less dependent on foreign technology. This change could have major consequences for the Chinese auto industry in the future.

3. The impact of State intervention: lights and shadows

There are three main effects of nearly four decades of state policy and intervention.

The <u>first</u> is certainly positive and in some ways surprising. Starting out as a complete outsider, China has grown into the world's leading vehicle manufacturer and largest car market in just a few decades, with 26 million units produced in 2021 (82% of which are passenger cars), more than three times greater than the production of Japan and USA[9], and a global market share of 33% (Figure 5).

The current structure of the industry is characterized by three main groups of firms, which reflects the two phases of state intervention. Table 1 shows the production data of the main players.

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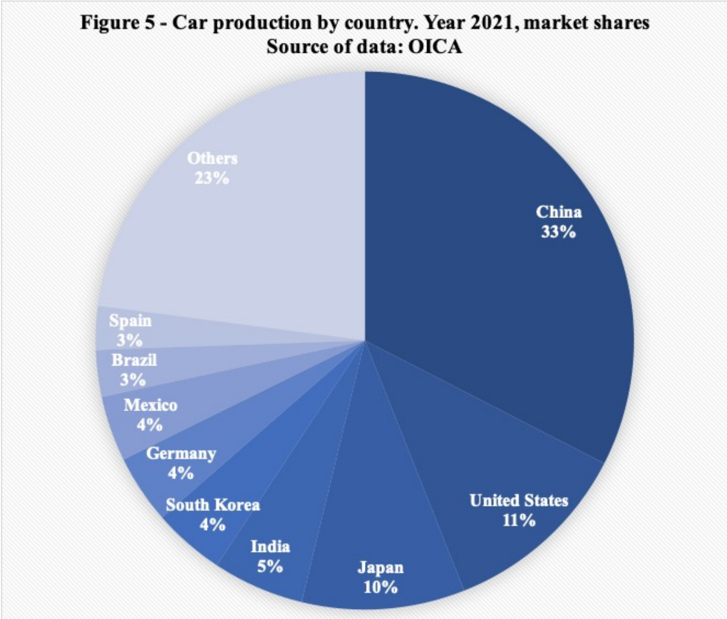
[8] Issued by NDRC (National Development and Reform Commission) and MOFCOM (Ministry of Commerce), see Wong (2018) and "China to open auto market as trade tensions simmer", by Shirouzu N. and Jourdan A., *Reuters*, April 17, 2018.
[9] Source of data: China Association of Automobile Manufacturers CAAM, OICA.

Large SOEs, born in the 1950s and all of them involved in JVs with foreign multinationals, play a dominant role in the industry. With 5.4 million cars produced in 2021, SAIC is among the top ten automakers in the world and the most important Chinese company, followed by FAW, Dongfeng, Changan, GAC and BAIC. These firms accounted for 3/4 of the total industry output in 2021.



The second group includes a set of independent producers, some of them privately owned, whose growth has not been based on partnerships with foreign OEMs. However, the output size of these firms is lower compared to the first group. Geely, a private company, is by far the most dynamic, followed by two other public companies, Great Wall and JAC, and by the state-owned Brilliance and Chery.

The last group contains firms specialized or strongly committed to NEVs. These are the results of the last phase of industrial policies aimed at promoting a more sustainable mobility. With over 730.000 auto produced in 2021, of which more than 81% are plugin cars (BEV+PHEVs), BYD Auto is the most important in terms of output[10]. The company entered the automotive industry in 2003 by selling conventional ICE cars and only recently switched to NEV production (Masiero et al., 2016). Financially backed by Warren Buffett (Berkshire Hathaway), who holds 8.2% of the shares (Berkshire's Report 2020). Inspired by Tesla, the smaller start-ups NIO and Xpeng are the other two more important firms of the group, with a 2021 production of 90-100.000 cars each. NIO sells premium smart electric vehicles that are actually manufactured by JAC under a joint manufacturing agreement. Xpeng has a similar profile, with a manufacturing cooperation with Haima-FAW. Other promising start-ups, not reported in the table, are Li-Auto and Hozon. (Meta). All these companies are technologically innovative and clearly aim at international markets. Some of them are listed on the New York Stock Exchange and enjoy the support of major international investors.

<u>Second</u> and despite the impressive growth of the industry, Chinese companies, brands and technology still do not play a leading role, not only in global markets, where they are

[10] "China: BYD Sold 593,743 Plug-In Electric Cars In 2021", *INSIDEEVs*, by Mark Lane, January 13, 2022. https://insideevs.com/news/560620/china-byd-plugin-sales-2021/

substantially unknown, but also domestically. From this point of view, the policies of 1994, 2004 and 2009, aimed at strengthening the Chinese companies to lead the domestic market and compete globally, have partly failed.

Table 1 - MAIN CHINESE AUTOMOTIVE GROUPS. Production data (including joint ventures, % and units)

Foundation year (auto)	Legal status	Chinese Group		JV partner	2021 Production ('000 units)	2009 %	2014 %	2019 %	2021 %
1955	SOE	**SAIC**	Shanghai Automotive Industry Corporation	VW, GM	**5.375**	19,8	23,8	24,0	20,6
1953	SOE	**FAW**	First Automobile Works	VW, Toyota, Mazda	**3.351**	14,3	13,1	13,4	12,8
1969	SOE	**DONGFENG**	Dongfeng Motor	Nissan, Kia, Honda	**3.205**	13,9	15,9	13,8	12,3
1955	SOE	**GAC**	Guangzhou Automobile Group	Honda, Toyota, Stellantis, Mitsubishi	**2.138**	4,6	4,8	8,0	8,2
1959	SOE	**CHANGAN**	Changan/Chana Automobile Group	Suzuki, Ford, Mazda	**2.296**	13,2	10,9	6,9	8,8
1958	SOE	**BAIC**	Beijing Automotive Industry Group	Hyundai, Daimler	**1.642**	9,1	10,2	8,7	6,3
						75,0	***78,8***	***74,8***	***69,0***
1997	Private	**GEELY**	Zhejiang Geely Holding Group	Daimler	**1.520**	2,4	1,8	5,9	5,8
1984	Public	**GWM**	Great Wall Motor	BMW	**1.265**	0,2	3,1	4,1	4,9
1949	SOE	**BRILLIANCE**	Brilliance Automobile Group	BMW	**928**	1,4	2,2	3,1	3,6
1997	SOE	**CHERY**	Chery Automobile	Jaguar-Rover	**938**	3,7	2,0	2,8	3,6
1964	Public	**JAC**	Anhui Jianghuai Automobile	VW	**527**	2,5	2,0	1,6	2,0
						10,1	***11,2***	***17,5***	***19,9***
2003	Public	**BYD**	BYD Auto	Daimler, Toyota	**730**	3,1	1,9	1,8	2,9
2014	Public	**XPENG**	Guangzhou Xiaopeng Motors Technology		**98**	0,0	0,0	0,1	0,4
2014	Public	**NIO**	NIO		**91**	0,0	0,0	0,1	0,4
						3,1	***1,9***	***1,9***	***3,6***
			Other total		**1.996**	15,9	12,1	9,3	7,6
			TOTAL CHINA			**100**	**100**	**100**	**100**
			Total production '000 (units)		**26.100**	**13.645**	**23.492**	**25.769**	**26.100**

Source of data: OICA, CAAM, company data, press reports.

Table 2 gives an idea of the production with own brands of a selected group of Chinese companies. The large State groups of SAIC, FAW, and Dongfeng, for example, sell under their own brands just 20.3%, 24.4%, and 33.3% respectively, a very small figure, while the bulk of production is placed by the JVs under VW, General Motors or Toyota brand names. Despite its involvement in several JVs (Ford, Mazda and Suzuki), only Changan places most of its production under its own brands. Not surprisingly, Geely, the first Chinese brand (5% market share), is a privately owned and independent company, with no history of JVs with foreign companies.

Even though the overall market share of Sino-foreign JVs has been steadily decreasing since 2004 (Figure 5), foreign companies still enjoy substantial first mover advantages in the conventional ICE vehicle market, thanks to the privileged access to the market guaranteed by the JVs long time ago. In 2021, their combined market share was more than 55%. VW is the market leader after more than 30 years after entry. Toyota and Honda are the other two top brands more than 20 years after entry. As can be seen from Table 3, these three best-selling brands have a combined share of 25%.

In terms of technology, the gap between Chinese and foreign companies has persisted for a long time, despite the technology transfer inside the JVs. According to an in-depth report, the technology level of Chinese firms in 2013 was far behind their global competitors (Wartburton *et al.* 2013). The best company, SAIC, had a technological level estimated at 70% of VW, taken as a reference, an assessment also confirmed by Nam (2015). FAW, Dongfeng (DFM), BAIC and Changan were ranked at 40% of VW, despite the long experience of partnerships with multinationals in the sector. Things have probably improved in the last decade, but there is no longer any interest on the part of Chinese companies to continue to invest in the old technology to fully catch up with foreign OEMs. The future is elsewhere, driven by NEVs and sustainable mobility.

More generally, and in the context of the global automotive industry, China has no national champions, i.e. indigenous companies that can compete head-to-head in global markets with major foreign players in terms of quality, technology, innovation and market appeal. From this point of view, the development of Chinese industry differs profoundly from the experience of Japan first, and Korea later (Zhang 2015). The State played a key role also in these countries, with specific industrial and export promotion policies. Technology transfer mainly occurred through licensing, reverse engineering, R&D investments rather than through direct investments by large multinational companies or JVs (Chu 2011). Firms innovated management and production methods, and this allowed indigenous companies to develop independently and become global players.

Table 2 - PRODUCTION UNDER SELF-OWNED BRANDS OVER TOTAL PRODUCTION (%)
MAIN CHINESE AUTOMOTIVE GROUPS

Chinese Group	2009 %	2014 %	2019 %	2020 %	2021 %
SAIC	6,0	4,2	12,3	13,4	**20,3**
FAW	39,2	20,0	7,8	7,5	**24,4**
DONGFENG	35,7	31,3	29,5	30,2	**33,3**
GAC	8,9	12,5	18,4	16,9	**21,0**
CHANGAN	58,2	44,6	60,1	65,4	**80,4**
BAIC	60,4	43,8	46,1	47,3	**44,6**
Production (units)	**13.600.000**	**23.500.000**	**25.600.000**	**25.300.000**	**26.100.000**
TOTAL CHINESE BRANDS (estimate)	**35-50 %**	**30-40 %**	**35-45 %**	**35-45 %**	**35-45 %**

Note: SAIC data does not include the production of the JV SAIC-GM-Wuling (SGMW).
Estimates based on OICA, CAAM, company data, press reports.

Table 3 - CHINA. SALES OF PASSENGER CARS BY FOREIGN AND CHINESE BRANDS (units and markets shares)

	FOREIGN BRANDS	2021 Units	%	CHINESE BRANDS	
1	VW (VW-FAW + VW-SAIC)	2.164.946	10,1		1
2	TOYOTA (FAW-TOYOTA+GAC-TOYOTA)	1.656.053	7,7		2
3	HONDA (DONGFENG-HONDA+GAC-HONDA)	1.531.486	7,2		3
4		1.072.405	5,0	GEELY	4
5		1.000.799	4,7	CHANGAN	5
6	NISSAN (DONGFENG-NISSAN)	1.000.292	4,7		6
7	BUICK (GM.SAIC)	828.636	3,9		7
8		818.041	3,8	WULING (SAIC-GM-WULING)	8
9		770.008	3,6	HAVAL (GREAT WALL)	9
10		730.093	3,4	BYD	10
11		708.728	3,3	CHERY	11
12	BMW (BMW-BRILLIANCE)	652.000	3,0		12
13	AUDI (FAW-AUDI)	643.500	3,0		13
14	MERCEDES-BENZ (MERCEDES-BAIC)	598.204	2,8		14
15	TESLA	473.103	2,2		15
16	*MG (SAIC)*	*456.243*	*2,1*		16
17		448.251	2,1	GAC	17
18		392.714	1,8	DONGFENG	18
19		369.852	1,7	ROEWE (SAIC)	19
20		369.045	1,7	FAW	20
21	HYUNDAI (BAIC-HYUNDAI)	360.565	1,7		21
22		300.613	1,4	HONGQI (FAW)	22
23	CHEVROLET (GM.SAIC)	269.818	1,3		23
24	FORD (FORD-CHANGAN)	248.202	1,2		24
25	CADILLAC (GM-SAIC)	233.119	1,1		25
26		221.897	1,0	BAOJUN (GM-SAIC-WULING)	26
27		221.740	1,0	LYNK&CO (GEELY)	27
28	JETTA (FAW-VW)	178.100	0,8		28
29	MAZDA (CHANGAN-MAZDA + FAW-MAZDA)	169.643	0,8		29
30	KIA (DONGFENG-KIA)	153.491	0,7		30
31	VOLVO (CHANGAN-VOLVO + GEELY)	140.204	0,7		31
	OTHERS		10,4		
	TOTAL	**21.407.962**	**100,0**		

Locally produced models only, imported cars are exluded.
*** : 2020 estimate.**
Source of data: CARSALESBASE, updated to March 2022.

Overall, this industry configuration is clearly inferior to government expectations. The policy of favoring JVs is the main responsible for this. In September 2012, during an industry forum in Tianjin, the former machinery and industry minister, He Guangyuan, told the press that China's policy of requiring all foreign car makers to form a local JV is "like opium. Once you've had it, you will get addicted forever"[11]. Li Shufu, the founder of Geely, labeled as "spoilt children" the domestic companies involved in JVs with foreign OEMs[12]. Since the JV guaranteed profits, they had no incentive to grow.

In their study of the Chinese auto industry, Liu and Tylecote conclude that: "*while the industry relied passively on technology spillovers when joint-venturing with foreign companies, little knowledge was gained along with production capacity. The foreign companies essentially selected what would be transferred and how, without necessarily teaching their Chinese partners anything significant"* Liu and Tylecote 2009, p.2). Furthermore, allowing Chinese companies to have multiple JVs with rival firms has probably made foreign partners even more cautious in transferring knowledge and investing in research.

These statements capture the difficulty of Chinese companies to grow independently and match world leaders in terms of technology, innovation capabilities, and brand appeal. For a long time, the continuous search for partnerships and collaboration with foreign companies has prevented a real competitive pressure in the domestic market. This has discouraged the necessary investments in technology, brands and innovation, thus hindering the development of autonomous national champions.

On the other hand, independent firms have struggled to grow in a market dominated by large state-owned enterprises and foreign brands. Their share of production in China in 2021 can be estimated between 10-12%. For a long time, politics has ignored and hindered them with barriers to entry, constraints and discrimination, penalizing their development and market penetration (Chu 2011, Liu and Tylecote 2009). For example, in the 2000s the income tax for the JVs was 17.5%, compared to 33% for independent Chinese companies (Jin 2004 cited by Chu 2011). Despite this, some successful independent groups have emerged in the industry. Companies such as Geely, Great Wall, Chery and BYD have constantly increased their presence in the Chinese market with their own brands and are trying to expand into global markets.

The **third** effect is the most important for the future of the industry. Thanks to the second phase of industrial policies, China currently represents the world's largest market of electric vehicles, with 3.5 million NEVs sold in 2021 and a share of 56% on total world sales of NEVs (6.7 million, 9% of total car sales).

In relative terms, electric vehicles correspond to 16% of total domestic car sales in 2021 (from 5% in 2020) (IEA 2022). NEVs are still relatively more important in Europe, with 17% of total car sales, particularly in countries like Norway (86% of total sales), Sweden (43%), Netherlands (30%), and Germany (25%), while USA is lagging behind with 4.5% (IEA 2022).
What is more striking is that, unlike what happens with ICE vehicles, Chinese manufacturers and brands play a leading role in the domestic market for NEVs. According

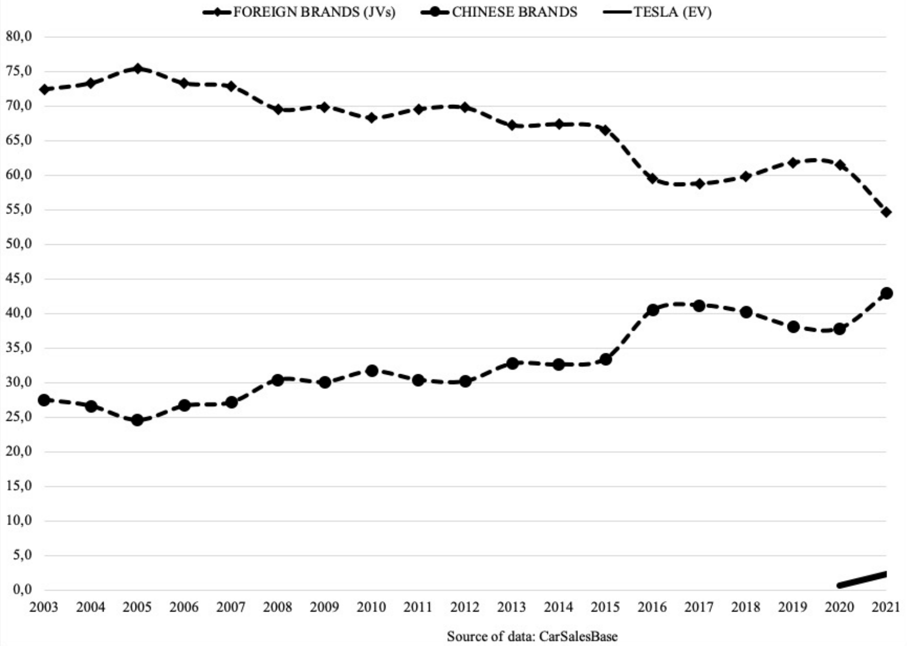
[11] "China ex-minister says foreign auto JV policy 'like opium': report", *Reuters*, September 3, 2012. https://www.reuters.com/article/us-china-autos-foreign-idUSBRE88208120120903
[12] "Geely chairman Li Shufu attacks Beijing strategy on car industry", by Andy Sharman, *Financial Times*, March 29 2015.

to 2021 data[13], 13 out of the top 15 sellers of electric vehicles are all Chinese companies. In the first half of 2022, Chinese brands accounted for a remarkable 78.5% of the domestic market for this type of vehicles. Tesla, with more than 470,000 vehicles sold in China and an estimated 14.6% market share, is the only powerful foreign competitor at the moment, while VW, with models produced by the JVs with SAIC and FAW, is the only other foreign brand with a non-negligible share (about 2%).

With 550-600,000 vehicles sold and a market share of about 18%, BYD Auto is the leader, followed by Tesla. The joint venture between SAIC, GM and Wuling supplies the single most popular EV model, the Wuling HongGuang Mini, a micro-car, with almost 400,000 units sold in 2021. Great Wall (with the specialized Ora brand), GAC (with the EV brand Aion), SAIC, Chery, Geely, and Changan Xpeng, Nio, Li Auto, Changan, and Hozon (Meta) are the other Chinese top EV sellers, each one with a market share between 2 and 4%.

More generally, Chinese brands have steadily gained ground over the past fifteen years in the domestic market (Figure 6). In 2003, cars sold in China under foreign brands and produced by JVs accounted for 72% of the market. This percentage has gradually decreased to 67% in 2015. However, the most significant reduction occurred in recent years, reaching 55% in 2021 (57% including Tesla), thanks to the radical change brought about by electric vehicles and the increased demand for sustainable mobility. Chinese brands now accounts for 43% of the market, and their sudden growth in the last year is basically due to some highly successful car models produced by Chinese electric car manufacturers.

Figure 6 - China. Sales of passenger cars under Foreign and Chinese brands. Market shares (2003-2021)

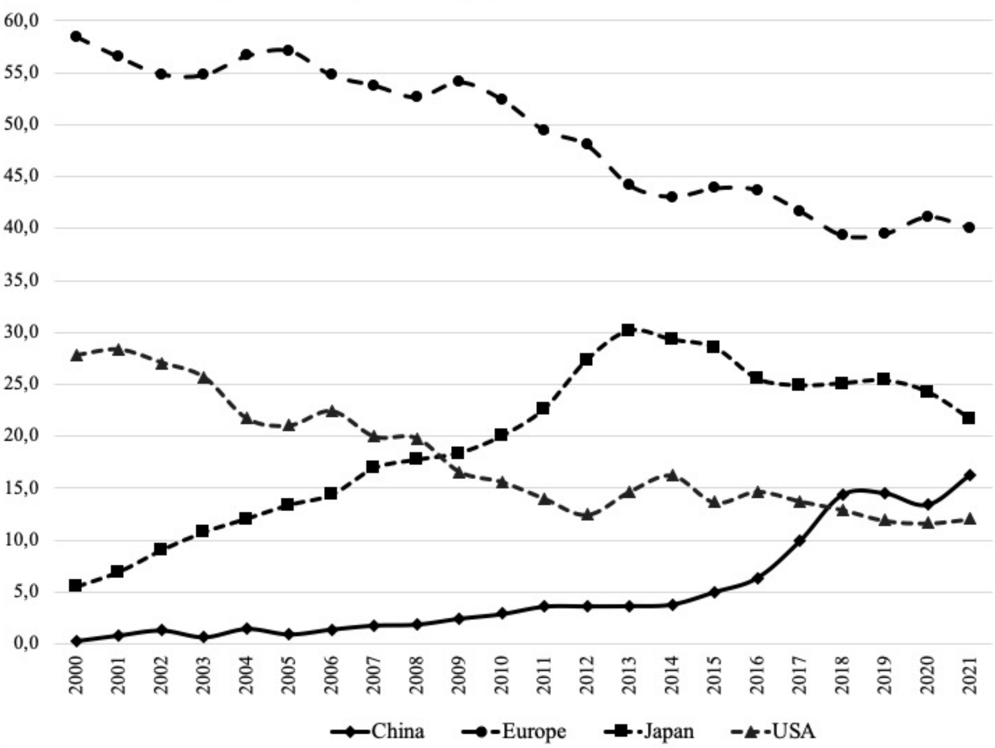


Source of data: CarSalesBase

[13] See: "China counts more than 3 million NEV sales in 2021", *Electrive.com*, January 11, 2022, https://www.electrive.com/2022/01/11/china-counts-more-than-3-million-nev-sales-in-2021/; "Chinese OEMs Dominate Domestic EV Market in 2021", by Hsu Y.-C., Researcher & Research LLC, *EETimes Asia*, 27 January 2022, https://www.eetasia.com/chinese-oems-dominate-domestic-ev-market-in-2021/; "Why China is outselling the US in EVs 5 to 1", by Shen Lu, *Protocol*, January 24, 2022, (based on CPCA data) https://www.protocol.com/china/china-record-ev-sales-tesla

The Chinese electric car market has some specific characteristics compared to other countries. Looking at the composition of the cars sold, BEVs represent about 80-83% of the total, while the rest are PHEVs (Jin and He 2019, IEA 2022). In Europe and USA, PHEVs represents respectively 50% and 68% of the EV market (2021 data). Second, an important share of China's BEV production is made up of microcars, partly as a consequence of the incentive policies followed by local and central government in the past. These are low-cost vehicles designed for urban mobility, with low technology and shorter electric range. It is estimated that in 2018, 33% of electric vehicles belonged to this type, compared to 13% in Europe, just 1% in the US, less than 0.5% in Japan (Jin *et al.* 2021). The best-selling electric car Wuling HongGuang Mini, quoted above, is the iconic example[14]. However, the relative share of microcars is decreasing (it was 55% in 2015), thanks to the incentive policies of the government which tend to favor cars with greater battery capacity and electric range. On the other hand, the production of models for the more profitable high-end of the market is growing, thanks to the effort of companies like SAIC, BAIC, Geely and Great Wall. In 2021, the last reported year, in China and Europe the market composition in terms of vehicle segments (small, medium, crossover, large, SUV) is roughly similar (IEA 2022).

Figure 7 - Transport technology. Patent (PCT) publications by technology (2000-2021, % of total)



Source of data: WIPO statistics database. Last updated: March 2022

Another important effect of the NEV policies is to provide support and stimulus for an autonomous technological development of the Chinese auto industry. The results seem encouraging. In the last six years there has been a significant increase in China's patenting activity in the transport industry, driven by the development of NEVs (Figure 7). Table 4 gives a more detailed information of the top preforming companies in patenting activities in the last seven years. Data are collected from Google Patents. Following Aghion *et al.*

[14] "Wuling small EV sales hit record high", *chinadaily.com.cn*, 2022-01-12.

(2016), patent classes were divided in two groups of "clean" patents, related to BEV, HEV and FHEV vehicles, and "dirty" patents, related to ICE vehicles. The Chinese companies NIO and BYD appear among the top performers in patenting clean technologies.

Table 4 - CLEAN AND DIRTY PATENTS IN THE CAR INDUSTRY. TOP PERFORMERS (Top 1000 results by filing date, %, 2015-2022)

CLEAN PATENTS (search query)				DIRTY PATENTS (search query)	
Battery electric vehicles		**Fuel cell**		**Internal combustion engine**	
Search query: B60L or B60K or B60W and battery electric vehicle	%	Search query: H01M 8 and hydrogen fuel cell and electric vehicle/s	%	Search query: F02 and vehicle	%
Ford Global Technologies	36.8	Hyundai Motor	12.6	Toyota	5.4
Nio Usa	6.3	Kia Motors	12.3	Denso Corporation	2.0
Hyundai Motor	5.9	Toyota	10.6	Jtekt Corporation	1.8
GM Global Technology Operations	5.4	GM Global Technology Operations	5.7	Ability Opto-Electronics Technology	1.8
Kia Motors	4.8	Honda Motor	5.4	Saint-Gobain Glass France	1.6
Honda Motor	2.6	Global Graphene Group	4.5	Mazda Motor	1.4
Witricity	2.0	CATL - Contemporary Amperex Technology	3.6	Nissan North America	1.3
Murata Manufacturing	1.3	Ford Global Technologies	3.5	Honda Motor	1.3
Toyota	1.2	Toshiba	2.9	PSA Automobiles	1.2
Samsung SDI	1.0	Samsung Electronics	2.5	Samsung Electronics	1.2
Cps Technology	0.9	Samsung Sdi	2.4	Largan Precision	1.1
Qualcomm	0.9	Lg Energy Solution	2.3	Ability Opto-Electronics Technology	1.1
Research & Business Foundation Sungkyunkwan Univ.	0.8	Lg Chem	2.1	Kantatsu	1.0
Thunder Power New Energy Vehicle Development	0.8	Toyota Motor North America	1.5	Valeo Systemes Thermiques	1.0
Byd	0.8	Ningde Amperex Technology	1.3	Komatsu	1.0
Johnson Controls Technology Company	0.7	Enevate Corporation	1.1	Nissan Motor	1.0
Hyliion	0.6	Samsung SDI	1.1	Fujifilm	0.9
Kwang Yang Motor	0.6	Korea Institute Of Science And Technology	1.1	Huawei Technologies	0.9
Audi	0.6	Nio Usa	1.0	GM Global Technology Operations	0.9

Battery technology: LFP		**Battery technology: NCM**		**Battery technology: NCA**	
Search query: H01M and lithium and iron and phosphate and LFP and electric vehicle/s	%	Search query: H01M and lithium and nickel and cobalt and manganese and NCM and electric vehicle/s	%	Search query : H01M and lithium and nickel and cobalt and aluminium and oxide and NCA and electric vehicle/s	%
CATL - Contemporary Amperex Technology	20.4	Samsung Electronics	10.1	Enevate Corporation	15.2
Global Graphene Group	9.6	Ningde Amperex Technology Limited	8.4	International Business Machines	10.4
Enevate Corporation	6.0	Enevate Corporation	8.4	Global Graphene Group	8.5
International Business Machines	6.0	Global Graphene Group	8.4	GM Global Technology Operations	5.7
Lyten	4.8	International Business Machines	6.7	StoreDot	4.7
Samsung Electronics	3.6	Lyten	5.0	Samsung Electronics	3.8
Volkswagen	3.6	Samsung Sdi	5.0	TeraWatt Technology	2.8
Sumitomo Osaka Cement	3.6	Samsung SDI	5.0	Volkswagen Aktiengesellschaft	2.8
Samsung SDI	2.4	Sk Innovation	5.0	Robert Bosch	1.9
Ford Global Technologies	2.4	Toyota	3.3	Sf Motors	1.9
StoreDot	2.4	Korea Institute Of Science And Technology	3.3	SF Motors	1.9
Commissariat à l'Energie Atomique et aux Energies Alternativ	2.4	GM Global Technology Operations	3.3	Lyten	1.9
Group14 Technologies	2.4	CATL - Contemporary Amperex Technology	3.3	Microvast Power Systems	1.9
WATTRII	2.4	Lg Chem	3.3	Seiko Epson Corporation	1.9
Samsung Sdi	2.4	TeraWatt Technology	3.3	Chongqing Jinkang New Energy Automobile	1.9
Element Energy	1.2	Weck + Poller Holding	1.6	WATTRII	1.9
GM Global Technology Operations	1.2	Uchicago Argonne	1.6	Ford Global Technologies	1.9
Chun-Chieh Chang	1.2	WKS Technik	1.6	Ecopro Bm	1.9
Commissariat Energie Atomique Energies Alternatives	1.2	Beijing Xiaomi Mobile Software	1.6	Samsung Sdi	1.9

Legenda patent classes (IPC, International Patent Classification). B60L: power plant equipment technology of electric vehicles; B60K: arrangement or installation of vehicles power devices and gear devices; B60W: control systems for vehicles; H01M8: fuel cells; F02: internal combustion engines.

SEARCH QUERY: Date (Priority, 2015-2022), Patent offices (WIPO, US, EPO), Status (Grant), Type (Patent). Top 1000 results by filing date - **Source of data: Google Patents**

4. Electric cars: an opportunity for the Chinese auto industry

In the recent 2021 UN climate summit in Glasgow (Cop26), the world leading countries pledged to achieve carbon neutrality by 2050 (USA, EU, Japan), China by 2060. Sustainable mobility plays a leading role in this process and the future car market will be dominated by electric and "green" cars. However, the agreement to sell only zero-emissions vehicles by 2040 was signed by a few countries, with the notable exclusion of the most important producing countries (US, China, largest EU countries, Japan).

There is still uncertainty about the best technology to cut carbon emissions that will prevail in the future, but the announced plans of most of the major global players seem clearly oriented towards zero-emissions vehicles, especially BEVs.

This scenario is a great opportunity for China. Electric vehicles represent a significant and radical technological leap, a paradigm shift (Teece 2019), which is changing the prospects of the entire automotive industry. China companies can try to follow a leapfrogging strategy, bypassing the first-mover advantages enjoyed by foreign OEMs in the past, and entering the new market with technologies and car models developed independently, and with own brands. The competitive advantages that could hardly be obtained with internal combustion cars (ICEs) can now be achieved with electric vehicles (EVs). The government has long been aware of this opportunity. In May 2014, during a visit to an electric car factory in Shanghai, President Xi Jinping stated that *"Developing new energy vehicles is essential for China's transformation from a big automobile country to a powerful automobile country"*[15].

As seen above, the electrification strategy is enjoying great success in China, also thanks to government's support, and this explain the reversal of the relative positions of Chinese companies in the NEV market compared to what happens in the market of conventional vehicles. Can the same happen in global markets where competition is much stronger and where legacy car manufacturers are firmly established? China currently enjoys some important advantages over other competitors, which can give the country a good chance of success.

First of all, China has a strong government that can implement sound and effective **policies,** capable of setting medium to long-term goals and enforcing their implementation. State intervention for NEVs began in 2004 and the results in terms of development of the NEV market are remarkable.

Some recent policy measures promise to accelerate the transition of the Chinese automotive industry towards the new era of sustainable mobility. At the end of 2020, the Chinese government launched a new plan for NEVs (BEV, PHEV, FCV), the *New Energy Vehicle Development Plan for 2021-2035*, much more ambitious than the first (Ibold et al. 2021, ICCT 2021). The explicit aim is to establish a globally competitive, technologically advanced electric car industry with Chinese brands. According to the plan, "by 2025, China's NEV market will be significantly more competitive, with major breakthroughs in key technologies such as traction batteries, motor and vehicle operating systems, and an overall improvement in safety standards. (…) It is expected that with another 15 years of continuous efforts, the core technology of NEVs in China will reach the international advanced level, and the quality of brands will have strong international competitiveness." (Ibold et al, 2021, p.4).

NEV's share is expected to reach 20% of total new car sales by 2025, approximately 6.1 million cars, more than five times as much as sold in 2020. The goal of electrifying 100% of public vehicles in the next fifteen years goes in this direction as well as the construction of an adequate infrastructure network for recharging or swapping the batteries. Research and technological innovation are the basis of these ambitions. The so-called "Three-by-Three R&D" program plans to focus research on BEVs, PHEVs and FCVs, and three key technologies: batteries, smart and connectivity technologies, key components (chips, operating systems, motors and control systems of the powertrain) (ICCT 2021).

China is committed to boost the development of autonomous vehicles (AVs) and the intelligent connected vehicle (ICV) technology. In February 2020, the National Development and Reform Commission (NDRC) and 11 ministries jointly issued the *Strategy for Innovation and Development of Intelligent Vehicles* (Eurasia Group 2021, Zhang et al 2022). The ambitious goal is to make China a global ICV ("smart car") leader.

[15] "Guide to Chinese Climate Policy. Electric Vehicles", China Climate Change, Center on Global Energy Policy, Columbia University, 2021. https://chineseclimatepolicy.energypolicy.columbia.edu/en/electric-vehicles

The potential implications for the whole automotive industry of the ICV technology are enormous but difficult to predict. As Xu et al. put it, ICV is “the foundation of a future innovative society” (Xu et al 2022, p.1). Whatever the future disruptive effects on the existing industry, China plans to be among the leaders of the development and application of this technology.

These programs are consistent with the guidelines of the 14th Five-Year Plan (2021-2025), formally adopted in March 2021 but drafted during the fifth plenum of the 19th Central Committee in October 2020. The 14th FYP indicates new energy vehicles and intelligent (connected) vehicles as a new, strategic pillar of the industrial system. The Plan promises “breakthroughs in key technologies such as high-safety power batteries, high-efficiency drive motors, and high-performance power systems for new energy vehicles and accelerate the R&D of key components such as the basic technology platforms for intelligent (connected) vehicles, software and hardware systems, steer-by-wire chassis, and smart terminals.”[16]

In line with these government commitments for sustainable mobility, Chinese automakers are planning to invest more than $100 billion over the next five-ten years on EVs and batteries, with companies like SAIC, Changan, Gac, Dongfeng and Great Wall on the front line[17].

China's **second** strength is world leadership in the development and production of **batteries**, a key component of electric cars, a market that has long been dominated by Korean (LG, Samsung, SK Innovation) and Japanese (Panasonic) companies. According to recent data, the Chinese CATL (Contemporary Amperex Technology) is the world's largest manufacturer of lithium-ion batteries, with a market share in 2021 of around 33% (Table 5). Founded in 2011, the company supplies all major Chinese automotive groups (SAIC, BAIC, Geely, GAC) and has supply relationships with many important foreign OEMs, such as VW, Daimler, BMW, Tesla, and Stellantis.

The second Chinese company is BYD ("Build Your Dreams"). Founded in 1995 for the production of lithium batteries for consumer electronics, the company is currently the fourth largest producer of batteries for electric vehicles in the world (about 9% market share in 2021). BYD recently developed the innovative blade battery and is in talks with Tesla and other OEMs for the supply.

Being a leader in manufacturing, however, doesn't mean being a leader in technology. According to a report from EPO and IEA, Japanese (Panasonic, Toyota, Hitachi) and Korean (Samsung, LG Electronics) companies are leading the technological development in batteries, as shown by the indicators related to patent applications (EPO-IEA 2020). In the 2014-2018 period, Japan alone accounts for 41% of all patent applications for Li-ion batteries. The authors of the study also calculate an index of the revealed technological advantage (RTA) in battery technology. The results confirm the supremacy of Korea and Japan, while China, the United States and Europe, with the exception of Germany, are still lagging behind.

[16] “Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035”, *Xinhua News Agency*, March 12, 2021.
[17] “Exclusive: Global carmakers now target $515 billion for EVs, batteries”, by Paul Lienert and Tina Bellon, *Reuters*, November 10, 2021. https://www.reuters.com/business/autos-transportation/exclusive-global-carmakers-now-target-515-billion-evs-batteries-2021-11-10/

Table 5 - MAIN GLOBAL EV BATTERY MANUFACTURERS						
COMPANY	**CATL**	**LG ENERGY SOLUTION**	**PANASONIC**	**BYD**	**SK INNOVATION**	**SAMSUNG SDI**
Market share (2021)	**32.6%**	**20.3%**	**12.2%**	**8.8%**	**5.5%**	**4.5%**
Customer / Partnerships	**BMW**	**Ford**	**Tesla**	**Toyota**	**Daimler**	**BMW**
	Volkswagen	**Renault**	**Toyota**		**Hyundai-Kia**	**Volvo**
	Daimler	**Hyundai**	**Honda**		**Ford**	**Volkswagen**
	Volvo	**Tesla**	**Ford**		**Volkswagen**	**BMW**
	Toyota	**Volkswagen**				**Stellantis**
	Honda	**Volvo**				
	Hyundai					
	Tesla					
	BAIC	**Geely**		**BYD**	**BAIC**	
	Geely					
	SAIC					
	GAC					
	Foton					

Source: electrive.com (retrieved from: https://www.electrive.com/2022/02/08/catl-outgrows-the-battery-competition/), Feb. 8 2022, reporting SNE Research data.

However, battery technology is constantly evolving and Chinese producers seem to be catching up quickly, as shown by patent data in Table 4. Several options based on different chemistries are currently available on the market, and new, more radical, possibilities are being explored for the future. What the future scenario will be is still uncertain (Xu et al. 2020). Several factors must be taken into account: energy density, battery endurance, battery weight, safety, and total battery pack cost, which depends on the availability and cost of materials and minerals used.

Nickel based lithium-ion batteries are the prevailing technology, widely used by global automakers in mid-range and high-end electric vehicles. It accounts for 88% of the electric car battery market outside China[18]. The most common chemistry employs nickel, cobalt and manganese (NCM or NMC). These are high-capacity, high-power batteries. However, these batteries are expensive because they depend on strategic minerals with increasing supply difficulties. NCM batteries are mostly developed by South Korean companies (LG Energy Solution, Samsung SDI, SK Innovation), but are produced also by CATL. A different and more powerful chemistry is based on nickel, cobalt and aluminum (NCA). Compared to NCM, this technology has a higher specific energy (power) but battery life is low and the production cost is still high. Panasonic, in cooperation with Tesla, is the leader in the development and manufacturing of this type of battery. NCA batteries are also produced by Samsung.

[18] "Tesla's reverse on battery cells signals shift for electric vehicles", by Yoon J., *Financial Times*, February 22, 2022. https://www.ft.com/content/accde2e1-08a2-4bc3-bbb1-1a1e72eb4508

An alternative chemistry for lithium-ion batteries, which is becoming increasingly popular especially in China, is lithium iron phosphate (LFP). LFP batteries have a lower energy density and are bigger and heavier as compared with other lithium-ion batteries, which negatively impacts fuel economy and range of EVs. However, they are cheaper, safer and more durable, and do not rely on critical minerals (Xu et al. 2020). China is world leader in the development and production of this technology, led by CATL and BYD. More than 95% of LFP batteries are made in the country. According to some recent estimates, LFP accounts for 44% of the Chinese EV market versus NCM's 56%, and the share is increasing[19]. LFP batteries are becoming increasingly attractive to many global carmakers, due to rising prices and supply problems of strategic minerals. Since 2021, Tesla is using LFP in some versions of its Model 3 not only in China but also in the US. Also VW and Ford are considering the use of FPL for some entry-level EVs. Should LFP technology emerge as the winner in the battery technology war in the future -a possible scenario according to Xu et al. (2021) - this would increase China's technological lead in the electric car market.

The **third** strength is the control over some **strategic minerals** -lithium, cobalt, rare earth- required for the production of lithium-ion batteries and other key components of electric cars According to the data provided by IEA (International Energy Agency 2021), China produces more than 60 per cent of global lithium chemicals (over 80% for lithium hydroxide). Chinese have also been buying stakes in lithium mining projects in Argentina, Chile, Mexico, Australia and Ireland. China plays a dominant role in cobalt refining for battery application (production of cobalt sulphate and oxides accounting for 80% of the global total output in 2020). Cobalt production and reserves are concentrated in the Democratic Republic of Congo (70% share in total production). However, over 52% of the cobalt mining capacity of the country is controlled by Chinese companies, such as China Molybdenum, with equity stakes and supply agreements as a result of decades-long investment and development in the country backed by the Chinese government and state-owned banks (FP Analytics 2019) [20]. Lastly, China currently processes more than 87% of global rare earth minerals, with 38% of global reserves and 60% of mining activities (International Energy Agency 2021).

Fourth. In addition to the electric motor, **connectivity** is the other great technological advance that defines the car of the future, the intelligent connected vehicle (ICV). Traditional automotive companies tend to become technology companies by opening up to new business and mobility models based on CASE (Connected, Autonomous, Shared, and Electrified) technologies. Software and sensors become key components, along with the connection with mobile devices, the satellite, and the cloud. Artificial intelligence is needed to analyze real-time data on road, atmospheric or traffic conditions and communicate them to the driver. All of this requires partnerships and collaborative arrangements between automotive companies and a broad array of technology and information technology (ICT) companies.

On this ground, Chinese companies still lag their US competitors in the development of the AV technology. Tesla, Waymo (Alphabet) and Cruise (GM) are currently the leaders, targeting fully AVs designed for individual consumers (Eurasia Group 2021). Furthermore,

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[19] "Tesla Shift to EVs With Lithium Batteries Closely Watched", *Asia Financial*, April 27, 2022. https://www.asiafinancial.com/tesla-shift-to-evs-with-lithium-batteries-closely-watched

[20] "Congo reviewing $6 bln mining deal with Chinese investors", by Ross A. and Strohecker K., *Reuters*, August 30, 2021.

chips are a crucial component of the CASE revolution, and Chinese companies remain heavily dependent on chips designed by foreign firms -such as Invidia, Qualcomm and Intel- and mostly produced in Taiwan and South Korea[21].

However, China is not far from the United States and is certainly ahead of Europe and Japan. The main focus of Chinese AV companies is the public transportation systems rather than the private consumer market (Eurasia Group 2021). Tech giants such as Tencent, Baidu, Huawei, Alibaba, Didi, Xiaomi have entered into collaboration agreements with various Chinese car manufacturers to explore the potential of AVs and sustainable mobility and propose new business models.

Some examples provide an idea. SAIC and Alibaba, together with Shanghai Zhangjiang Hi-Tech Park Development, formed a joint venture in January 2021 to develop and produce premium electric cars with the brand IM ("Intelligence in Motion") to compete with Tesla in the Chinese market[22]. The delivery of the first sedan is scheduled for the first quarter of 2022. Huawei produces SUV models with the American Seres, part of the Chinese Sokon group, owned by Dongfeng DFM, which began selling in China through the Huawei network. Huawei and Changan with CATL have a partnership for the development of EVs[23]. The target is the mid to high-end market, in competition with Tesla and NIO. The tech giant is in charge of developing the vehicle's operating system and cabin technologies. In 2021, the search engine giant Baidu set up a company with Geely, Jidu Auto, to produce smart electric vehicles[24]. In 2021, Geely and Tencent signed an agreement to cooperate in the fields of digitalization, intelligent cockpits, autonomous drive, and low carbon development. Foxconn and Geely created a joint venture to provide a one-stop solution for automobile assembly, automotive parts production and electronic vehicle supply chain management[25]. AutoX is a dynamic Chinese self-driving car startup backed by Alibaba and based in California. It has several partnerships with SAIC, Dongfeng, and Fiat Chrysler Automobiles (now Stellantis).

5. The reaction of the legacy car manufacturers

In China, as we have seen, Chinese OEMs currently enjoy first mover advantages and are leading the growth of the NEV market together with Tesla. However, foreign OEMs are not standing by and are trying to catch up, and for good reason.

China represents a critical and strategic market for many global players, as shown by the data reported in Table 6. In 2021, GM produced 51% of its global production in China, Honda 38.5%, VW 36.7%, BMW 28.1%, Daimler 26.2%. Foreign OEMs will certainly do their best to keep control over the large Chinese market and to challenge the current leadership of local producers in the growing EV market.

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[21] "China's driverless car dreams troubled by US chip dependency", by White E., *Financial Times*, February 21, 2022.

[22] "Alibaba unveils electric car with SAIC Motor", *S&P Global*, January 14, 2021. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/alibaba-unveils-electric-car-with-saic-motor-62097301

[23] "Huawei-Changan smart car partnership expands to include chips", by Sun Y. and Zhu J., *Reuters*, May 21, 2021.

[24] "Baidu's Jidu Auto to invest $7.7 bln in 'robot' smart cars", by Yang Y., Sun Y. and Munroe T., *Reuters*, April 23, 2021.

[25] "Alibaba unveils electric car with SAIC Motor", *S&P Global*, January 14, 2021. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/alibaba-unveils-electric-car-with-saic-motor-62097301

One way is to leverage the recent elimination of the equity cap on FDI inflows into the auto industry to strengthen the role of foreign OEMs in existing JVs and gain more space of action. Theoretically, foreign OEMs can increase their equity holdings and gain control of the JV, or buy out the JV partner, converting the JV into a wholly owned enterprise (WFOE).

Table 6 - MULTINATIONAL GROUPS. VEHICLE PRODUCTION IN CHINA AND WORLD ('000, Year 2021)

MNC Groups	CHINA	WORLD	%
GM Group	3.003	5.893	**51,0**
HONDA	1.551	4.033	**38,5**
VW Group	2.947	8.020	**36,7**
BMW Group	700	2.492	**28,1**
DAIMLER Group	618	2.362	**26,2**
RENAULT-NISSAN-MITSUBISHI	1.205	6.756	**17,8**
TOYOTA Group	1.657	9.427	**17,6**
MAZDA Group	165	1.108	**14,9**
FORD Group	368	3.666	**10,0**
HYUNDAI-KIA	497	6.428	**7,7**

Source: Estimates based on MarkLines data and company data.

In reality, these options seem difficult to realize, and the status quo is the more likely outcome, at least in the near future (Li 2018, Schaub and Zhao 2020). Any change in equity holdings requires the agreement or the cooperation of the Chinese partners, which are mostly large SOEs backed by the government. Moreover, the Chinese partners are unlikely to accept the reduction of their stakes in profitable JVs. In addition, foreign companies still depend on Chinese partners for market access and the understanding of consumer preferences and market dynamics (Li 2018, Schaub and Zhao 2020).

The first impact of the regulation seems to confirm this expectation. According to press reports, in 2019, Daimler had a plan to raise its stake to 75% from 49% in highly profitable Beijing-Benz Automotive, its JV with BAIC Group, but met strong resistance from the Chinese partner[26]. Eventually, the plan was abandoned. At the end of 2021, Dongfeng Motor put up for sale its 25% stake in the underperforming Dongfend Yueda Kia joint venture, in which the Korean Hyundai-Kia held 50%[27]. However, since Hyundai-Kia was not interested in the deal, state-owned conglomerate Jiangsu Yueda, the other partner in the JV, bought the stake[28]. More recently, in January 2022, Stellantis (ex Fiat-Chrysler) announced a plan to increase to 75% from 50% its stake in the JV with GAC, which

[26] "Exclusive: Daimler seeks majority control of its main China joint venture", by Zhu J., Taylor E., Sun Y., *Reuters*, December 17, 2019.

[27] "Kia Corp. to Part Ways with Chinese Joint Venture Partner", by Herth M., *Business Korea*, December 10, 2021.

[28] "State-Run Conglomerate Buys Dongfeng Motor's Entire 25% Stake in Kia Joint Venture", by Cong Y. and Yi D., *Caixin Global*, December 24, 2021.

produces vehicles with the Jeep brands[29]. The two parties did not sign any formal agreement, and GAC soon after criticized Stellantis for issuing the statement. The resistance from GAC and probably from the government, which should have approved the agreement, forced Stellantis to terminate the JV with GAC in July 2022[30].

So far, the only cases in which the foreign partner succeeded in raising its control are BMW and VW. BMW-Brilliance Automotive is a highly successful JV between BMW Group and Brilliance. The increase of the stake of BMW from 50% to 75% was agreed by both partners in 2018 and it was realized, with government's approval, in February 2022[31]. The deal was certainly favored by the precarious financial situation of the Chinese partner Brilliance, which in 2020 went into bankruptcy administration[32]. JAC-Volkswagen is a recent JV for the production of EVs. In 2020, VW secured a controlling majority stake, from 50 to 75%[33].

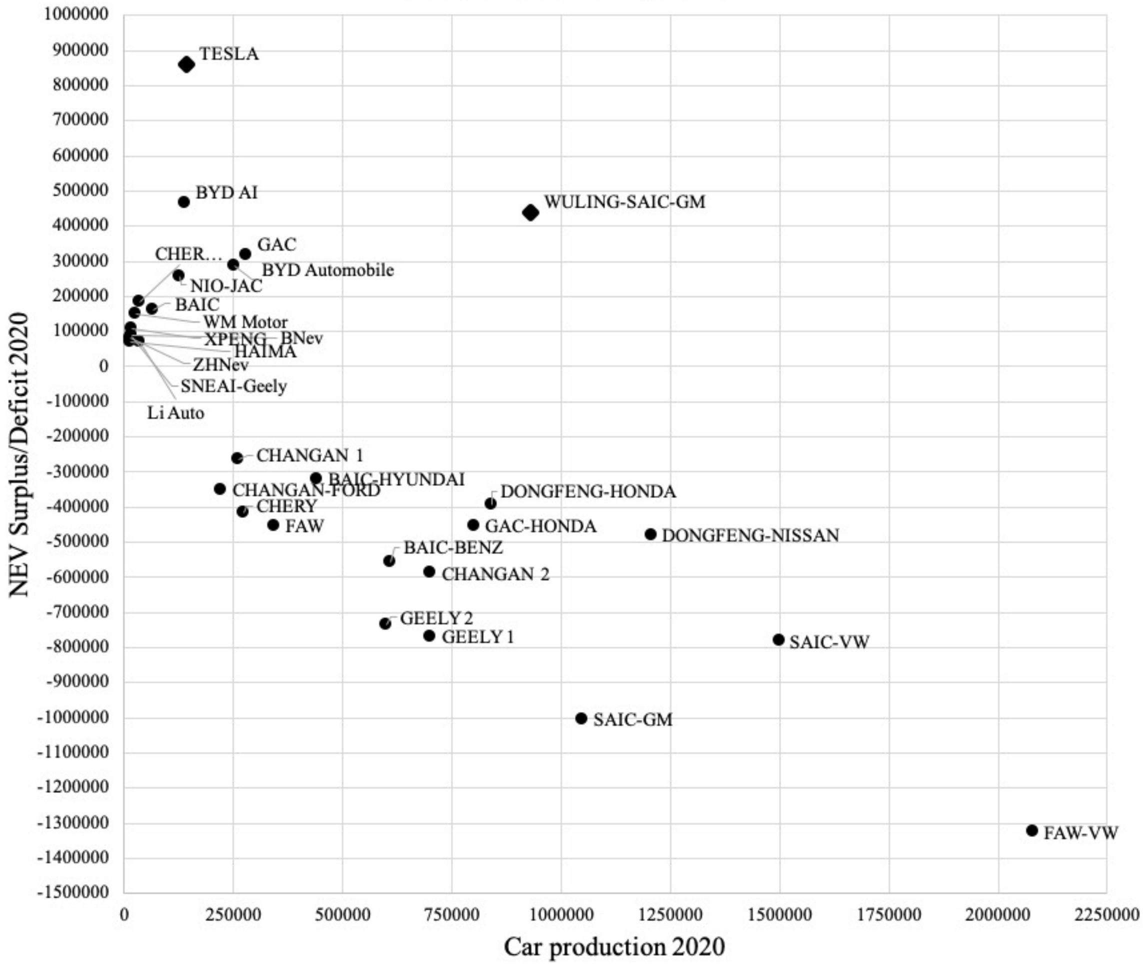
The new regulation on FDI also allows foreign companies to build new production plants in China (greenfield investments), wholly owned by them. However, no historic OEMs has so far followed this path. The only notable exception is the American company Tesla, the first mover and the strongest competitor in the EV market both in China and in global markets. In 2019, Tesla opened in China its own Gigafactory for the production of approximately 250,000 electric cars per year[34]. Production capacity was doubled in 2021[35], and there are plans to further expand to 1 million units in the near future, making the Shanghai Giga plant the largest manufacturing and export hub of EVs in the world.

A better option than trying to control equity stakes, is to enter the NEV market by leveraging existing JVs. The *dual-credit policy* is a big push in this direction. ICE vehicles are now subject to restrictive requirements and their future prospects are not encouraging. Figure 8 shows the companies with NEV credit surpluses and deficits in 2020 in relation to passenger cars production. While all OEMs of EVs and specialized producers show NEV credit surpluses, all traditional Sino-foreign JVs based on conventional ICE vehicles reveal heavy deficits. This is especially the case of FAW-VW, SAIC-GM and SAIC-VW, but also of Geely, the most important independent company.

[29] "China's GAC scolds Stellantis over joint venture plan", by Piovaccari G. and Goh B., *Reuters*, January 27, 2022.
[30] "Stellantis, China's GAC to terminate loss-making joint venture", *Reuters*, July 18, 2022.
[31] "BMW AG acquires majority stake in BMW Brilliance Automotive Ltd. leading to full consolidation effective", BMW Group, Press release, 11 February 2022. https://www.press.bmwgroup.com/global/article/detail/T0367989EN/ad-hoc:-bmw-ag-acquires-majority-stake-in-bmw-brilliance-automotive-ltd-leading-to-full-consolidation-effective-11-february-2022?language=en
[32] "Brilliance Auto's parent goes into bankruptcy procedure", *Gasgoo*, *China Automotive News,* November 20, 2020.
[33] "VW takes majority stake in joint venture with JAC", by Randall C., *Electrive.com*, December 8, 2020. https://www.electrive.com/2020/12/08/vw-takes-over-majority-of-joint-venture-with-jac/, "VW's China plan with JAC sparks tensions with other partners, report says", *Automotive News Europe*, September 13, 2021. https://europe.autonews.com/automakers/vws-china-plan-jac-sparks-tensions-other-partners-report-says
[34] "Tesla goes big in China with Shanghai plant", by Goh B., *Reuters*, July 10, 2018.
[35] "Tesla ramps up electric car production in China", *Electrive.com*, June 9, 2021. https://www.electrive.com/2021/06/09/tesla-ramps-up-production-in-china/

To comply with the dual-credit targets, the best choice is to engage in the production of NEVs[36]. This option is the most convenient in the medium and long term and the most consistent with the government's expectations.

Figure 8 - Car Manufacturers and NEV Surplus/Deficit (2020 data)
Source of data: FitchRatings (2021)



VW-SAIC, the most important JV in China, was among the first to move. The first factory dedicated to NEVs started production in October 2020, with an annual capacity of 300,000 vehicles[37]. The model produced, ID.4 X of the ID family, is based on MEB (modular electric drive matrix) technology developed in Germany by VW for all the group and subsidiaries[38]. GAC-Toyota started in 2021 a new energy vehicle (NEV) project for the production of Toyota's new-generation global model with an annual capacity of 200,000 vehicles[39]. GAC-Mitsubishi set up a new R&D center for a jointly developed NEV scheduled for mass production in 2021. GAC Honda planned to increase its production

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[36] The other options are to reduce the average fuel consumption for the existing model range, or buy NEV credits from other producers or compensate with surplus credits of the subsidiaries. However, the market for conventional vehicles is going to shrink in the future, and the purchase of credits creates great financial pressure on the company.

[37] "VW takes majority stake in joint venture with JAC", *Electrive.com*, December 8, 2020. https://www.electrive.com/2020/12/08/vw-takes-over-majority-of-joint-venture-with-jac/

[38] "SAIC VW's EV-only plant starts official production", *Gasgoo, China Automotive News,* October 27, 2020.

[39] "GAC Toyota's NEV project with annual capacity of 200,000 units goes into operation", by Dorothy Zhang, *CNEVPOST*, July 26. https://cnevpost.com/2021/07/26/gac-toyotas-nev-project-with-annual-capacity-of-200000-units-goes-into-operation/

capacities for NEVS by 120,000 vehicles per year with the construction of a new plant, which will be completed in 2024[40]. Dongfeng Motor Company (DFL), the Chinese joint venture of Dongfeng and Nissan, plans to introduce 17 electrified vehicles by 2023. The share of electrified models in the total sales of the company should reach 30 per cent by 2024. Dongfeng Honda Automobile, the JV between Honda and Dongfeng, will build a new dedicated electric vehicle (EV) plant with a production capacity of 120,000 units aiming to start production in 2024. Toyota plans to build a new electric vehicle plant with its partner FAW Group for the production of 200,000 cars[41].

The good prospects of the Chinese NEV market have given impetus to a new wave of joint ventures between Chinese groups and foreign OEMs, this time only related to electric cars, favored by the dual credit policy (Yeung 2018). The aim is to replicate, with the new technology, the same success that foreign OEMs had in the past with conventional cars. This third wave of agreements has been developing over the last ten years (Figure 4).

BYD is among the first companies to have undertaken this path, alongside the autonomous development of its own models. With its first partner, the German Daimler, BYD created BYD-Daimler New Technology Automotive in 2010 for the production of the Denza (brand) line of premium electric cars designed by the Mercedes-Benz team. However, this agreement has so far not achieved the expected results in terms of sales. Recently, the two companies agreed for an equity transfer from Daimler to BYD[42]. After government approval, expected in mid-2022, the Chinese company will hold 90% and Daimler 10% of the company. In this way, the role of the German firm in the JV will be greatly reduced. In 2020, BYD set up another joint venture with the Japanese group Toyota. The new company, BYD-Toyota EV Technology, is committed to the development and production of BEVs for the Chinese market.

Much more promising is the agreement signed in 2020 by Geely with Daimler-Mercedes-Benz, which gave rise to the establishment of the JV Smart Automobile Co.. Note that Geely has a stake of nearly 10% in the Daimler group. The new company will be involved in the development and production in China of a new all-electric model of the Smart for the global market. The goal is a production of 300,000 cars.

China's JAC (Anhui Jianghuai Automobile) and VW formed a joint venture in 2018 to develop and manufacture EVs for the Chinese mass market (JAC-Volkswagen Automotive). The company is expected to make 250,000 vehicles in 2025 and 400,000 in 2029.

The private group Great Wall (GWM) together with BMW formed the JV Spotlight Automotive in 2019 with the aim of producing the electric version of the MINI, as well as a compact SUV[43]. Production capacity should reach 160,000 vehicles per year when fully operational[44]. FAW and VW, which produce together in one of the first JVs in China, signed an agreement in 2021 for the establishment of a new JV between AUDI and FAW for the production of BEVs with the PPE (Premium Platform Electric) platform developed

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[40] "GAC Honda to build new plant with 120,000 annual capacity", *Electrive.com*, August 18, 2021.
[41] "Toyota plans new $1.2 billion EV plant in Tianjin with FAW: document", *Reuters*, February 29, 2020
[42] "Daimler Cuts Stake in Chinese Electric-Car Venture With BYD", By Rauwald C., *Bloomberg*, December 24, 2021.
[43] "GWM-BMW's JV Spotlight Automotive granted business license", *Gasgoo*, China Automotive News, December 31, 2019. https://autonews.gasgoo.com/70016710.html
[44] Company news: GWM News 2018 12 03.

by AUDI. The group Audi-VW will held the majority share (60%) of the company. Production is scheduled to start in December 2024 with the capacity to manufacture 150,000 cars a year.

In Europe and other advanced markets, the competitive scenario is completely different. Major incumbent legacy automakers dominate the scene and strictly control the development of the NEV market. These companies are trying to transfer the strong market position gained with conventional vehicles to the fast growing NEV market. Most OEMs do not make profits (Baik ert al 20219) from selling electric vehicles and are basically following a preemptive strategy in order not to be left behind.

In these markets, Chinese firms are new entrants, and their market share is still negligible. In the European Union, for example, no Chinese marques appear among the top 25 battery electric passenger cars registered in 2021. Chinese companies are clearly lagging behind and have a hard time selling their products. Why should consumers prefer them and stop favoring historic brands whose reliability, innovative capacity, sales and service network have been known for a long time?

All incumbent companies have expanded their product range with various types of electric models and are investing heavily in sustainable mobility, albeit in different ways and intensities. In 2021, for example, the VW Group sold globally more than 750,000 plug-in electric vehicles (BEVs+PHEVs), ranking second after Tesla[45]. Stellantis produced 361,000 electric vehicles (PHEVs), Hyundai-Kia more than 300,000. BMW, Mercedes-Benz, and Renault-Nissan-Mitsubishi close the list of the top sellers with 220-280,000 electric vehicles sold each.

According to company targets, by 2030, fully electric cars will account for 100% of sales for Volvo, 100% of European sales for Stellantis and Ford, 70% for VW (in Europe), BMW 50%. GM plans to reach carbon neutrality in 2040, and for Mercedes all new models will be fully electric from 2025 (IEA 2022). Given their leadership in the HEV and PHEV technology, Asian companies are more cautious: Toyota is the most skeptical about the future of electric vehicles, and plans to sell not more than 40% of BEV + PHEV by 2030, Honda 40% Hyundai-Kia 25% (IEA 2022, Corporate Sites 2021, Gimbert 2021). Toyota, in particular, is the company that has invested the most in HEVs and still shows strong skepticism about the future prospects for BEVs (see the press statements of Toyota President Akio Toyoda[46]).

More importantly, these announcements are backed by a significant and ambitious program of investments in sustainable mobility by the main global players. VW group is by far the most committed to electric vehicles, with more than $100 billion of planned investments[47]. All together, German companies are leading the race with a planned investment by 2030 of roughly $185 billion. Stellantis is rapidly catching up, with

[45] Data estimated by EV Volumes for CleanTechnica.com. See also: "World's Top 5 EV Automotive Groups Ranked By Sales: 2021", by Mark Kane, *INSIDEEVs*, February 02, 2022. https://insideevs.com/news/564800/world-top-oem-sales-2021/

[46] "Carbon is our enemy, not ICE – Akio Toyoda urges Japan to not follow Europe's EV model blindly", by Tan D., *Paultan.org*, 28 September 2021. https://paultan.org/2021/09/28/carbon-is-our-enemy-not-ice-akio-toyoda-urges-japan-to-not-follow-europes-ev-model-blindly/. "Toyota's Chief Says Electric Vehicles Are Overhyped", by Landers P., Wall Street Journal, December 17, 2020.

[47] Exclusive: Global carmakers now target $515 billion for EVs, batteries", by Paul Lienert and Tina Bellon, *Reuters*, November 10, 2021. https://www.reuters.com/business/autos-transportation/exclusive-global-carmakers-now-target-515-billion-evs-batteries-2021-11-10/

announced $35 billion investments. The American companies Ford, GM and Tesla plan to invest more than $80 billion, while Japanese companies are lagging behind, with less than $40 billion of planned investments in EVs.

6. Entry options for the Chinese companies

However, the NEV market is rapidly growing and, with appropriate and smart entry strategies, Chinese firms can increase their market appeal. There are several options available, all of which are not easy to follow.

(1) The first is **direct entry** with own brands, via exports or greenfield investments. This strategy was followed in the past by some Chinese firms with conventional vehicles, but it failed. For a long time, the cars made in China were perceived by consumers as being of low quality and reliability. Sales of Chinese cars in Europe have always been negligible.

Landwind, a marque of Jangling Motor Holding (JMH), was the first Chinese company to try to enter the European market in 2005 with a copy of the Opel Frontera[48]. However, the car failed miserably a crash test performed by ADAC, the German Automobile Club, irreversibly damaging the brand's reputation for quality and safety. The same fate happened to Brilliance in 2007, which obtained only one in five possible stars in the safety test. As a consequence, after few years both companies pulled out of the European market. The impact of these two cases went far beyond the companies involved. Since then, sales of Chinese conventional cars in Europe have always been negligible.

Things are starting to change with NEVs. Many opportunities for Chinese companies are opening up in the countries most committed to sustainable mobility, like Norway, where EVs accounted for around 86% of sales in 2021 (IEA 2022), but also Sweden, Germany and other North-European markets.

NIO, Xpeng, BYD, and Li Auto are shipping an increasing numbers of electric cars in Europe, in direct competition with Tesla, VW and other top manufacturers. Other Chinese EV carmakers, like Geely with the Zeekr brand[49], are ready to follow. However, although the product and brand image of these firms and start-ups is much better compared to the past experience, competition is very tough and market shares are still low.

The market appeal and prospects of Chinese brands in Europe do not yet justify substantial greenfield investments in car assembly. Very few companies have followed this option so far. In the conventional technology, the first example is Great Wall, which opened the first wholly owned vehicle manufacturing plant in Russia in 2019, with a production capacity of 150,000 units, targeting the Russian and European markets. In 2012, the company operated a small-scale assembly facility in Bulgaria in joint venture with a local manufacturing partner (Litex Motors), based on semi-knockdown (SKD) kits imported from China[50], targeting Eastern European markets. However, the plant shut down in 2017 for bankruptcy[51].

[48] "Landwind Sales Data & Trends for the European Automotive Market", by Demandt B., *CarSalesBase*. https://carsalesbase.com/europe-landwind/
[49] "Zeekr is getting ready for EU entry", *Electrive.com*, January 11, 2022.
[50] "Great Wall plants export foothold in Europe", *Automotive Logistics*, February 29, 2021.
[51] "Great Wall intende tornare a costruire auto in Europa", *Il Sole24Ore*, 13 settembre 2019.

Things does not seem to be different with EVs. William Li, founder and CEO of NIO, recently stated that he would only consider opening a manufacturing facility in Europe if sales in the region reach 200,000 units[52], a goal still far from being achieved for all the Chinese EV sellers.

The only example of greenfield investment in Europe is the announced one billion euro investment of FAW in Italy, in joint venture with Silk, for the production of high-end electric sports cars, a niche market. However, after a year, the promised investment still has to be made and many think it will never be realized.

(2) An alternative option is to gain reputation and market recognition by **acquiring brands and companies** already rooted in European markets. SAIC and Geely are successful examples of this strategy. According to a recent report, Chinese-owned European brands accounted for 35% of Chinese EV exports to Europe in 2021, compared to only 2% of Chinese brands (Sebastian and Chimits 2022)

In 2005, Nanjing Automobile acquired most of the assets of MG-Rover Group, after the bankruptcy of the British company. The aim was to resurrect the MG and Austin brands by using the production facilities located in UK. In 2007, Nanjing Automobile merged with SAIC and became a subsidiary of that company. Sales were very low for many years (few hundred units). Things started to change after 2013, with new successful models designed in Europe. According to *CarSalesBase* data, SAIC sold 54,000 cars in UK and other European markets in 2021, almost four times more than in 2019 and doubling the sales of 2020.

Geely, a privately owned company, is probably the first Chinese company trying to become a global carmaker[53]. According to an interesting anecdote reported by Norihiko Shirouzu of Reuters[54], when Li Shufu, the founder and owner of Geely, went to Detroit in 2008 to discuss the purchase of Volvo Cars, Don Leclair, finance chief of Ford Motor that owned the Swedish company, told the unknown businessman from China “Do you know how big Volvo is?” and dismissed the meeting by showing him the door of the Ford headquarters. At that time, Geely had less than half of Volvo’s size and its most successful car was the “King Kong” sedan. Two years later, Geely bought the company. Today, Volvo is a crucial part of Geely’s global strategy. The company clearly benefited from Volvo’s research center and reputation for high safety standards. Together with Volvo, Geely is pursuing the strategy of launching a specific brand for the electric car. Polestar, a premium brand developed by Volvo in the late nineties, offers high-end electric models made in China. Lynk & Co, another recent BEV car brand jointly developed by Geely and Volvo and targeted at advanced markets, offers SUV crossover with a new business model: connectivity, direct online sales and the possibility of subscription services. In 2017, Geely acquired a controlling stake in Lotus, a historic British sports car maker. With another specialized brand, Zeekr, the company intends to compete globally with Tesla in the premium EV segment.

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[52] “Chinese carmaker Nio warns energy crisis slowing European expansion”, by Peter Campbell, *Financial Times*, September 27, 2022.
[53] “Geely sets its sights on becoming China’s first global carmaker”, by Campbell P., Milne R., Shepherd C., *Financial Times*, February 16, 2020.
[54] “Special Report-How the Chinese tycoon driving Volvo plans to tackle Tesla”, by Shirouzu N., *Reuters*, September 2, 2021.

It is worth mentioning in this context that Geely in 2018 and BAIC in 2019 have acquired minority stakes in the German luxury carmaker Daimler-Benz, becoming the single largest shareholders, with respectively 9.69% and 9.98% of the company. Both firms are involved in joint ventures with Daimler in China, BAIC since 2006 and Geely since 2020. These equity holdings strengthen the links and cooperation between these automotive groups both in China and globally.

Mergers and acquisitions can be an effective strategy to gain a quick access in mature markets dominated by strong incumbents. Some opportunities of new acquisitions may arise in the future with other struggling historical brands or companies in Europe or elsewhere. However, the most valuable brands are in the pocket of leading multinational groups and, in the new competitive scenario, it is quite unlikely that these will be sold to Chinese competitors.

A variant of the brand acquisition strategy is the **export of complete knock-down (CKD) or semi knock down (SKD) kits** of auto parts and components[55]. These kits must be later assembled by a local producer. This entry strategy is widely used by Chinese car producers in many developing countries. According to some estimates, these shipments represent around 40% of the exports of Geely, Chery and Great Wall[56]. A successful example of this strategy in Europe is the DR Motor in Italy (DR stands for Di Risio, the name of the entrepreneur). This firm imports car components produced in China by Chery Automobile and JAC Motors and, after assembling them under license, markets the finished vehicles in Italy with the DR and EVO brands. The advantage of this strategy is that import taxes applied on knock down kits are much lower than those applied to finished vehicles. The importers/assemblers can sell the cars with a competitive price and a good value for money.

7. Concluding remarks

After decades of relative stability, the auto industry is currently in a phase of a **major transition**, marked by profound technological change, the evolution of mobility models, and government policies that dictate the agenda and timing of the ecological transition in each country. In this scenario, trying to predict the future structure of the industry on the basis of data from the last few years or months can be misleading. The real and decisive battle has probably yet to begin. This will happen when the electric car will no longer be a niche and very expensive product, but it will invade the mass market. This step will be crucial to understand the future configuration of the oligopoly and all major global players are gearing up to meet this challenge.

Recent business history has shown that Chinese companies and brands can successfully compete in advanced markets and challenge large multinationals in established, apparently untouchable consumer goods oligopolies. This is what is happening, for example, in the home appliance and consumer electronics industry with Haier, Hisense, and Tlc, and in the smartphone and mobile device industry, with Huawei, Xiaomi, Oppo and others, where Chinese brands are common and appreciated in many advanced countries. Although

[55] "CKD and SKD kits refer to all or nearly all of the auto parts and components necessary to assemble a complete vehicle, which must be packaged and shipped in a single shipment, and which must go through the assembly process to become a complete vehicle once they have been imported into the importing country" (WTO, *China – Measures Affecting Imports of Automobile Parts*, AB-2008-10, 15 December 2008, p.4.
[56] "Developing with China's export demand", by Coia A., *Automotive Logistics*, April 1, 2013.

Chinese products are usually competitive in price, they are increasingly perceived as being of good quality, reliability and innovative.

More importantly, industrial history suggests that radical technological changes can favor a reorganization or even a disruption of existing oligopolies, with the emergence of new competitors and a new geography of production.

This is what happened, for example, in the mid-1960s, with the transition from vacuum tubes to transistors in consumer electronics (Chandler 2005, Gliese et al. 2020). Large American companies, such as RCA, General Electric, Westinghouse, and Philco, or German firms, such as Telefunken and Grundig, have been almost wiped out from the industry by the emergence of Japanese manufacturers, such as Sony and Matsushita (Panasonic). A similar story happened in the watch industry. Swiss companies have long dominated the market with traditional mechanical technology. With the spread of quartz and digital technology, in the 1970s and early 1980s, the industry was disrupted. Again, Japanese companies, such as Seiko, Casio, and Citizen, have benefited from the radical technological change.

In the above examples, path dependency probably sealed the fate of the incumbents. To protect the investments and the accumulated experience with the old technology, these companies have delayed the adoption of the new and promising technology for too long.

Can this happen in the auto industry? Legacy automakers that have so far dominated the global industry are certainly aware of these risks. It is therefore very unlikely that they will remain rooted in the old combustion technology, of which they are undisputed leaders, to leave the development of the electric car and the future of the rich automotive market in the hands of new entrants -startups or Chinese manufacturers. Although with delays and hesitations, the investments and commitments on electric cars and sustainable mobility by the major world players are significant and growing, as we have seen in the previous pages, and will be even more so in the future.

Uncertainty about the future technology still characterizes the industry. Companies are offering and experiencing different production mixes of "green" cars (HEVs, PHEVs, BEVs, and FCVs). Although battery electric cars (BEVs) seem to emerge as the winning technology, batteries can have different chemistries and the search for new solutions is constantly evolving (Ncm, Lfp, Solid-state Li-ion, lithium-sulphur (Li-S) and lithium air batteries (Li-Air)) It is not clear if there will be a single standard or if different technologies will coexist, as in the case of petrol, diesel or natural gas engines, as seems more likely. What matters is that the emergence of one technology rather than another could give a market advantage to those who have invested more and better than others in it. But even this advantage could be short-lived in the context of ever changing technologies.

For sure, costs will play a major role. The costs of the battery in the first place, since it represent the most important component of the electric car. From this point of view, companies operating in China have an edge, because the production volumes guaranteed by the size of the NEV market allow companies to test models and technologies on a large scale and to reach economies of scale and learning experience before others. This is the reason why foreign companies have a strong interest in continuing to invest in China, in direct competition with local companies or in partnership agreements with Chinese groups. Although Chinese brands seem to prevail over foreign ones in the electric car market at the moment, the effects of investments by international players in China, especially VW and

Tesla, but also by other German and Japanese companies, will be seen more clearly in the future.

In this scenario, Chinese companies, backed by a strong government, have the opportunity to play a leading and prominent role with their own brands and innovative car models, not only in the large domestic market but also globally. Based on cost advantages, efficient supply chains, new connectivity solutions, and new business models, Chinese companies can be strong competitors especially in the mass market and in the segment of urban mobility vehicles.

From the Chinese point of view, the past experience of South Korea, and formerly of Japan, is very encouraging. Since the 1970s, Japanese companies have conquered the global market, where they were virtually unknown until then. Toyota is still the largest carmaker in the world. Not so long ago, South Korean cars were considered low-quality and poorly innovative products. South Korean companies have made huge progress in the automotive industry and now the perception has completely changed. Thanks to electric cars and sustainable mobility, China can follow the same path and achieve similar results in world markets. Given the size of Chinese industry, the impact on international markets could be even stronger. Recalling the example of the recent investment promised by Silk-FAW in the Italian motor valley, we expect the red flag ("hongqi") to be planted in the mass market of electric cars, rather than in the top and luxury segment of the world market. If geo-political conflicts do not put a spanner in the works, it's probably just a matter of time.

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