POLITECNICO DI TORINO

Analysis of China’s Automotive Industry Economy

Tutor：

Luigi Benfratello

Candidate:

Zhuoyan Liu

July 2020

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor Prof. Luigi Benfratello for his instructive advice and guidance while I worked on my thesis.

I would like to thank my parents and my grandmother for their continuous support and encouragement which make me persistent with my study.

I would like also to express my deep gratitude to Politecnico di Torino where I have learned valuable knowledge, expanded my horizon and enriched my life. The experience in Politecnico di Torino and Torino will be an invaluable asset to my life.

Contents

List of Figures

List of Tables

1. Introduction

1.1 Overview of Global Automotive Industry

As one of the world's largest economic sectors by revenue, the automotive industry has historically been one of the most important industries in the world. Europe is the cradle of automotive industry. The automotive industry began in the 1860s with the development of internal combustion engine in France and Germany. In 1885, Karl Benz designed the world's first automobile driven by an internal combustion engine. From that moment on, the world has been put on wheels. For many decades after the invention of motor vehicle, the United States dominated the world's automotive industry in production through the invention of mass production techniques. For example, the United States produced almost 75 percent of world's motor vehicles after the World War II. Figure 1 shows the famous Model T manufactured by Ford's assembly line. From 1980 to 2009, the United States and Japan have been alternatingly the leader in motor vehicle production. From 2009 on, China has taken the first position thanks to its automotive industry boom after stepping into 21st century. In the past few decades, the automotive industry in the world remains generally a continuously expanding trend. Figure 2 shows the world motor vehicle production since 1950. Figure 3 presents correspondingly the shares of major producer countries in the world. In 2017, the global automotive industry achieved a total production of 97 million vehicles.

Figure 1. Ford Model T Car

The automotive industry includes a wide range of companies and organizations dedicated to the design, research and development, manufacturing, marketing and selling of motor vehicles. The automotive industry can be divided into different segments according to different criteria such as passenger automobiles and commercial vehicles from the perspective of vehicle category.

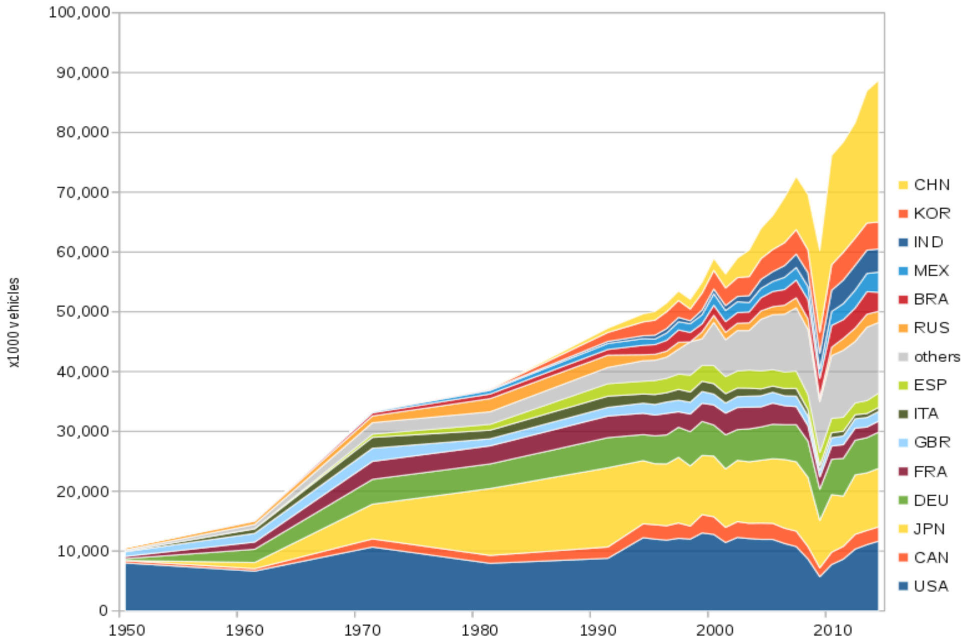


Figure 2. World Motor Vehicle Production
(Ref. https://en.wikipedia.org/wiki/Automotive_industry)

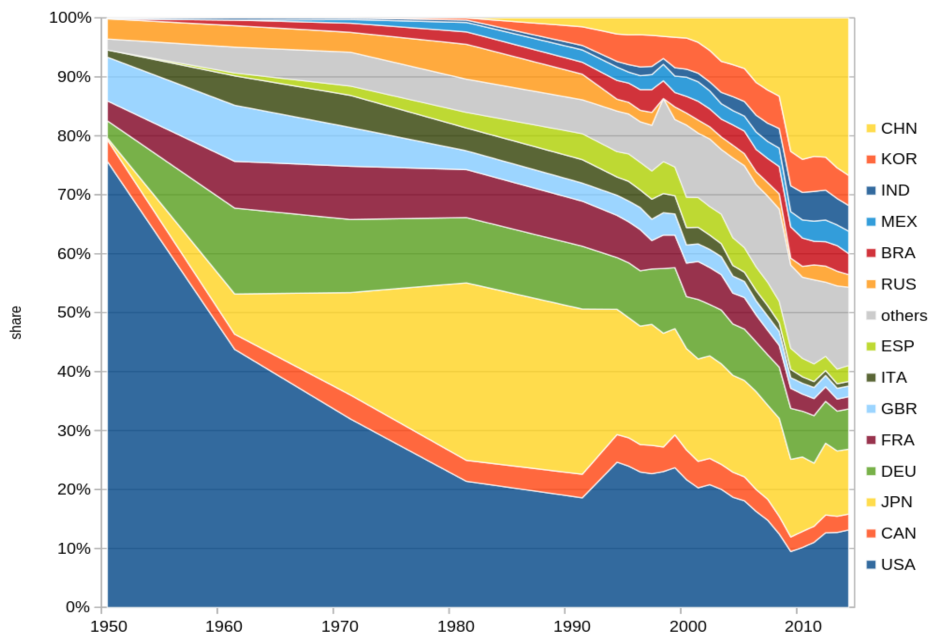


Figure 3. World Motor Vehicle Production Shares Evolution
(Ref. https://en.wikipedia.org/wiki/Automotive_industry)

More than one hundred years' development of the automotive industry has witnessed the birth of multiple vehicle brands, the construction of automotive corporations, and the development history of individual countries. There are incumbents that have developed into global presence and new entrants as new market trends emerge. Table 1 shows the largest vehicle manufacturers of 2018 from the perspective of sales volume of light-duty vehicles. The data were from the statistics of Focus2Move. Due to the global scope of competition, these major manufacturers have formed groups or alliances to increase their competitive strength. As is shown in Table 1, most of the largest automotive manufacturers are located in Europe, Japan and the United States. China's automotive industry also fostered several large indigenous groups such as SAIC and Geely and Chang'an. In correspondence to the largest automakers in the world, Table 2 shows the top vehicle manufacturers of China according to the data of 2018. It's necessary to mention that the global ranking and ranking of China's automakers are based on the data of automotive groups. One automotive group generally has several subsidiaries or brands. And almost every Chinese automotive group has cooperation with foreign automotive groups. When the comparison is made among global automotive groups, the sales volumes by these joint-ventures in China are attributed to foreign automotive groups instead of their Chinese partners. But the data in Table 2 include the sales amount generated by joint-ventures under the automobile groups. Besides, the data of production and sales presented in this thesis to make comparisons among countries or regions in China are all based on the origin of production rather than origin of brands.

Rank	Group	Region	Sales Volume
1	Volkswagen Group	Germany	10,830,625
2	Toyota Group	Japan	10,520,655
3	Renault-Nissan-Mitsubishi	France/Japan	10,360,992
4	General Motors	USA	8,786,987
5	Hyundai Group	South Korea	7,507,945
6	Ford Motor Company	USA	5,734,306
7	Honda Motor Company	Japan	5,265,125
8	Fiat Chrysler Automobiles	Italy/USA	4,840,664
9	Groupe PSA	France	4,125,683
10	Suzuki	Japan	3,213,224
11	Shanghai Automotive Industry Corporation	China	2,899,530
12	Daimler Group	Germany	2,742,249
13	BMW Group	Germany	2,493,740
14	Geely Holding Group	China	2,293,780
15	Mazda Motor Corporation	Japan	1,633,977

Table 1. Global Largest Automotive Manufacturers by Sales Volume in 2018

Rank	Group	Sales Volume
1	SAIC (Shanghai Automotive Industry Corporation)	7,051,700
2	DFM (Dongfeng Motor Corporation)	3,831,000
3	FAW (China FAW Group Corporation)	3,418,000
4	BAIC (Beijing Automotive Industry Corporation)	2,402,000
5	Geely Auto Group	2,150,000
6	GAC (Guangzhou Automobile Group Corporation)	2,147,000
7	Chang'an (China Chang'an Automobile Group)	2,137,800
8	GWM (Great Wall Motor Company)	1,053,039
9	Brilliance Auto Group	779,000
10	Chery Automobile Company	737,000
11	BYD Company	520,687
12	JAC (Jianghuai Automobile Group Corporation)	462,000

Table 2. Largest Vehicle Manufacturers of China

For more than one century after motor vehicle was invented, the automotive industry has been a major contributor to world economy. Due to the complexity of automotive manufacturing network, many tiers of suppliers distributed in a wide range of industries are involved such as metal processing, rubber products, plastics. Because of automotive industry's consumption of products and resources from many other manufacturing sectors, it is a major propeller of manufacturing contribution to GDP. The automotive industry has historically contributed 3.0-3.5 % to the overall Gross Domestic Product of the United States. The automotive industry has shaped not only the global economy but how billions of people live. In the United States, there are more than 8 million jobs generated by automotive industry; in Europe, roughly 12 million jobs are offered; in Japan, more than 5 million, and in China, this number achieves more than 32 million. It is reasonable the automotive industry is seen as one of the pillar industries in many countries. Automotive industry is also a domain which concentrates high technology research necessities. Professional and technical services have been a critical part of automotive industry development. In addition to those aspects, finance and insurance, transportation, logistic and retail trades etc. become more tightly associated with automotive industry as it become diversified. Considering the aforementioned significance of automotive industry, the economic performance and automotive industry development trends can be used as indicators of the national economy since the automotive manufacturing growth is closely linked to the growth of economy as a whole.

Apart from these aforementioned positive effects of automotive industry on global economy, employments, ways of how to live, environmental pollution and protection and humanity safety etc. have also become the associated major concerns of automotive industry. More stringent regulations have been prescribed in order to address the emission and energy source consumption issues. Consequently, technologies of alternative fuels and new energy propulsion systems have become a main role in modern automotive development. As a main part of global automotive industry, China is also making its effort to face the challenges and to be involved in the new evolution trends. In the following part, an introduction of China's automotive industry development history is made.

1.2 Development Roadmap of China's Automotive Industry

China's automotive industry has relatively a short development history compared to the US, Japan and Europe. But as revealed by reports, China has overtaken United States and Japan in 2009 to become the world's largest car producer. In the past several decades, the automotive industry of China has been growing with a dramatic speed and expanded into a scale with 29 million vehicles produced in 2017, more than 14,000 automotive enterprises and more than 100 vehicles brands, though China has quite a late start compared to many western countries. There are several milestone events in China's automotive development history, such as the first automotive plant, the creation of first domestic brand, China entering into WTO, the characteristic joint-venture pattern and emerging new-energy automotive industry.

China's automotive industry started in 1950s at which stage the main alliance of China was with the USSR. China built its first automotive plant i.e. the First Automobile Works (FAW) in 1953 with plants and licensed auto design under the help of USSR. Figure 4 demonstrates the first motor vehicle i.e. the Jiefang truck. In the first 30 years after establishment, the first product Jiefang truck remained almost unchanged. Following the establishment of FAW, China relied on her own sources to design and construct several new automotive factories in Nanjing, Shanghai, Jinan, Beijing and the Second Automobile Company which was later called Dongfeng. The naming of the first several vehicle models such as Jiefang and Yuejin showed significant correlation with the time period background when they were created. In the first three decades of China's socialist economy, the majority of production of vehicles were trucks and passenger car industry accounted for only a minor part of vehicle production. In 1958, the first self-produced car Dongfeng CA71 was born, which represented the creation of domestic car brand. Figure 5 presents the first car produced by FAW. During these thirty years, China just produced a total amount of 5200 cars. Besides, the production and sale volumes of whole automotive industry were quite small, with a maximum of 200 thousand per year.

Figure 4. China's First Jiefang Truck

Figure 5. First Self-produced Car CA71 by FAW

As the Third Plenum of the 11^{th} Chinese Communist Central Committee took place in 1978, which signified the start of reform and opening of China, China's automotive industry came into the proliferation phase. From that moment on, China has begun to open up to the reset of the world and the transition from planned economy to market economy led the automotive industry or more precisely speaking the whole industry field to a new stage. The increase in volume of output and also the range of products were witnessed. With the relaxation of planning of economy, there were more customers and market requests for cars and other vehicles other than trucks increased dramatically. There has ever been a fabricated story about China' s first peasant to own a car to stimulate personal spending and attract foreign investment. Car sales increased greatly in this time period, although most of cars were purchased by government offices. Besides, saloons and mini vans started to be produced to provide the taxi market. Under the stimulation of demand, some machinery factories belonging to Weapon and Aviation Industry also began to produce light trucks, mini vans and passenger cars. As recorded by the historic report, the number of automotive factories increased from 55 in 1978 to 114 in 1985. However, due to the imbalance between domestic production and great increase of demand, automotive import trade begun to rise also dramatically, in spite of the high import duty on foreign vehicles. There were several main exporters of cars to China, such as Soviet Union, Japan. In middle 1980s, Japan's vehicle exports to China increased from 10800 to 85000, and consequently China became Japan's second largest export market after US. Taxi companies showed particular thirst for Japanese cars.

In 1994, the Chinese government published the 'Automotive Industry Policy'. The government designated several industries as 'Pillar Industries', which was dedicated to stimulating the national economy. Among these 'Pillar Industries' the automotive industry was chosen within expectations considering the fact that the automotive industry is a highly comprehensive industry. A lot of other industries such as petroleum, metallurgy, electronics are all involved in the process of car manufacturing. In the early stage of automotive industry development, the lack of market mechanism to balance the demand and supply resulted in the situation that domestic small-scaled manufacturers didn't have capabilities to compete with foreign automakers. When the government realized the situation and the necessity to make some adjustments on automotive industry, the policy was come up with. The Automotive Industry Policy specified four key objectives: to construct large scale groups of car and light truck producers to concentrate the automotive development sources; to improve components industry; to build up automotive product development and research capabilities; to personal car ownership. The policy was seen an aggressive and ambitious schedule for the Chinese automotive industry's development. The conditions of foreign investment on automotive industry were also regulated in this policy.

Another very important event in China' automotive industry development history is China's entering into WTO in 2002. This critical event means the further opening up of China to the world. The automotive industry went through a number of important changes, including the tariff reductions. Before China's entering into WTO, the Chinese automotive market was protected by high tariffs. The reduction of tariffs was indeed an important change, not only to China' domestic vehicle manufactures but also the foreign automakers. The Chinese government had ever protected local vehicle enterprises by imposing high tariffs on imported vehicles. The tariff rate for imported cars reduced to 30% in 2005, and dropping further to 25% in 2006. As a matter of fact, in 1990s, the rapidly developing automobile market and growing presence of foreign manufactures had imposed pressure on China to build competitive automakers. When China begun to negotiate to join WTO, there was a limited tariff protection period left for Chinese enterprises. Therefore, the joining of WTO and these associated policy changes implied a new era of China's domestic automotive industry. The actions after joining WTO significantly propelled the growth of China's automotive market, with an average increase rate of 21% between 2002-2007 and correspondingly an increase of one million sales. The overall production witnessed an increment of 38.8% and 36.7% in 2002 and 2003 respectively. As a consequence, China became the fourth largest auto producer and the third largest auto-market in the world in around 2005. Under the effects of this automotive industry boom, a variety basic and service-associated fields e.g. machinery, textiles, auto-financing, aftermarket distribution and repair services embraced their fast development.

Within the development of China's automotive industry, there has been a characteristic enterprise pattern i.e. the joint-venture between domestic automaker and foreign vehicle manufacture. The joint-venture pattern has played a significant role during the development roadmap. With the coming up of China's reform and opening in 1978, de facto leader Deng Xiaoping said the joint-ventures in automotive field were allowed to be built. Under this strategic background, domestic automotive enterprises sought actively for foreign investment and introduced advanced technologies. The first joint venture was found in 1983. The American Motors Corporation signed a 20-year contract with Beijing Automotive Industry Corporation to produce their Jeep-model vehicles in Beijing. In 1984, Volkswagen started its cooperation with Shanghai Automotive Industry Corporation to make passenger cars in Shanghai, and Peugeot signed a contract with Guangzhou Automobile Group upon a passenger car project. As prescribed in the Automotive Industry Policy of 1994, domestic firms had to take up more than 50% of share of the joint-venture which produced complete vehicles and engine products. This regulation remained its effect in the following 25 years until 2018. In 2018, Chinese government announced that the limitation on portion of foreign equity was canceled for special vehicle and new-energy vehicle enterprises. Moreover, the limitation will be abrogated for commercial vehicle and passenger car enterprises respectively in 2020 and 2022. With China entering into WTO, the dramatic growth in automotive industry, particularly in 2002 and 2003, attracted a great amount of foreign investment in automotive field. Those existing foreign manufactures sought to expand their manufacturing capacity and extends the production line. Many new enterprises came also on Chinese ground. Table 3 summarizes the automotive joint-ventures in China with their dates of establishment.

Chinese Automakers	Sino-Foreign Joint Ventures
BAIC (Beijing Automotive Industry Corporation)	Beijing Benz (1983), Beijing Hyundai (2002), Foton Daimler (2012)
Brilliance Auto	Brilliance BMW (2003), Brilliance Renault (2017)
BYD Auto	Shenzhen BYD Daimler New Technology (2010)
Chang'an Automobile Group	Chang'an Ford (2001), Chang'an-Mazda (2005), Chang'an-PSA (2011), Chang'an-Suzuki (1993)
Changhe Auto	Changhe Suzuki (1995, broke up in 2018)
Chery Auto	Qoros Auto (with Israel Corporation) (2007), Chery Jaguar Land Rover (2012)
DFM (Dongfeng Motor)	Dongfeng Nissan (2003), Zhengzhou Nissan (1993), Dongfeng Peugeot Citroen (2002), Dongfeng Honda (2003), Dongfeng Nissan-Diesel (with AB Volvo) (1996), Dongfeng Renault (2013)
FAW Group Corporation	FAW Volkswagen (1991), FAW Audi (1988), FAW GM (2009), FAW Mazda (2005), FAW Toyota (2000)
Fujian Motor Corporation	Soueast Mitsubishi (1995), Fujian Benz (2007)
GAC (Guangzhou Automobile Group Corporation)	GAC Honda (1998), GAC Toyota (2004), GAC Fiat Chrysler (2010)， GAC Mitsubishi (2012)，GAC Hino (2007)
Geely Auto	Volvo Cars (2010), LYNK & CO (2017)
JMH (Jiangling Motor Holding Company)	Jiangling Ford (1996)
Jonway Auto	ZAP Jonway (2010)
Wuling Motors Company	SAIC-GM-Wuling (SGMW) (2002)
SAIC (Shanghai Automotive Industry Corporation)	Shanghai GM (1997), Shanghai Volkswagen (1984), SAIC-GM-Wuling (SGMW) (2002), Nanjing Iveco (Naveco) (1996), Shanghai Sunwin Bus (2000)
JAC (Jianghuai Automobile Group Corporation)	JAC-Volkswagen (2017)

Table 3. Joint Venture Enterprises in China

In 2004, the National Development and Reform Commission issued the 'New Automotive Industry Policy' to address the emerging challenges in automotive industry after WTO accession and make adjustments to changes in this critical industry. Significantly from the policy version release in 1994, the new industry policy provided encouragement and strategic direction for automotive industry. The release of this policy showed great correlation with the economic cooling-down polices after the boom of automotive taking place in 2002-2003. The new policy came up with several key objectives: to encourage autonomous product and brand development to build up a few globally competitive automotive groups and famous vehicle brands; to encourage independent R& D and production for key components and parts and to foster local suppliers; to make industrial structural adjustment; to promote light duty vehicles and new-energy-efficient vehicles. Previous requirements concerning local content rates have been eliminated to encourage global platforms. It could be seen that the government has adapted its role in economy and determined to use market forces to influence the industry's future trend. In the meanwhile, domestic automotive enterprises of China obtained not only encouragement but also pressure to develop themselves. The indication of promoting new energy vehicles implied a new trend in Chinese automotive market.

With the rapid growth of China's automotive market in 21st century, energy consumption and exhaust emission has become a new major concern for China's automotive industry. As a matter of fact, the increased focus on energy-consumption and emission from motor vehicles put intense pressure on the global motor vehicle industry. European Union and the United States all promulgated regulations since 1990s targeting fuel economy and exhaust emissions in order to reduce fuel consumption and alleviate air pollution from motor vehicles. These regulations become more and more stringent as the automotive industry develops. Global automotive industry has been seeking to develop alternative powertrain technologies to satisfy regulations. As was stated in the 2004 'New Automotive Industry Policy', the Chinese government encouraged China's automotive OEMs (Original Equipment Manufacturers) to develop energy-efficient vehicles from a strategic point of view. The new-energy vehicle came into China's motor vehicle market in early 2000s. After Beijing was announced to be the host of 2008 Olympic Games, the Chinese government came up with the slogan of 'Green Olympics, High-tech Olympics and People's Olympics' and new energy vehicle encountered its opportunity. Under the advantageous policies and financial support by the Chinese government, the new energy automotive industry has stepped into a rapid development trace since 2010, while a lot of small-scale enterprises were weeded out in this hyper-competitive domain. China's production of new-energy vehicles grew from around 17,500 units in 2013 to more than 1.27 million in 2018. And it is projected that the annual production of new-energy vehicles in China's automotive market will be 1.5 million. The foreign major OEMs such as Toyota, General Motor also seize on this opportunity and put more investment in China's new energy automotive industry. It is universally recognized that electrification is one of the development orientations of global automotive industry. And this emerging industry subsector remains to be a hot spot attracting capital investment.

Throughout the aforementioned development phases, China achieved a production of 13.79 million vehicles in 2009 including 10.38 million passenger cars and 3.41 million commercial vehicles and surpassed US to become the largest automotive production country by volume. From 2009 on, China has held the first position of production in the world. The annual production of motor vehicles in China has exceeded the production of Europe and even the sum of United States and Japan. In 2017, China achieved the ever highest production and sales, 29.01 million and 28.88 million respectively. At the end of September of 2018, China had 322 million motor vehicles in use, including 235 million passenger cars, which makes China the country in the world with the largest motor vehicle fleet. Foreign invested automotive joint-ventures account for a large proportion of both production and sales. Moreover, the growth roadmap witnesses the continuous development of indigenous automotive enterprises. The growth of production and sales of Chinese indigenous automotive brands is quite evident in the past years. The cooperation and competition between Chinese indigenous corporations and joint-ventures invested by foreign groups are elaborated in 4.2. In addition, the rapid development of automotive industry boosts the growth of the national economy, offers millions of employments, and attracts billions of foreign direct investments.

2. The Role of Automotive Industry in China's Economy

2.1 China in the World Economy

China is the world's second largest economy by nominal gross domestic product (GDP) and ranks first in terms of purchasing power parity (PPP) based economic size, manufacturing, export, merchandise trade and holder of foreign exchange reserves.

Prior to the economic reforms in 1979, China's economy went through a centrally controlled, relatively stagnant period. During this time period, a large share of the country's economic output was controlled by the state, and foreign trades were generally limited with the goal to make China's economy relatively self-sufficient. According to the statistics by Chinese government, the GDP of China grew at an average annual rate of 6.7% from 1953 to 1978. From 1950 to 1978, China's purchasing power parity based per capita GDP almost doubled. However, the growth of purchasing power density of China economy was quite low in comparison to those of developed economies.

In 1979, China's economy stepped into the new stage with the announcement of implementing economic reforms by Chinese government. The economic policies aimed at opening up trade and investment with foreign countries according to free market principles. Since 1979, China has been among the world's fastest growing economies and China's economy has grown substantially faster. China has experienced the fastest sustained expansion by a major economy in history as described by the World Bank. From 1979 to 2018, China's annual real gross domestic product grew at an average annual rate of nearly 10% with reference to Figure 6. In 2001, China entered into the WTO, which means a further opening up of China's economy to the world. It can be seen that the annual rate of China's GDP experienced a continuously increase after 2001, with a high level of 14.2% in 2007. This spectacular increment was interrupted in 2008 when the global economic crisis took place. The global economic slowdown happening 2008 had a significant impact on China's economy. It was reported that the real GDP growth in the fourth quarter of 2008 fell to 6.8%. A recorded number of 20 million workers lost their jobs because of the economic crisis. Although the real GDP growth of China encountered a general recovery from 2008 to 2010, it slowed for the next eight years, decreasing from 10.6% in 2010 to 6.6% in 2018. According to the predictions by the Economist Intelligence Unit, China's real GDP growth will slow considerably in the next following years, approaching the growth rates of the United States by 2036 when China and the United States GDP growth are both projected at around 1.6%. In comparison to the convergent tendency of China, the GDP growth of the United States is predicted to remain around 2% from 2020 to 2050.

In spite of the declining GDP growth, China is still among the fastest-growing economies in the world with reference to Figure 7, which demonstrates the GDP growth world map in 2017. Figure 8 shows the comparison of nominal GDP growth rates among several major economies in the world. Upon the occurrence of global economy crisis in

2008, these several major economies except China all encountered a negative nominal GDP growth, with almost negative 6% achieved by both Germany and Japan in 2009. Since 2009, the United States, Japan and Germany recovered from economy crisis, remained generally a growth rate no more than 2.5%.

Figure 6. China's Real GDP Growth from 1979 to 2018
(Data Source: The World Bank)

Since 2010, China has surpassed Japan to become the second largest economy by nominal GDP behind the United States. In 2018, China achieved a gross domestic product of 90.03 trillion CNY with services accounting for 52.16%, industry 40.65% and agriculture 7.19%, correspondingly a growth of 6.6 % compared to 2017.

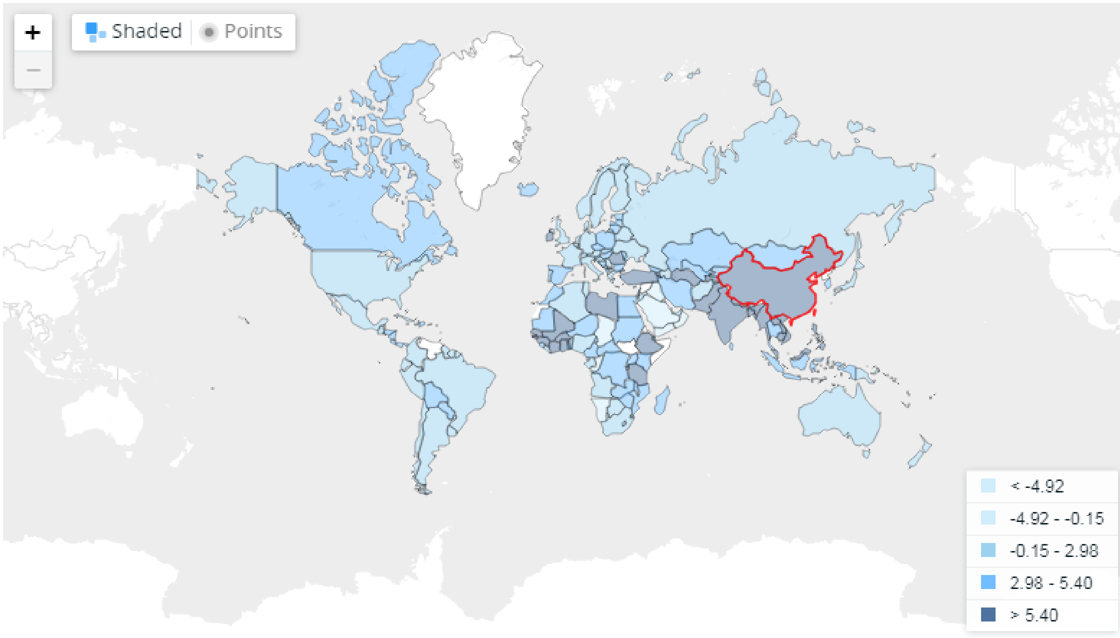


Figure 7. Nominal GDP Growth World Map in 2017

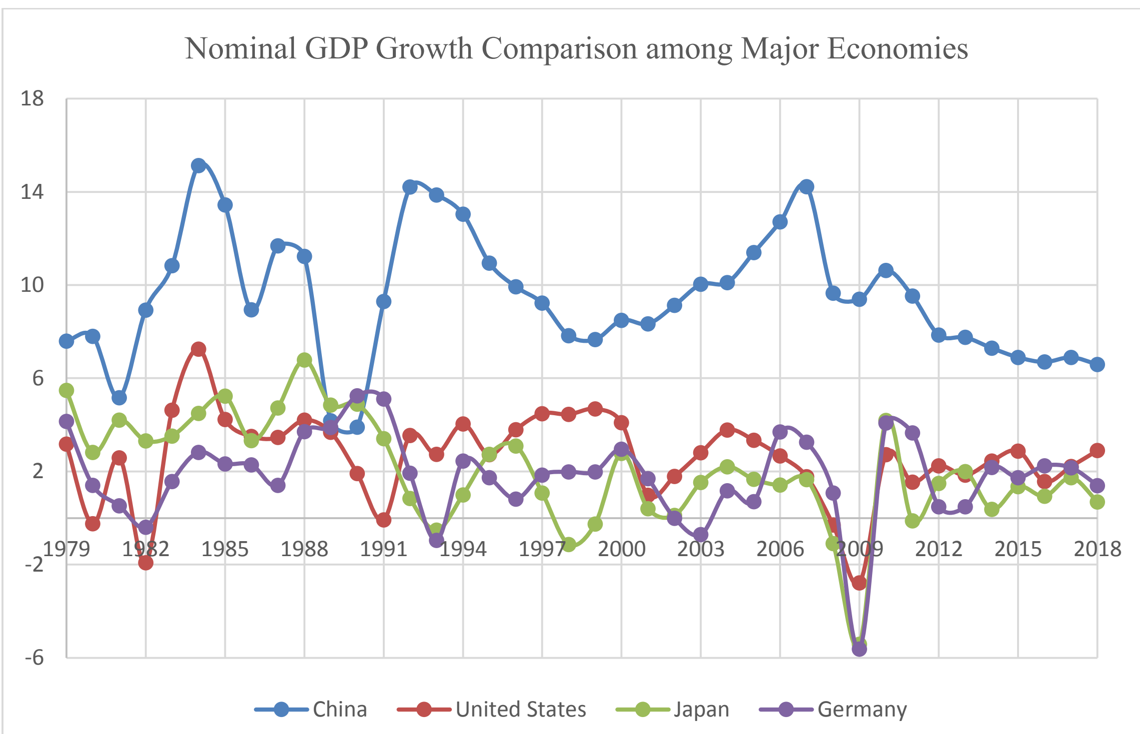


Figure 8. Nominal GDP Growth Comparison among Major Economies
(Data Source: The World Bank)

As revealed by the aforementioned GDP growth statistics, China's economy has achieved a rapid growth in the past forty years. From the economic analysis point of view, the size of an economy is a main subject. Many economists argue that using nominal exchange rates to convert GDP data is not able to reflect the true size of an economy. Thus, estimation of exchange rates based on actual purchasing power relative to dollar are developed to make more accurate comparisons of economic data across countries. The indicator is usually referred to as the purchasing power parity. According to results by International Monetary Fund, the PPP based GDP of China in 2018 is raised from 13.5 trillion dollars to 25.3 trillion. Consequently, China outplays the United States to take the first position regarding economic size. Meanwhile, the per capita GDP is also raised as a result of adjustment for price differentials in terms of goods and services. As a matter of fact, China has overtaken the United States as the world's largest economy since 2014 on a PPP GDP basis. Figure 9 demonstrates the evolution of China's nominal GDP and PPP based GDP, and their corresponding shares of global GDP (both nominal and PPP basis).

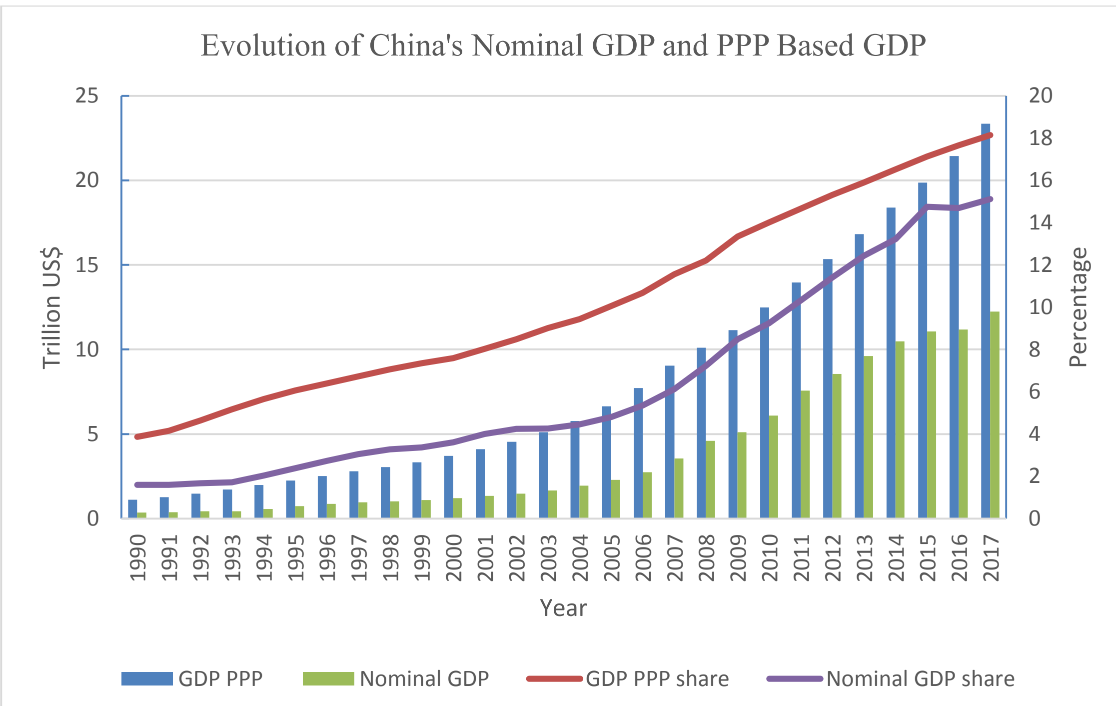


Figure 9. Evolution of China's Nominal GDP and PPP GDP
(Data Source: The World Bank)

China is ranked as the largest exporter and second largest importer worldwide. Thanks to the economic reforms implemented since 1997 and the entrance into WTO in 2001, China has grown to be a major trading power in the world. In 2012, China surpassed the United States to become the largest merchandise trading economy in the world. Imports and exports include the value of merchandise, freight, insurance, transport, construction, communication, information etc. while the compensation of employees and investment income and transfer payments are excluded. According to the statement of the Chinese government, China is the largest trading partner for almost 130 countries. Figure 10 shows the imports and exports of China in the past 20 years. The annual growth of China's exports and imports averaged 25.1 % and 24.2% respectively. These rapid growths were interrupted by the global economic crisis in 2008 and 2009. Both the exports and imports recovered in 2010. However, the trade flow growth slowed since 2011, reflecting a sluggish global economy. Figure 11 shows the share of China's GDP by import and export. It can be seen that export accounts for a quite significant role in China's economy, with a peak value of 36.03% reached in 2006. As a component of GDP, the trade balance has a decreasing share in China's economy since 2007.

The major trading partners of China are: European Union, the United States, the Association of Southeast Asian Nations composed of 10 nations, Japan, South Korea. In 2017, China exported a total value of 2.41 trillion US $ with European Union accounting for 16.5%, the United States 19.07%, ASEAN 12.43%, Japan 6.06%, South Korea 4.53%. And China imported a total value of 2.21 trillion US $ with European Union taking up 13.28%, the United States 8.131, ASEAN 11.95%, Japan 8.96%, South Korea 9.63%. As a result, China achieved a total trade surplus of 20.9 billion US $.

Figure 12 and Figure 13 shows respectively China's imports and exports by sectors classified according to SITC (Standard International Trade Classification) in the past years. Particularly, the machinery and transport equipment sector accounts for large percentage of both import and export volumes. Thanks to the labor cost advantage, China is quite competitive in plenty of labor-intensive manufacturing areas. Manufactured products constitute an important share of China's trade. In 2017, the top exports were electrical machinery accounting for 26.3%, nuclear reactors and machinery 16.8%, furniture and bedding 4%. Major imports were electrical machinery and equipment 25.5%, mineral fuels 11.5%, machinery such as machines used to make semiconductors 9.5%. Particularly, China imported motor vehicles worthy of 79 billion US $ which took up around 3.6% of the total imports in 2017.

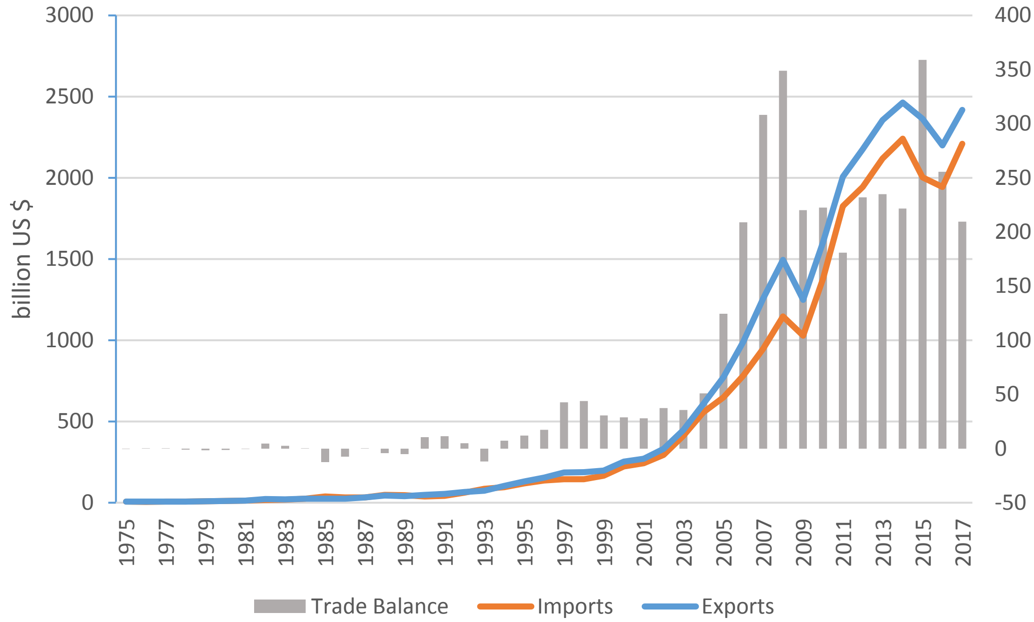


Figure 10. China's Imports and Exports from 1995 to 2017
(Data Source: The World Bank)

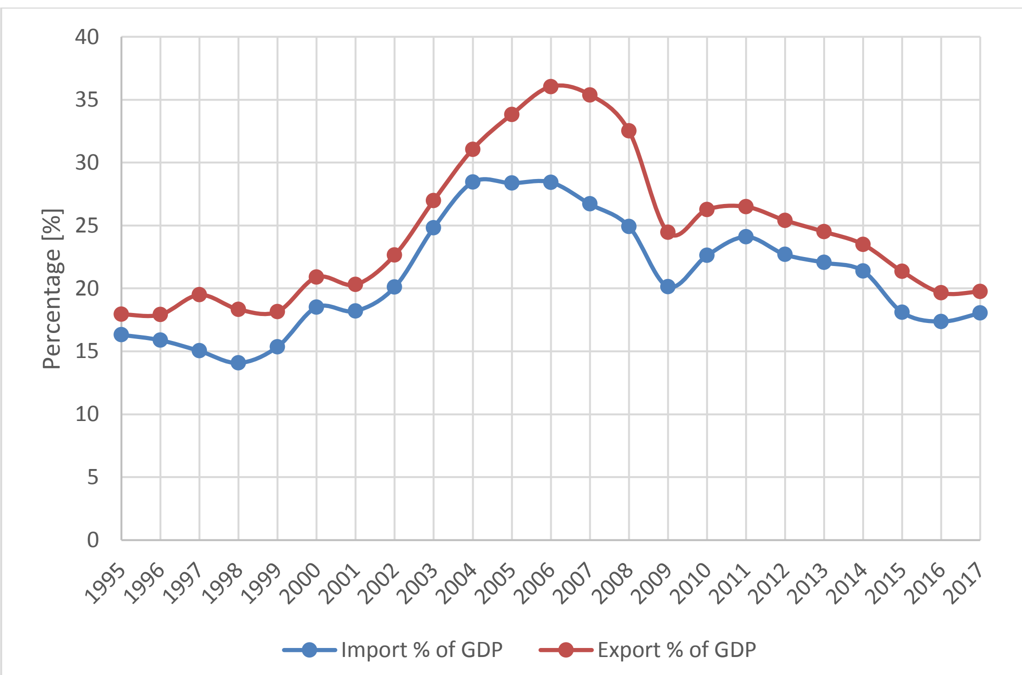


Figure 11. Share in China's GDP by Import and Export
(Data Source: The World Bank and National Bureau of Statistics of China)

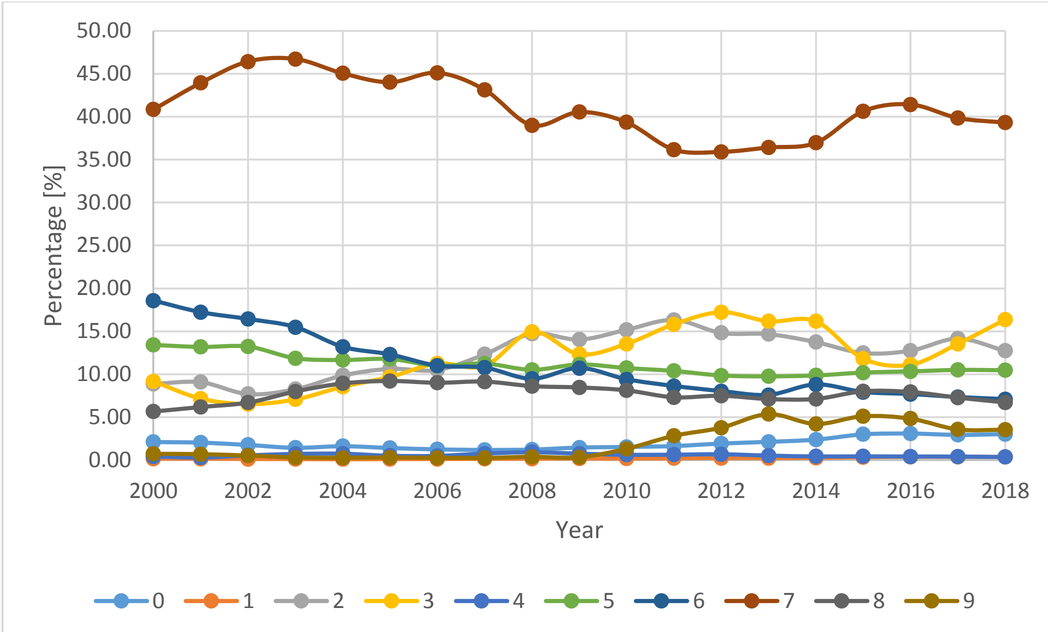


Figure 12. Imports by Sector of China in The Past Years
(Data Source: National Bureau of Statistics of China)
Note: 0-9 represent category indices by Standard International Trade Classification

Figure 13. Exports by Sector of China in The Past Years
(Data Source: National Bureau of Statistics of China)
Note: 0-9 represent category indices by Standard International Trade Classification

Moreover, China is ranked as the largest manufacturer in the world. China makes more manufactured goods than any other country. The range of Chinese goods include steel, aluminum, textiles, electronics etc. China overtook Japan as the second largest manufacturer and surpassed the United States in 2010 to become the largest on the basis of industrial added value. Value-added is the measurement of the value of goods and services produced in industry or other sectors of an economy. It is the sum of profits, rent, interest, and labor compensation. The value-added is used to reflect the actual value of manufacturing in one country with the subtraction of value of intermediate inputs and raw materials. Figure 14 compares the industrial value-added of manufacturing and their corresponding share of nominal GDP among three biggest manufacturers in the world i.e. China, the United States and Japan. As is indicated by the figure, China remained generally a continuous increase in terms of value-added generated by manufacturing, though the growth slowed since 2012. The manufacturing scale of the United States showed a quite small growth rate. Japan's manufacturing encountered a decline since 2013 in spite of the recovery in 2016. China achieved a value-added of 3.591 trillion US $ in 2017, which was almost the sum of the United States and Japan. Manufacturing accounts for a more important share in Chinese economy than it does for the United States and Japan. In 2017, the value added by manufacturing of China took up 29.32% of its GDP, in comparison to 11.6% for the United States. As is described in the 'Made in China 2025', manufacturing is the foundation of national economy, the main contributor to growth of China economy.

Due to the important role of manufacturing in one economy, many institutes, organizations research on global manufacturing and make rankings of major economies in terms of their competitiveness. According to the Global Manufacturing Competitiveness Index by Deloitte, China is the most competitive manufacturer followed by the United States. However, China is predicted to be overtaken by the United States to fall to the second most competitive manufacturer by 2020 based on their analysis of investment on high technologies, level of R&D activities, government policies, labor cost and demographic structure etc. As technological development of China converges with major developed countries, the previous strengths such as labor cost advantages become weak and the level of productivity gains decline. The manufacturing industry of China is facing a set of challenges. The growth of industrial value added or more broadly speaking the GDP growth have significant dependence on development of advanced technologies. The United States shows more advantages on research and development activities, presence of top universities, large investment in advanced technologies, which explains the projection in manufacturer ranking.

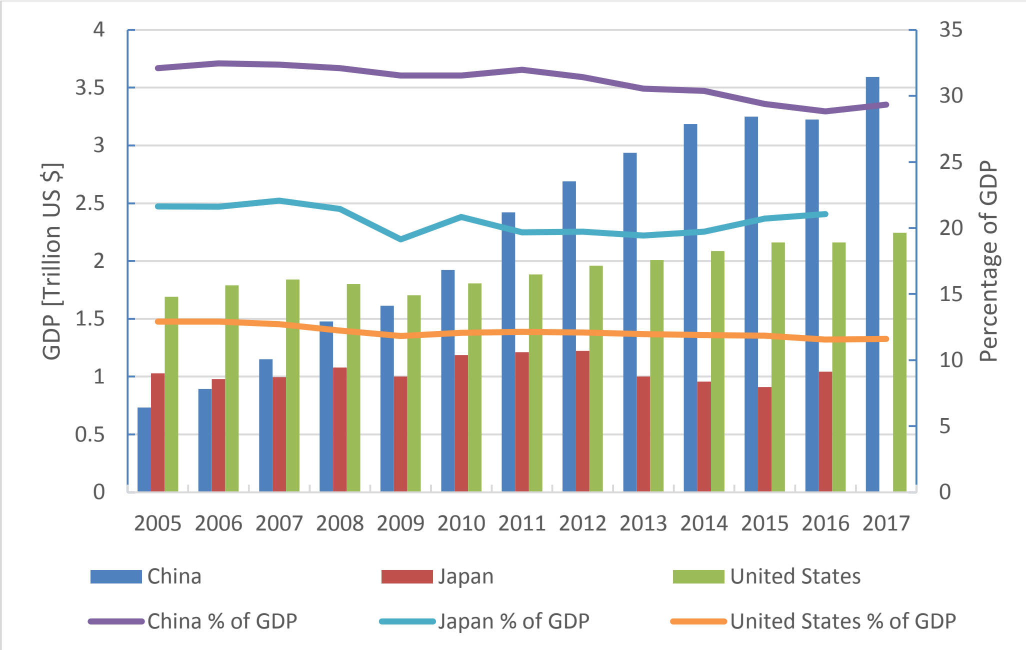


Figure 14. Manufacturing Scale Comparison
(Data Source: The World Bank
https://www.theglobaleconomy.com/rankings/manufacturing_value_added/)

In 2015, the Chinese government published the 'Made in China 2025' plan [1]. The initiative is aimed at stimulating innovation and development of advanced technologies, increasing the competitiveness of Chinses manufacturing industry and making China a dominant global manufacturer of various technologies. The document identified ten key sectors, i.e. next-generation information technology, high-end numerical control machinery and robotics, aerospace and aviation equipment, maritime engineering equipment and high-tech maritime vessel manufacturing, advanced rail equipment, energy-saving and new energy vehicles, electrical equipment, agriculture machinery and equipment, new materials, biopharmaceutical and high-performance medical devices. As an industry involving miscellaneous components, materials, the automotive industry presents strong correlation with the development of those mentioned sectors. Particularly, the development of new-energy vehicles was regarded as one of the key targets in 'Made in China 2025' project. According to the updated version of the giant plan, China aimed to become the second or third global manufacturer in new energy vehicles industries by 2025. The manufacturing industry is constituted by a lot of sub-sectors. In the past decade, the ten largest industries in China haven't changes. They are metals production, electrical & electronic production, chemical & pharmaceutical production, food & beverage production, automotive production, textile production, aggregates production, semiconductors & electronic components, equipment & goods production, rubber & plastics production. In 2017, these top ten largest industrial sub-sectors accounted for almost 87% of China's manufacturing industrial output.

2.2 Economic Significance of Automotive Industry to China

The automotive industry is one of the largest economic sectors by revenue in the world. As is described in OICA, if automotive manufacturing were a country, it would be the sixth largest economy in the world. The automotive industry has been a major contributor to economy in major economies such as the United States, China, Japan, Germany, Italy. In the United States, the automotive industry produces a higher level of output than any other single industry, and the motor vehicle is the second largest possession of the great majority of Americans following housing. The automotive industry in European Union is the largest provider of employment. The automotive industry accounts for the largest export of Europe and it's an economic sector at which European Union achieves positive trade balance. And the automotive industry in Europe attracts largest foreign investment in research and development. In China, the government has historically placed the automotive industry at the forefront of China's economic policy as aforementioned in the development roadmap of China's automotive industry. The automotive industry in China is named as a 'pillar industry', which is generally used to describe industries that makes up over 5 percent of the country's GDP growth. The significance of automotive industry lies in not only the direct contribution to national GDP, direct employment, foreign investments, exports and imports, but also the economic influence on other industries. The automotive industry is a huge consumer of commodities and services from many correlated sectors, including metals, plastics, machinery, semi-conductors. The automotive industry produces also a high employment multiplier e.g. 6.6. for the United States [2], due to its strong and wide association and interaction with other industries. In this section, the economic significance of automotive industry to China is elaborated from the perspectives of GDP contribution, employment, revenues, foreign investment, exports etc.

Gross domestic product i.e. GDP is the sum of gross value added by all producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is the most relevant summary of aggregated economic performance for an economy. It is usually calculated by means of three approaches i.e. production approach, income approach and expenditure approach. Different countries use different approaches to estimate their economic size and different industries in one economy use different approaches. Considering that the GDP is one of most important indicators of one economy's performance, the share of it by one economic sector is the common method to evaluate the significance of this sector to one economy.

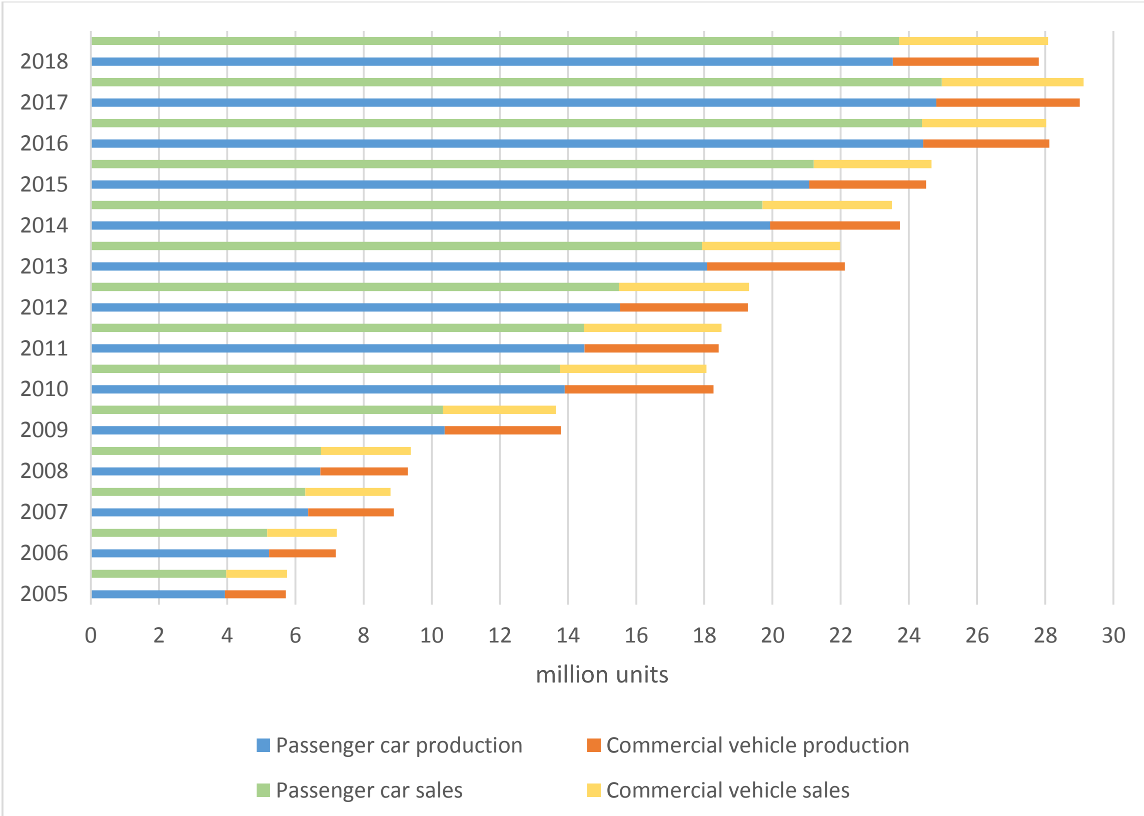


Figure 15. Vehicle Production and Sales in China
(Data Source: International Organization of Motor Vehicle Manufacturers)

Figure 15 demonstrates the annual motor vehicle production and sales in China's automotive market. It can be seen that both the production volume and sales volume of motor vehicles in Chinese market show a continuous increase in the past decades, while both of them went through a decrease in 2018. China as one of the most important investment targets for automotive enterprises, optimistic development of vehicle sales in China are expected. According to the analysis by KMPG [3], more than 3/4 of the executives think sales volume in China will achieve 40% globally by 2030, corresponding to a volume larger than 43 million units, while the market forecast makes a relatively conservative prediction that is share of 30% with 33 million units.

From the production and sales volume point of view, it's not easy to directly reflect the economic significance to one economy. However, as is shown in Figure 16, it summarizes the motor vehicle market scale (in terms of sales volume) for the top four major economies. The largest economies also have the world's largest automotive sale volumes. Correspondingly, these four major economies produce more than 60% motor vehicles in the world with reference to Figure 2. According to the expenditure approach for GDP calculation, the GDP accounts for the consumption, investments, net exports, and government spending during a given time period. The sales volume of motor vehicle is deemed as a major stimulator to national consumptions and consequently major contributor to GDP growth. Therefore, many countries implement a series of policies to promote the development of their automotive economies. Particularly, the Chinese government have issued policies in 2009 and 2015, aimed at reducing vehicle purchasing tax to propel vehicle sale. In the subsector of energy saving and new-energy vehicle, the promulgated policy in 2012 prescribed that the purchase tax was halved for energy-saving vehicle and vessel and free for new energy vehicle and vessel. Besides, the purchase tax of NEVs has been removed since 2014. With respect to the results of sale in 2009 and 2015, the effects of this kind of policy were prominent.

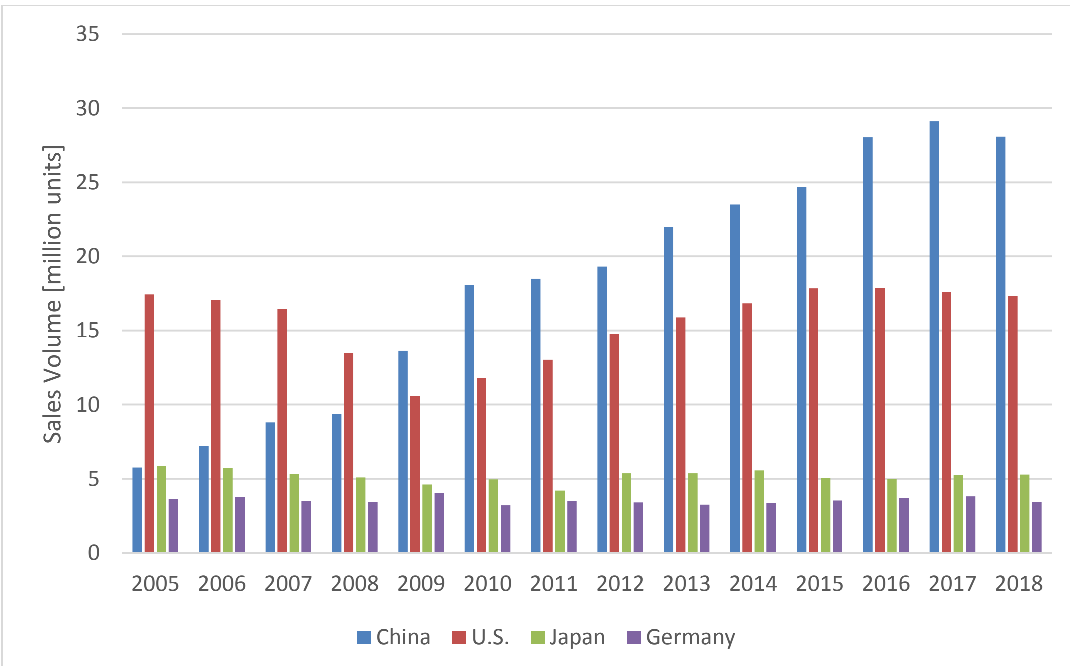


Figure 16. Vehicle Sales in Major Economies
(Data Source: International Organization of Motor Vehicle Manufacturers)

In 2018, China's GDP growth is 6.6%. According to the statistic of the Chinese government, final consumption expenditure took up 5% of the growth amount, which means a 76% share of contribution. Figure 17 elaborates the shares in gross sales by sectors in 2018. With reference to Figure 17, the sales of motor vehicle accounted for 29% of the total sales value, which is the largest contributor to the gross sales value. It is understandable why the automotive industry is seen as one of the pillar industries in China.

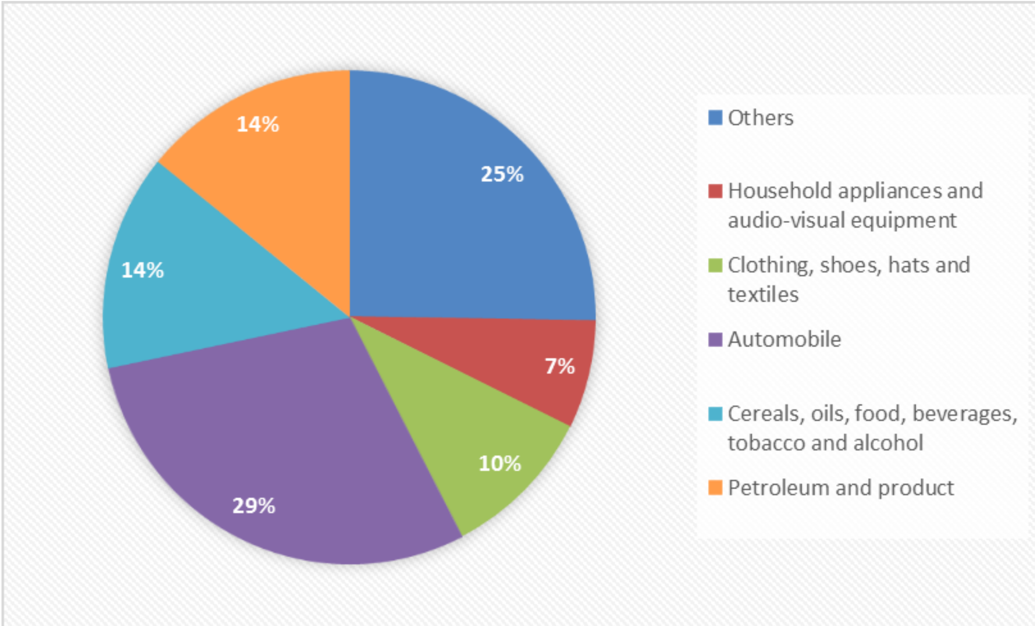


Figure 17. Gross Sales of China in 2018

Figure 18 makes a comparison between China and India in terms of annual GDP growth and their motor vehicles sales volume in the past decades. As is revealed by the GDP growth data, India is one of the fattest-growing countries in the world, in the meanwhile, ranked as the sixth largest economy in 2018. It can be found from Figure 18 that automotive industry indeed makes significant contribution to the growth of these two economies. The increment in motor vehicle sales volume means the increase in gross national consumption expenditure and consequently growth in gross domestic product. Actually, as the economy of India develops fast, the automotive industry also grows in a rapid step. There are several large-scale motor vehicle enterprises in India e.g. Tata Motors, Mahindra.

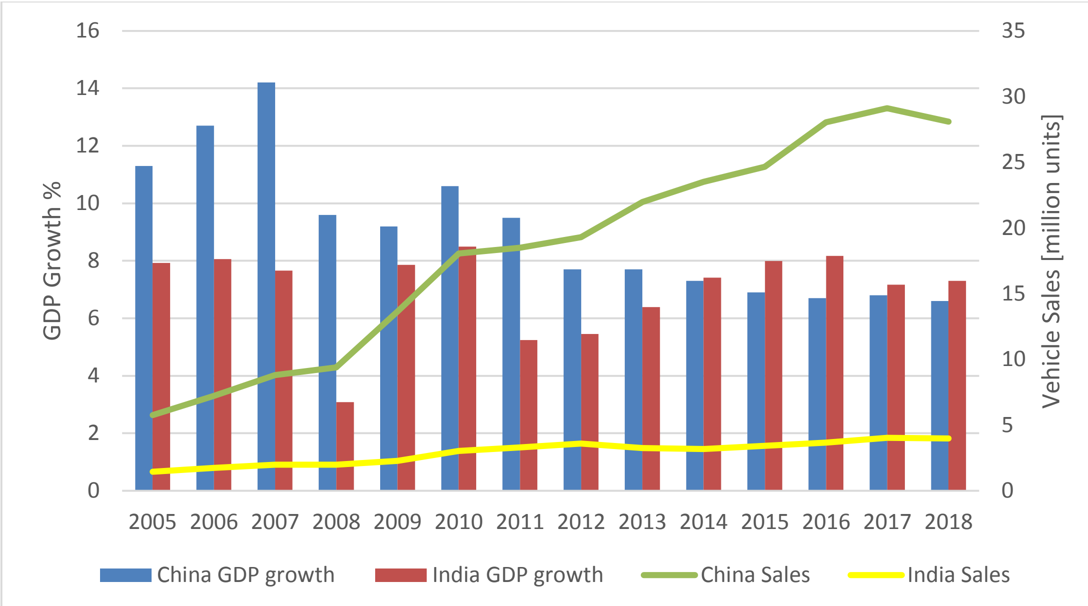


Figure 18. GDP Growth vs. Vehicle Sales in China and India

The importance of the automotive industry for one economy can be also evaluated by means of calculating the value-added and its contribution to economy growth. As is implied by the production approach for GDP calculation, the gross domestic product is the sum of added value generated by all producers. The more value-added one economic sector creates, the larger contribution to GDP this sector has. Figure 19 exhibits the industrial added value generated by China's automotive industry and its contribution to economic growth in the past decades. These data are derived from China's Automotive Industry Yearbook. The gross output value and added value of automotive industry both increased continuously. The output and value-added of 2016 are almost five times the size of 2005. The output of automotive industry has historically taken up 5%-7% of China's GDP, and the growth in automotive industrial added value generally contributes 3% to economic growth.

Figure 19. Value-added by Automotive Industry and Its GDP Growth Contribution
(Data Source: China's Automotive Industry Yearbook)

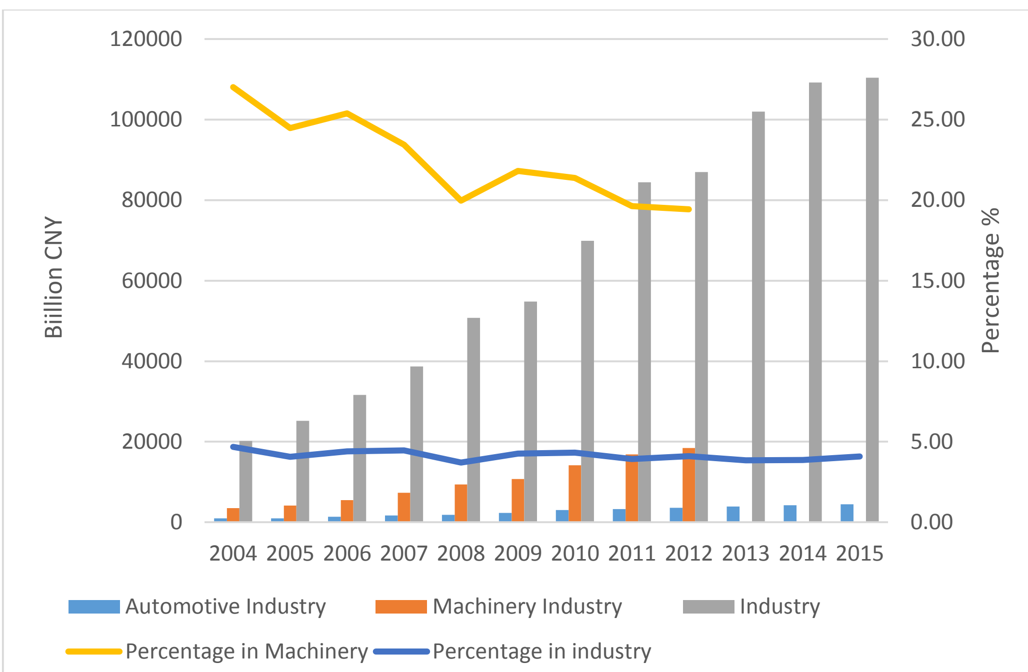


Figure 20. Output Values of Automotive Industry, Machinery Industry and Whole Industry

Figure 20 shows the historical data of outputs generated by automotive industry, machinery industry and whole industry in China. As the data reveal, the automotive industry plays significant role not only in machinery industry but also in whole industry of

China. Despite the continuous decrease of percentage of automotive industry in machinery industrial outputs, the automotive industry still accounts for a high percentage around 20% reached in 2012. Besides, the automotive industry contributed 3.7%~4.7% to China's gross industrial outputs, which was relatively steady.

Another major factor used to evaluate the significance of any economic activity is the employment. This importance of automotive industry extends beyond people directly employed in the industry. The automotive industry has a complex supply network with upstream and downstream enterprises across a wide array of industries. Apart from the jobs in motor vehicle manufacturing, the automotive industry provides directly or indirectly jobs in technical services, retail trade, logistics, transportation, insurances and services. In the United States, the automotive industry provides an employment more than 150 ten thousand. Figure 21 summarizes the employment of China's automotive industry since 2001. As the economic scale of automotive industry grew, the employment supported by this industry also presented a significant increment tendency. Particularly in 2013, the employment experienced a remarkable increment of almost 900 thousand. In 2017, the total employment supported by automotive industry is 535 ten thousand. Moreover, the automotive industry in China achieved an employment multiplier effect of more than 10, which means more than 10 other employments were generated in addition to the direct employment [4]. These additional employments mainly focused on downstream to motor vehicle manufacturing, e.g. vehicle sale, after-sale services. It is necessary to mention that the employees in engineering and technical division increased continuously, which revealed the fact that the automotive industry of China have been putting more emphasis on product development to improve product quality and competitiveness in the market. As a matter of fact, the domestic motor vehicle enterprises have ever gone through a phase, relying on foreign automotive enterprises both OEMs and suppliers to gain profits, particularly for those enterprises having joint-ventures. But now, most of the major indigenous enterprises have built the capability to autonomously design and manufacture vehicles. The rising expenditure on product development and incremental employees dedicated to R&D make significant contribution to the success of domestic vehicle brands in the past few years. In 2017, the automotive industry witnessed an expenditure on motor vehicle R&D more than 100 billion CNY [5].

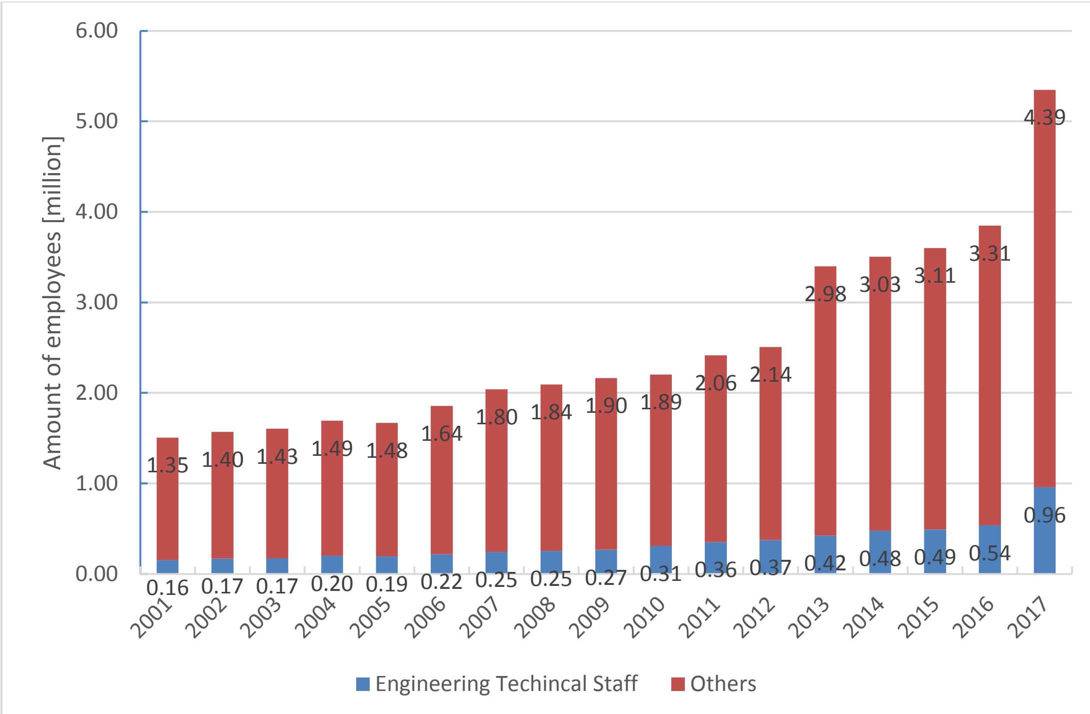


Figure 21. Employment of Automotive Industry in China
(Data Source: China's Automotive Industry Yearbook 2018)

Apart from the number of jobs supported, the automotive industry contributes substantially to national, local tax revenues. Taxes are generated at various points during the lifecycle of automotive products. The variety of tax sources include corporation income taxes, value added tax, licensing fees from automakers, suppliers and dealerships, individual income tax from employees working in the automotive industry, fuel taxes, purchase tax and license fees from vehicle owners. Even though some provinces in China don't have their local automotive industry, taxes are generated in phase of vehicle sale and usage.

3. Automotive Industry Geography in China

As mentioned in the previous chapter, the automotive industry as a whole in China brings about benefits in terms of national GDP, employment etc. It's of interest to analyze the geographic characteristics of this important economic sector. As a matter of fact, the motor vehicle market in China has strong regional characteristics, similar to the trend of urbanization. The breadth of operations of motor vehicle industry extends to many provinces' economies in China. For those regions owning automotive industry enterprises, the industrial output created, the employments provided, the revenues contributed to local economy are all important factors among regional economy analysis. Due to the complex network of industrial operation, individual regions show tight linkages. For example, some regions own many enterprises upstream to the motor vehicle manufacturing, which are mostly material-producing enterprises such as steel, aluminum, rubber, plastics. Many of these regions are resource-based. As regards the downstream of motor vehicle manufacturing, motor vehicle dealerships have a presence in nearly every province in China. In this chapter, the geographic distribution of the automotive industry in China is introduced, and the economic contribution to regional economies are also studied.

China is composed of 34 provincial administrative regions, 29 of which have automotive industry (three of 34 provincial administrative regions i.e. Hong Kong, Macao and Taiwan are not considered in following data tables). The map of China is shown in Figure 22. China's automotive industry is mainly distributed in the eastern and middle China. Beijing-Tianjin Region, Yangtze River Delta, Pearl River Delta and north-eastern three provinces, Central China are the zones characterized by widely-distributed motor vehicles enterprises. Particularly, the Yangtze River Delta, center of which is Shanghai, agglomerates a great amount of enterprises dedicated to automotive components supply and vehicle manufacturing. Table 4 summarizes the number of automotive enterprises in each region including vehicle OEMs, spare parts manufacturers and those dedicated to vehicle refit.

Figure 22. Map of China

As revealed by the data, there were totally more than 16000 enterprises, large-scale or small-scale recorded in the automotive industry in 2017. Yangtze River Delta that is comprised of Shanghai, Jiangsu Province, Zhejiang Province and part of Anhui Province, accounts for almost one-third of automotive enterprises in China. It is necessary to mention that Shanghai acts as not only the geographic center but also the economic center of this huge city cluster. Apparently, the number of enterprises in Shanghai isn’t so much compared to other three provincial regions, but the economic scale of automotive industry in Shanghai is the largest within the economic zone. Shanghai has the largest automotive group of China i.e. Shanghai Automotive Industry Corporation. And a lot of foreign car maker or suppliers make investment and establish subsidiaries in Shanghai. As the economy of Shanghai grows continuously in the past few decades, land cost, labor cost etc. has increased significantly. Consequently, many enterprises have transferred to the surrounding cities such as Suzhou, which promoted the development of local economy and its automotive industry. Jiangsu Province is ranked as the first in terms of industrial output and the second in terms of number of enterprises. Zhejiang Province has the most enterprises but relatively low output value.

Region	Enterprises			Output billion Euro	Value-added billion Euro
	OEM	Other	Total		
Beijing	8	229	237	45.350	11.176
Tianjin	23	257	280	17.973	5.242
Hebei	8	73	81	23.590	4.205
Shanxi	4	36	40	1.037	0.272
Shandong	14	1,248	1,262	38.409	6.524
Henan	56	1,017	1,073	18.607	2.852
Liaoning	15	399	414	14.286	3.255
Jilin	3	457	460	55.633	16.029
Heilongjiang	8	198	206	1.527	0.722
Neimenggu	3	46	49	2.175	0.432
Shanghai	10	130	140	65.210	16.605
Jiangsu	26	1,867	1,893	71.691	14.632
Zhejiang	11	1,940	1,951	28.904	3.932
Anhui	6	830	836	25.620	12.342
Fujian	8	430	438	6.495	0.844
Jiangxi	9	300	309	15.323	2.996
Chongqing	58	1,218	1,276	49.959	13.379
Sichuan	16	437	453	13.293	3.471
Shanxi	6	102	108	8.166	1.368
Hubei	23	1,402	1,425	54.740	14.013
Hunan	51	349	400	11.449	1.959
Guangdong	55	780	835	58.528	13.869
Guangxi	4	319	323	14.330	3.644
Guizhou	13	50	63	1.757	0.461
Hainan	1	21	22	0.749	0.078
Yunnan	4	30	34	2.880	0.351
Xinjiang	3	11	14	0.277	0.023
Ningxia	0	-	-	0.020	0.004
Gansu	3	-	-	0.158	0.036
Qinghai	0	-	-	0.122	0.023
Tibet	0	0	0	0.000	0.000
Total	449	14,176	14,622	648.26	154.74

Table 4. Automotive Industry in Each Region of China

(Data Source: China's Automotive Industry Yearbook of 2015)

Note: The enterprises include vehicle OEM, components manufacturer and those dedicated to vehicle refit. '-' means no available data for this area. The data of Hong Kong, Macao and Taiwan are not included in the table.

Figure 23 demonstrates the shares of total automotive industrial output value for regions. In 2015, the Yangtze River Delta accounted for almost 30% of the total industrial output in China. Beijing-Tianjin-Hebei, Jinlin-Liaoning-Heilongjiang, Hubei-Hunan, Sichuan-Chongqing and Pearl River Delta are five large economic regions that totally takes up more than 50% of the industrial economic output. Actually, Beijing-Tianjin-Hebei, Jinlin-Liaoning-Heilongjiang, Yangtze River Delta, and Pearl River Delta are named the four industrial bases of China. The Pearl River Delta as part of the Guangdong Province, is famous for manufacturing, and the Guangzhou Automobile Group is one of the largest motor vehicle manufacturing corporations in China. Jinlin Province has a quite large automotive industrial output compared to most of the individual regions, in which the First Automobile Works Corporation is located. Another two important provincial administrative regions are Chongqing and Hubei, which respectively have Chang'an Automobile Group and Dongfeng Automobile Group.

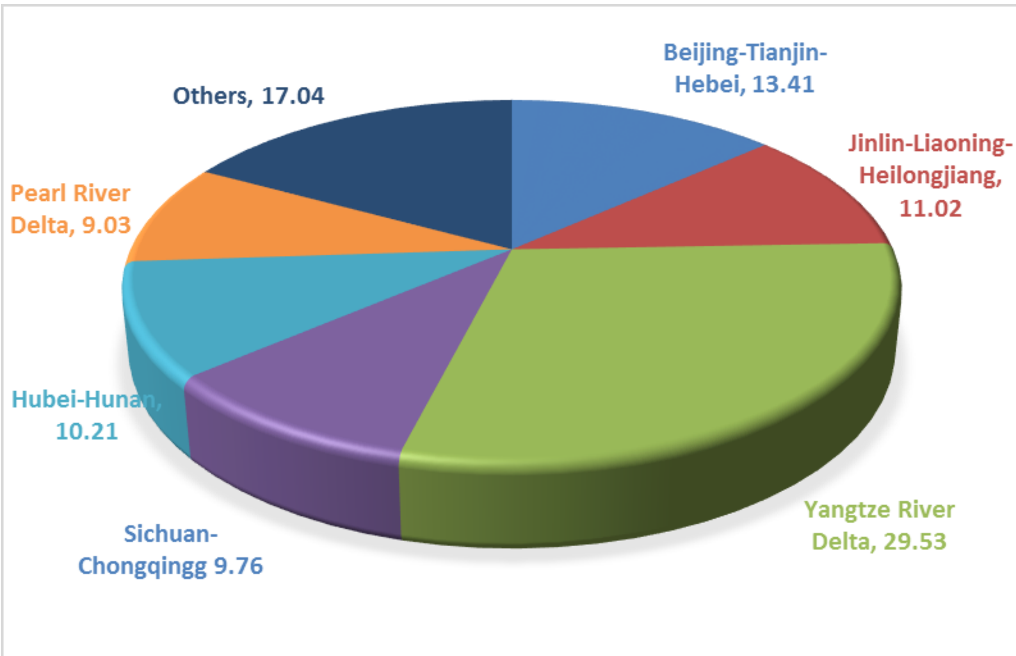


Figure 23. Percentage of Each Region in China's Automotive Industry
(Data Source: China's Automotive Industry Yearbook of 2015)

As far as the economic contribution of the motor vehicle industry to individual region economies is concerned, industrial added value created and employment in each region are of major interest. According to [6],some regions with relatively few automotive enterprises can still benefit from the proximity to neighboring regions that have motor vehicle manufacturing or technical facilities. As a consequence, direct economic contribution and local employment can also be witnessed. This phenomenon is called 'employment multiplier', which means the automotive industry employment contribution in one region is not attributable only to the investment in that region, but also supported by automotive industry investments and activities in nearby regions as well. Considering this mentioned effect, the employment multipliers are usually not evaluated for individual regions but is applied to the economy of whole country. In [6], the economic contribution of the motor vehicle industry to the United States and to individual states were estimated. The method used to evaluate employment and income were derived from a regional economic model supplied by Regional Economic Models, Inc. The direct employment data were relatively easy to obtain, but the estimation of spin-off effects should rely on the economic regional model. The compensation and personal income taxes were used in the model to evaluate how many employments could be supported, which were called spin-off employments. The direct employees include researchers, engineers, managers, administrative support, workers on assembly lines, and those working in automobile dealerships. The intermediate employments referred to the employment necessary to satisfy manufacturers' demands for materials and services needed to design, produce and sell motor vehicles. Some of these companies can be several steps removed from vehicle design and manufacturing process and serve multiple industries. The spin-off employment mean those supported by the incomes and spending of the people who work in the direct and intermediate jobs, i.e. expenditure-induced jobs. Besides, employment contribution was estimated in a way that manufacturing activities and motor vehicle dealership were separately analyzed. It was said the local car dealer would always take the top prize if there were a competitive event to measure the philanthropy of business in America. The automotive dealership plays an important role in America economy. Compared to the manufacturing activities, the automotive dealership had a mild multiplier effect, since manufactured goods needs a lot from underlying intermediate supplying industries.

In the following content, the employment includes direct employments attributed to automakers, parts manufacturer, vehicle refit. As for the intermediate, spin-off employments, the employments in automotive dealership segment are not included considering the lack of relevant data. Table 5 summarizes the economic contribution of local automotive industry for each region from the perspective of GDP share and employments generated. Beijing, Jilin, Shanghai, Anhui, Chongqing, Hubei witnessed remarkable contribution to local economy by automotive industry. Particularly, the automotive industry in Jilin had a share of annual GDP almost equal to 8% which was unquestionably a great amount. Chongqing witnessed a GDP contribution of 5.9% by local automotive industry. The automotive industry in Shanghai contributed 4.6% percent to the local GDP. Besides, Guangdong, Jiangsu, Zhejiang, Shandong were the top four regions where automotive industry supported a great number of employments.

Region	Value-added billion Euro	GDP billion Euro	GDP contribution %	Employment thousand
Beijing	11.176	330.79	3.38	141
Tianjin	5.242	238.17	2.20	100
Hebei	4.205	429.25	0.98	110
Shanxi	0.272	184.38	0.15	16
Shandong	6.524	907.33	0.72	331
Henan	2.852	533.00	0.53	250
Liaoning	3.255	413.94	0.79	131
Jilin	16.029	205.57	7.80	277
Heilongjiang	0.722	217.23	0.33	60
Neimenggu	0.432	259.70	0.17	24
Shanghai	16.605	359.53	4.62	151
Jiangsu	14.632	1,009.78	1.45	421
Zhejiang	3.932	617.62	0.64	410
Anhui	12.342	316.92	3.89	142
Fujian	0.844	374.15	0.23	70
Jiangxi	2.996	240.85	1.24	92
Chongqing	13.379	226.39	5.91	-
Sichuan	3.471	433.53	0.80	119.7
Shanxi	1.368	261.70	0.522	80
Hubei	14.013	425.57	3.29	297.8
Hunan	1.959	418.32	0.47	-
Guangdong	13.869	1,048.62	1.32	434.2
Guangxi	3.644	241.99	1.51	134.4
Guizhou	0.461	151.26	0.30	15
Hainan	0.078	53.33	0.15	30
Yunnan	0.351	197.56	0.18	18.2
Xinjiang	0.023	134.29	0.02	5
Ningxia	0.004	41.94	0.01	-
Gansu	0.036	97.79	0.04	-
Qinghai	0.023	34.81	0.07	-
Tibet	0.000	14.78	0	0

Table 5. GDP Contribution and Employment Supported by Automotive Industry

(Data Source: China's Automotive Industry Yearbook of 2015)

Note: '-' means no available data for this area.

4. The Cooperation and Competition between Indigenous and Foreign-invested Enterprises

As aforementioned in the introduction of China's automotive industry development roadmap, foreign investments have played a significant role, particularly by foreign automotive enterprises. These foreign automotive manufacturers and parts suppliers made investment in China's automotive market, built manufacturing plants and even research centers dedicated to developing products targeting China's market, expanded production scale, established cooperative relationship with indigenous automotive enterprises. In the early age, the establishment of the First Automobile Works under the help of USSR set an example for China's development of automotive industry. Due to the lack of technologies and the urgent hope to develop autonomous automotive industry particularly upon the opening up of Chinese market in 1979, most indigenous automakers resorted to joint development and setting up joint-ventures.

As part of the policies in automotive industry, foreign automotive OEM should find a domestic vehicle enterprise to build their joint-venture and have a share of ownership less than 50% for those joint-ventures producing complete vehicle and engines. This regulation has helped indigenous automakers to develop in the past decades. However, there have been different voices concerning this cooperative pattern. Some people argue that this pattern is a form of regional-protectionism and indulges the dependence of indigenous enterprises on foreign car makers to gain profits and consequently weakens indigenous enterprises' autonomous research and development capability. On the other hand, some people say this cooperative pattern is in line with the situation of China's automotive industry. The 'infant industry' [7] in developing countries always have a limited market. Domestic firms need entry barrier for foreign competitors and certain protection period to develop, so as to form capabilities to compete with technologically advanced multi-national corporations. Without protection by governmental intervention, the risk of being crowed-out by foreign competitors is high. And indigenous enterprises have actually learnt a lot from their cooperation with their partners. [8] studied the main organizational structure of major auto groups and thought the compact organization through collaboration, and resource sharing reduced the cost of mobilizing internal sources, production cost on supply side. As a matter fact, joint-venture is not an unusual collaboration form in automotive industry. The rules of equity limit in China's automotive industry has remained its effect since 1978. In 2018, the Chinese government made the decision to cancel this rule step by step with a transitional period lasting five years. The restriction on proportion of foreign equity was removed in 2018 for new-energy vehicle manufacturing industrial sector and will be canceled for commercial vehicle and passenger car sectors respectively in 2020 and 2022. In this chapter, the history, effects of foreign investment in automotive industry are introduced. Moreover, the cooperation and competition between domestic and foreign enterprises are presented.

4.1 Foreign Investments in Automotive Industry

During the period of 1980-1990, foreign automotive enterprises started their involvement in China's automotive industry mainly by means of technology outsourcing and technology license. During this period, Volkswagen, Peugeot, Daimler-Chrysler etc. entered into China's automotive industry and started their cooperation with Chinese automakers such as SAIC, BAIC, GAC. Following the authorized Jeep model vehicle in 1983 under collaboration between BAIC and American Automotive Corporation, Santana model was authorized by Volkswagen to SAIC, Peugeot 505 project to GAC by Peugeot. Qingling Auto Group, Beijing Light Vehicle co.Ltd and Jiangling Automobile Co., Ltd. successively established cooperative relationship with Isuzu. In 1988, Volkswagen authorized FAW to produce Audi 100 and the model was produced by their joint-venture in 1995. In 1988, Volkswagen and FAW signed their long-term Memorandum of Cooperation. China North Industries Group signed a contract with Daimler-Chrysler to introduce licensed heavy duty vehicle in 1988. Besired, China introduced a series of technologies of automotive parts to supply vehicle manufacturing. Foreign automotive parts enterprises also started to enter into China's automotive industry. For example, Hella built its proprietorship and joint-venture in Changchun, Shanghai and Beijing to produce automotive lighting systems and electronic components. In 1991, the joint venture of FAW and Volkswagen was set up in Changchun. In 1992, Dongfeng Automobile Corporation built its joint-venture with Peugeot-Citron. In 1997, General Motor and SAIC established the first joint-venture research and development company PATAC in China with a 50-50 split.

The foreign direct investment inflows in China's automotive industry started to accelerate quickly from 1992. Until 1998, the accumulated number of foreign invested enterprises reached 604 [7] with accumulated investment of 20.9 billion US dollars. As far as the pattern of foreign investment is concerned, there have been three main patterns: equity joint venture, cooperative joint venture and foreign proprietorship. The equity joint-venture was the major pattern. Until 1998, there were 531 joint-ventures recorded, representing a percentage of 88% of foreign invested automotive enterprises. Compared to automotive industry in China, other industries had foreign proprietorships with a percent of almost 37% of total foreign investment, which meant that the degree of involvement by indigenous enterprises in automotive industry was much higher than other industrial sectors.

Chinese government regulated inward investments in automotive industry in various ways, such as foreign equity limits, local content requirements, screening. The trade barrier was also used to limit imports. The tariff rate before 1986 was quite high, reaching 180-220%. Besides, Chinese government applied import licensing on motor vehicle, motorcycles, engines, vehicle tyres etc. However, China's automotive industry didn't benefit from these policies as expected. The high tariffs resulted in smuggling, high car price. For example, the domestic sale price of a manufactured Santana by Shanghai VW in

1993 was nearly 200,000 CNY, almost doubled the world price. Moreover, a lot of small-scale producers were born due to the policy. Most of the small-scale producers relied heavily on KD kits, but could also gained significant profit. With the enactment of 1994 Automotive Industry Policy, tariffs were gradually lowered. Nevertheless, the tariff reduction in automotive industry was still lower than the average reduction of tariffs as China gradually opened up to world economy.

Investments from foreign automotive firms was faced with rigorous screening process in the early stage. The screening depended on the nature and economic size of the investment. For example, complete vehicle, key components e.g. engine, ABS, passenger SRS and all investments over 30 million US dollars were screened by Chinese central governmental. Afterwards, local provincial governments were authorized to review foreign-invested projects. Thanks to this change, foreign investments were faced with relatively simple screening process. Starting from 2000, several measures were taken to remove restrictions on FDI in order to promote the foreign investment in automotive components sector.

The foreign equity limit is another important policy promulgated by Chinese government, which could trace back to 1984 when the collaboration between foreign automotive corporations and Chinese automakers started. Before 1994, the share of holding of automotive joint-ventures by foreign corporations was no more than 50%, though there was no specific rule to regulate the limit. The Automotive Industry Policy of 1994 was the first policy that specified the requirements for foreign investments in automotive industry. According to policy of 1994, foreign enterprises with complete vehicle and engine manufacturing as main business, were allowed to invest in China based on joint-venture cooperative pattern with domestic enterprises. The number of joint-ventures in China were limited to two and the equity limit was set to less than 50%. This policy seems to be unfavorable to foreign automotive enterprises, but almost all foreign investors have joint-ventures in China. The investment pattern of joint-venture helps them to managing cross-cultural aspects and lower investment risks. As said in [7], this policy doesn't reach the original objective of policymakers to enhance technology improvement and management control by domestic enterprises. According to [9], parent firms generally transfer technology to proprietorships faster than to joint-ventures in developing countries. Despite the cap of foreign equity, foreign investors have larger discretion on the operation of joint-ventures. Such phenomenon is quite common in China's automotive industry. The joint-venture pattern has been the core of debates on automotive industry policies and is a major concern for policymakers. With the macroscopic development of indigenous major automotive corporations and the emerging of new-energy automotive industry, joint-venture pattern and foreign equity limit policy went through a series of further adjustments. In 2017 and 2018, National Development and Reform Commission of China announced that the restriction on number of joint-ventures manufacturing complete vehicle and foreign equity would be gradually cancelled in 2018 for new-energy vehicle and special vehicle, 2020 for commercial vehicle, and 2022 for passenger vehicle. The government even made the decision to allow foreign proprietorships manufacturing new-energy vehicle.

Stepping into 21st century, the automotive industry became more diversified. The Automotive Industry Policy of 2004 canceled the foreign equity limit for engine manufacturing subsector. More enterprises manufacturing engine and automotive parts of majority shareholding by foreign companies emerged. And some sales & marketing joint-venture were established such as SAIC-Volkswagen Sales Company, FAW-Toyota Sales Company. In 2002, the joint-venture SAIC-GM-Wuling Automobile Co., Ltd. was built under the cooperation of SAIC, General Motor Corporation and Liuzhou Wuling Automobile Co., Ltd., with respective share of 50.1%, 15.9% and 34%. In the same year, the cooperation between SAIC and GMC continued to establish their second joint-venture in Yantai to produce GM brand cars. In 2005, SAIC signed framework agreement with IVECO S.p.A. to set up SAIC-IVECO Commercial Vehicle Investment Co., Ltd., which then in 2007 established the joint-venture SAIC-IVECO HONGYAN Commercial Vehicle Co., Ltd. based on Chongqing HONGYAN Commercial Vehicle. Toyota Motor Corporation started its investment in China from 1980s. Successive to joint-ventures to produce engine and chassis components, the complete vehicle joint-ventures were set up in 1998 by FAW and Toyota, in 2000 by Tianjin Automotive Corporation and Toyota, which was transferred to FAW on occasion that Tianjin Automotive Corporation and FAW signed union and reorganization agreement in 2002. In 2004, the cooperation between domestic automotive enterprises and Toyota extended to the joint-venture shared by Toyota and GAC. In 2010, F.I.A.T. reentered into China's automotive market by means of cooperation with GAC to set up their joint-venture GAC-FCA Automobile Co., Ltd. F.I.A.T. started its investment in 1999 to build a joint-venture with Nanjing Automotive Corporation, while the joint-venture was announced to break up in 2007.

With the fast development of new-energy automotive industry in China in 21st century, foreign automotive enterprises have increased their investment in this emerging area. With more stringent regulations being implemented, fuel consumption and engine emission have been important concerns for global automotive industry. In 2017 Chinese government released the draft regulation 'Corporate Average Fuel Consumption and New-Energy Vehicle Credits Management Methods', which is called 'Double-Credits Policy' in China. This regulation is intended to reduce fuel consumption and propel the development of new-energy vehicles. Since early 21st century, Chinese government has used different policies to propel the development of new-energy vehicles such as the financial subsidy and implementation of credits policy for OEMs, which are elaborated in Section 5.2. Under this background, traditional automotive enterprises have also extended their cooperation with China's domestic automotive enterprises. For example, BYD and Daimler set up their joint-venture DENZA New Energy Automobile Co., Ltd in 2012 to design and produce new-energy cars. In 2017, Volkswagen extended its domestic collaboration to JAC Motors to set up their joint-venture to design and manufacturing new-energy cars. The foundation of joint-venture between Volkswagen and JAC Motors also broke the convention that foreign enterprises could have no more than two collaborators. The joint-venture between Zotye Auto and Ford was also announced to be set up in 2018, which was intended to design and manufacture pure-electric vehicles. In 2018, the new entrant of electric car manufacturer Tesla announced its plan to build its sole proprietorship plant in Shanghai. This is the first case in complete vehicle manufacturing sector after the Chinese government canceled the restraints on foreign equity for new-energy vehicle enterprises in 2018. Table 6 makes a summary of investments by foreign major OEMs, including the information of joint-ventures and proprietorships. These major foreign automotive OEMs have invested more than 210 enterprises in China, half of which are dedicated to complete vehicle manufacturing with their partners and half of whose major business focus on automotive parts manufacturing e.g. engine and transmission, engineering work for localization of products, financial services and investment management in China. With the expansion of their business in China, most of these corporations set up investment management proprietorships. And some major OEMs such as Toyota, GM, Daimler, Honda establish technical centers in China to develop products dedicated to Chinese market.

Foreign Enterprise	Joint Venture	Proprietorship	Total
GM	10	2	12
Ford	5	4	9
VW	6	1	7
Toyota	15	9	24
Honda	7	4	11
Nissan	11	1	12
Suzuki	2	1	3
Isuzu	4	2	6
Mazda	4	1	5
Mitsubishi	5	3	8
Hyundai-Kia	50	15	65
PSA	6	4	10
Renault	3	1	4
BMW	1	3	4
Daimler	7	8	15
FIAT & Chrysler	2	5	7
IVECO	6	1	7
Volvo	4	5	9

Table 6. Enterprises Invested by Foreign Major Automotive OEMs
(Data Source: China's Automotive Industry Yearbook, enterprise information search websites)

Compared to complete vehicle manufacturing enterprises, foreign automotive parts manufacturers have had a more rapid growth in terms of its number of invested enterprises in China. Unlike complete vehicle manufacturing, Chinese government didn't use the foreign equity limit rule to restrict foreign investments in automotive parts sector. Since 1991, the largest automotive parts supplier started their investment in China such as Bosch, Delphi, BorgWarner, ZF, Schaeffler, TRW. These automotive parts suppliers have built their proprietorships and joint-ventures. During the early stage of China's automotive industry development, Chinese government implemented the local content requirement, which was designed to achieve an all-round industrial development and self-reliance. The local content rule combined tariff rate on complete vehicle and percentage of components produced domestically. For example, the tariff rate on imported parts was 40% for passenger cars with local contents exceeding 80%, compared to 75% for those with local content lower than 60%. This policy was intended to encourage development of domestic automotive component industry sector. The domestic automotive parts industry benefitted from this policy. Foreign automotive corporates outsourced automotive parts demands to local producers to comply with the local content rule. The quality of produced products by domestic firms was improved. There was a comparison between two earliest joint-ventures, Shanghai-VW and Guangzhou-Peugeot. The latter preferred to import knock-down kits instead of outsourcing parts demands to local suppliers. In contrast, the SAIC-VW adopted seriously a local content program such as the Shanghai Santana Local Content Cooperative. Consequently, the Shanghai-VW embraced success in Chinese market, while the Guangzhou-Peugeot project came to an end in 1997. Although this policy helped domestic automotive parts industry make a successful step integrated into global automotive supply chain, the positive effect was limited to the absorption of imported technologies. In the early development stage, most domestic automotive parts suppliers showed reliance on imports of technologies.

Until 2018, 70% of the top 100 automotive parts enterprises have their business in China and there are more than 1200 foreign invested enterprises in automotive parts sector. However, the cancellation of local content requirement pushed domestic automotive parts producers to a more severe predicament. As a consequence, foreign automotive parts suppliers have a share of market more than 70% as recorded by 2018. As is said in China's Automotive Industry Yearbook, China's automotive industry has historically been 'pay much more attention to complete vehicle than automotive parts'. In contrast to foreign automotive parts suppliers, China's domestic enterprises generally lack for capabilities to develop critical components and systems. China's domestic OEMs show significant dependence on foreign suppliers in electronic components and systems, automatic transmissions, engine fueling systems, automotive hydraulic components. Table 7 summarizes the automotive enterprises invested by foreign major automotive parts corporations until 2018.

Bosch as the largest automotive parts supplier in the world, has almost 60 invested companies in China, with more than half of them concentrating on automotive industry. In 1995, Bosch built its joint-venture United Automotive Electronic System Co.,Ltd. (UAES) with SAIC, Wuxi Weifu High Technology Group Co.,Ltd., FAW, DFMC, BAIC, Xi'an Kunlun Industry Group Co.,Ltd.. The UAES is the one of the largest automotive parts joint-ventures, with main business in traditional and hybrid powertrain control systems, such as gasoline engine control unit, automatic transmission control unit, electronic sensors, actuators serving for control units.

Foreign Enterprise	Joint Venture	Proprietorship	Total
Aisin	3	11	14
Bosch	6	29	35
BorgWarner	2	7	9
Continental	1	9	10
Delphi	3	11	14
Denso	9	18	27
Faurecia	30	23	53
Magnetti Marelli	5	8	13
Schaeffler	0	13	13
TRW	2	5	7
Valeo	6	29	35
ZF	11	15	26

Table 7. Enterprises Invested by Foreign Major Automotive Suppliers
(Data Source: China's Automotive Industry Yearbook, enterprise information search websites)

4.2 Competition between Indigenous Enterprises and Joint-ventures

In the previous part 4.1, the history of foreign automotive enterprises' investments and involvement in China's automotive industry is introduced. It can be known that foreign investments have been highly involved in China's automotive industry.

How the foreign investments have affected China's automotive industry in the past few decades, particularly on indigenous automakers and how the competition situation is existent on China's automotive market are also widely researched by a lot of studies. Girma and Gong (2008) [10] researched the influence of foreign capital participation on Chinese state-owned enterprises in terms of employment, productivity, profitability etc. It was found that foreign investment by foreign automotive enterprises had strong negative impact on state-owned enterprises without access to any foreign capital because of the competition. However, those indigenous vehicle makers benefitted from their foreign collaborators thanks to more advanced technologies and know-how of their joint-ventures and were endowed with more competitive advantages over other independent indigenous enterprises. [8] analyzed the effects of foreign investment on China's automotive corporations from the perspective of consumer choices. The analysis adopted a structural model to obtain estimations of demand and supply curves. The analysis suggested that joint-ventures casted positive shadow on vehicles produced by indigenous manufacturers. Additionally, consumers tended to infer that auto-manufacturing and assembly enterprises within one automotive group were closely connected and indigenous brands had better quality due to the technology transfer. Moreover, the analysis revealed the spillover from a joint-venture member to a local indigenous member within the same auto group, which was in consistence with management studies by [11].

[12] analyzed the foreign investments in the Chinese automotive industry from the perspective of drivers, distance determinants and sustainable trends. Within the thesis, the competition of China's automotive industry was also investigated by means of Porter's Five Force Analysis. According to the analysis, the rivalry among market competitors in China was enhanced due to the existence of powerful international companies. And new entrants needed very high capital expenditures despite the strong market growth. [13] researched into the effects of governmental policies on foreign automobile companies' investments in China and the detailed investment strategies of Volkswagen and General Motor. According to the thesis, automobile multinationals have basically completed their strategic set-up in China and are now moving deeper into their operations in China. The intensified competition in this industry would eventually spill over to the scramble for customers. Besides, the gradual loosening up of governmental restrictions would compel mutual infiltration of various automotive manufacturers.[14] researched into the competitiveness of automotive enterprises, particularly large-scale indigenous corporations in China. The author evaluated the competitiveness of 11 corporations be means of Factor Analysis Tool which incorporated eleven evaluation indices such as debt to asset ratio, net profit, asset turnover. According to the analysis, the selected eleven evaluation indices contributed to 81% of the competitiveness of one automotive enterprise. And the FAW was evaluated as the most competitive indigenous automaker in China. [8] made a suggestion of giving consumer welfare more consideration in setting policy goals in automotive industrial field, since the paper evaluated the welfare gains to consumers and profits changes to auto groups owing joint ventures. Nevertheless, there is the opinion that the joint-venture collaboration pattern didn't achieve the incipient targets of 'trading market for technology'. And indigenous automakers could have more competitiveness through a few decades' development despite the spillover effects of joint-ventures. Core competitiveness is always seen as the cornerstone for indigenous automotive enterprises. In this section, the competition between foreign invested enterprises and state-owned indigenous enterprises is analyzed by means of a series of data.

Since foreign automotive investors started their investments in China, the competition between China's national automotive firms and foreign counterparts have been a key topic of China's automotive industry. As aforementioned, Chinese government prescribed several policies in the early development stage of domestic automotive industry, in order to protect national enterprises and to prevent them from being crowded out. However, the results and effects of these policies and the competitiveness improvement of national automotive industry have also been an important discussion topic.

Chinese automotive industry achieved a total production of 4.5 million automobiles in 1998. From the perspective of production volume, Chinese automotive industry has stepped out of the infant learning stage. In [15], the author criticized the short-termism of policies e.g. trade barrier, local content etc. and thought that these protections led to fragmentation of Chinese automotive industry. The rent-seeking behavior of both domestic and foreign automotive enterprises resulted in the lack of competitions in China's automotive market. Actually, the policies adjustments in early 21st century promoted the restructuring of this industry to get rid of fragmentation and miniaturization. Besides, the entrance into WTO brought about more trade liberalization in whole China economy. The opening-up generated stress on domestic firms and joint-ventures to push them to improve competitiveness. Both domestic firms and joint-ventures invested by foreign automotive enterprises were confronted with severe competition with market new-entrants. And consequently, the technology transfer from foreign automotive enterprises was facilitated.

In spite of the lag of technologies injection from foreign automakers and the improved condition thanks to policy adjustments, joint ventures generally have higher performances than domestic automotive manufacturers in terms of market share and productivity in China. As revealed by historical data of 1997, the joint-ventures had a productivity five times as high as the domestic ones [7]. Table 8 [7] summarizes the performance indicators based on the comparison between foreign invested joint-ventures and domestic enterprises. The analysis revealed that multi-national corporations had firm-specific advantages over local counterparts, which was in accordance with the FDI theories.

	JV*	***JV with HK Macao, and Taiwan***	***SOE***	***Collective***	***Holding***	***Others***	***Average***
Productivity (1,000 yuan/employee)	564.1	271.8	104.1	98.7	130.5	279.0	138.1
Profit/employee (1,000 yuan/employee)	28.2	21.1	1.0	1.6	9.7	29.1	3.9
Return on assets (%)	4.20	6.04	0.50	1.59	3.99	12.54	1.73
Return on sales (%)	5.56	8.62	0.98	1.74	7.26	9.68	2.93

NOTES: Return on assets = the ratio of profit to the total equity for the year, Return on sales = the ratio of profit to the total sales of the year.

Table 8. Performance Difference by the Nature of Automotive Firms of China in 1997

Figure 24 shows the market share evolution in automotive industry.

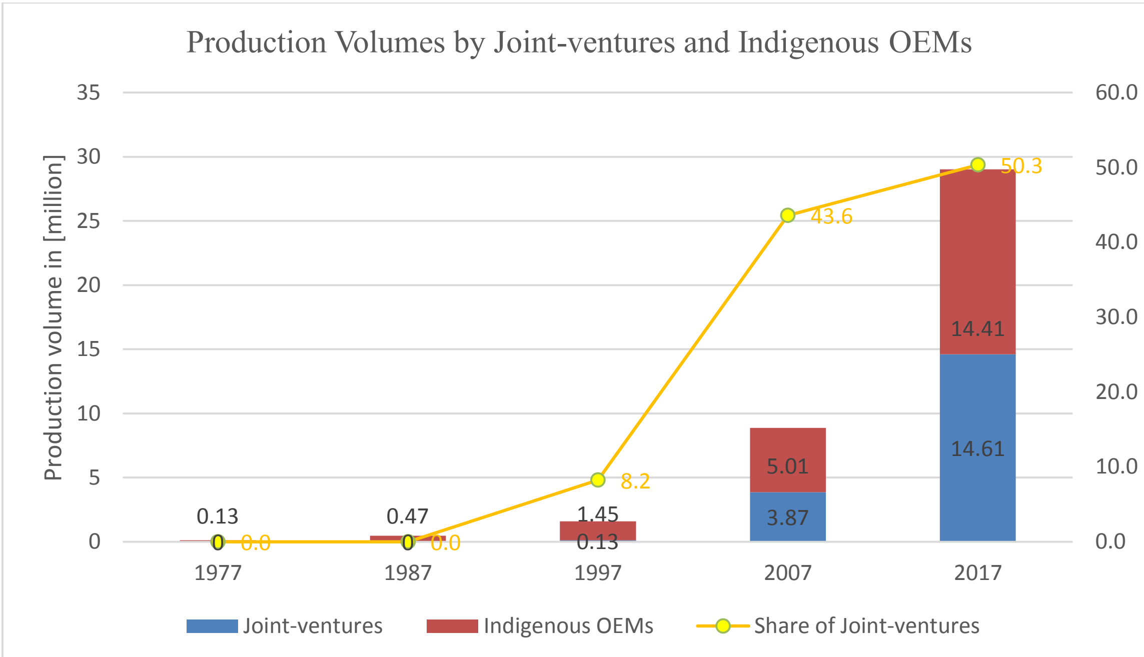


Figure 24. Production Volumes by Joint-ventures and Indigenous OEMs

Despite having achieved a substantial measure of success in automotive production and sales, the market is dominated by foreign brands. New launched vehicle models, 221 new launched vehicle models in 2009, a total of 120 were indigenous brands. Market research seems to corroborate that Chinese consumers have more favorable attitudes toward foreign branded cars. In the J.D. Power Asia Pacific 2010 China New-Vehicle Intender Study for 38 automobile brands and 105 models among Chinese consumers, it was found that Buick (produced by SAIC-GM), FAW-Volkswagen and SAIC-Volkswagen were the brands that has the greatest brand influence in the non-luxury cars category.

5. Future Scenario of China’s automotive industry

With more than sixty years’ development, China’s automotive industry has achieved the transition from startup to mature phase. China’s automotive industry has get involved into the global automotive industrial system. This largest auto market is witnessing the fierce competition among automotive corporations and the emergency of cutting-edge developing trends such as powertrain electrification, automation and networking. This chapter focuses on the fast development of new energy automotive industry in China.

5.1 Emerging New-energy Vehicles and Development Trends

Since motor vehicle was invented, fossil fuels have been the dominant energy source for human’s transportation. Within the development history, there have ever been ideas put up with to develop vehicles which use other energy sources such as electricity or fuel cell of hydrogen. However, the increasing demands of developing new-energy vehicles are not witnessed until the emergency of a series of megatrends.

The global climate change has been a major concern for all countries. Policies and regulations have been promulgated to promote significant reduction of CO2 emissions to mitigate global warming, particularly automotive CO2 emissions which accounts for approximately 23 percent of the global CO2 emissions. European Commission, NHTSA (National Highway Traffic Safety Administration) and EPA (Environmental Protection Agency) of the U.S. and Chinese government all introduce fuel penalty standards to promote automotive fuel consumption and CO2 emission reduction. In Europe, the community target for averaged CO2 emission from all combined new car fleets is 95 g/km based on NEDC by 2021. And the target is significantly reduced to 65 g/km in 2030. Each automotive manufacturer has its individual CO2 emission target based on average mass of passenger car and light-duty commercial vehicle fleets registered in Europe. If manufacturer’s average CO2 emission exceeds its specific target, emission penalties will be applied. In China, the governmental target is to reduce CAFC (Corporate Average Fuel Consumption) to around 5L/100km which is equivalent to 120g CO2/km by 2020 and a further decline to 4L/100km by 2025 according to the proposal for tightened fuel economy standard. The US has two sets of parallel standards i.e. the Corporate Average Fuel Economy by NHTSA and Green House Gas emission standards by EPA. EPA and NHTSA issued harmonized CAFE and GHG rules in 2012 for MY 2017-2025. According to the rules, each vehicle has a different CO2 emission compliance target depending on its footprint value. The projected fleet-wide CO2 and fuel economy compliance levels are respectively 163g CO2/mile and 54.5 miles/gallon by 2025. With respect to the [16] development vision of automotive industry by International Energy Agency, global CO2 emission quantity needs to achieve a 50% decrease until 2050 with reference to the emission quantity in 2005 and the transportation area needs to achieve a reduction of 30%. Under the pressure of more and more stringent energy saving and CO2 emission reduction policies, promoting faster development of new-energy vehicles is of great importance.

The rising concern of economic and security issues associated to oil is another main factor, particularly for those countries relying on oil import. It was reported that vehicle gasoline and diesel consumptions account for more than 70% of total gasoline and diesel consumptions in China. Besides, continuous increase of motor vehicle quantity leads to severe transportation congestion. Pollutants from engine emissions generate significant air quality issues. Cost of emission post-treatment and vehicle pipe emission are also an important tradeoff to balance when OEMs manufacture vehicles. Those vehicles complying with inferior level emission standards are critical sources of automotive emission pollutants.

Moreover, the rapid technology advancements in battery field over the past few decades make electric vehicles more feasible in mass market applications. For example, the power and energy density of onboard energy storage systems have been the main restraints for the development of new-energy vehicle. Traditional fossil fuels have very high specific energy, e.g. 11.8 kWh/kg of gasoline, 13.3~13.7 kWh/kg of diesel. Compared to traditional fossil fuels, electrochemical batteries generally have energy density lower than 200 Wh/kg with power density less than 2Kw/kg. Through the development of several decades, onboard battery packs achieve higher energy density. According to the statistics of 2018 in Chinese automotive market, all electric car models have battery packs energy density larger than 160 Wh/kg. The significant improvement in onboard battery packs is one of the main driving forces for new energy vehicle industry. Battery cost is another major restraint for developing battery electric and plug-in hybrid vehicles. According to the evaluation of International Energy Agency, it is necessary to reduce the target cost of battery to 300 US $/kWh by 2020 so as to keep the competitiveness of battery electric and plug-in hybrid vehicles.

Figure 25 makes a demonstration of powertrain electrification revolution based on global achieved and projected productions of vehicle models by major OEMs. Powertrain electrification includes partially and completely electrification i.e. hybrid and electric powertrain. Electrification rate is calculated as the ratio of electrified vehicle production to total production. As indicted by the figure, the electrification rate is just no more than 10% in 2011 but is projected to be larger than 70% in 2023. The large increment in percentage of electrified automotive powertrain indicates one of the megatrends in automotive industry. As a matter of fact, major OEMs are all planning and designing new energy vehicle to keep up with the development trend. As said in previous chapter, not only traditional automotive OEMs have transferred their focus on this emerging field, but also a series of new entrants are dedicated to it.

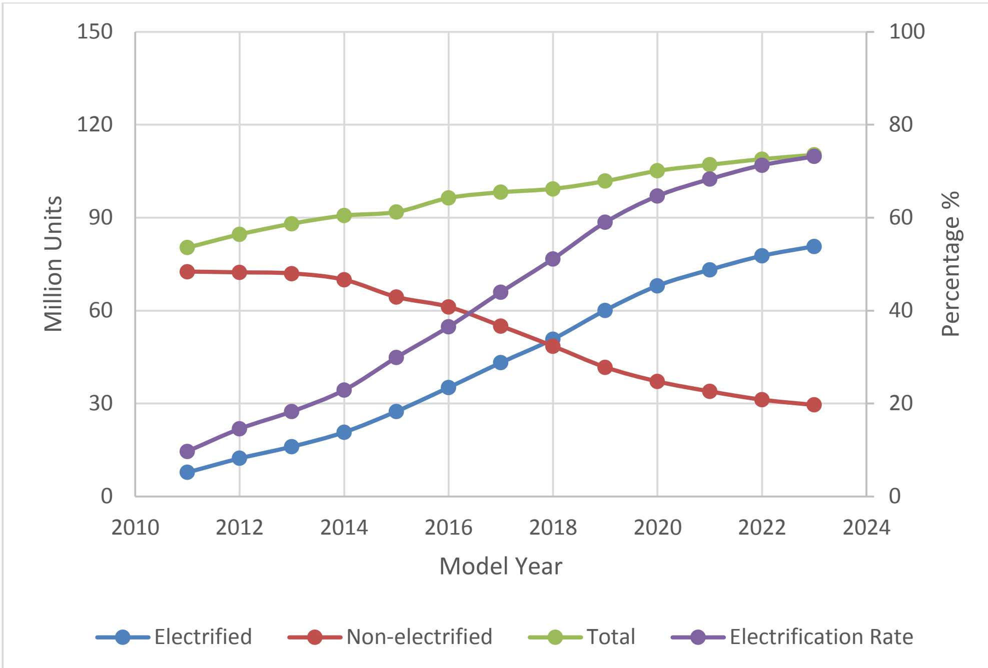


Figure 25. Global Powertrain Electrification Evolution

Internationally famous powertrain and vehicle engineering company FEV makes a prediction of future automotive powertrain development scenario in passenger vehicle as is shown in Figure 26. The analysis compares the scenarios in Europe and China. In most likely case, the predicted electrification rate in Europe is 91% in 2030, including 20% without traditional internal combustion engine.

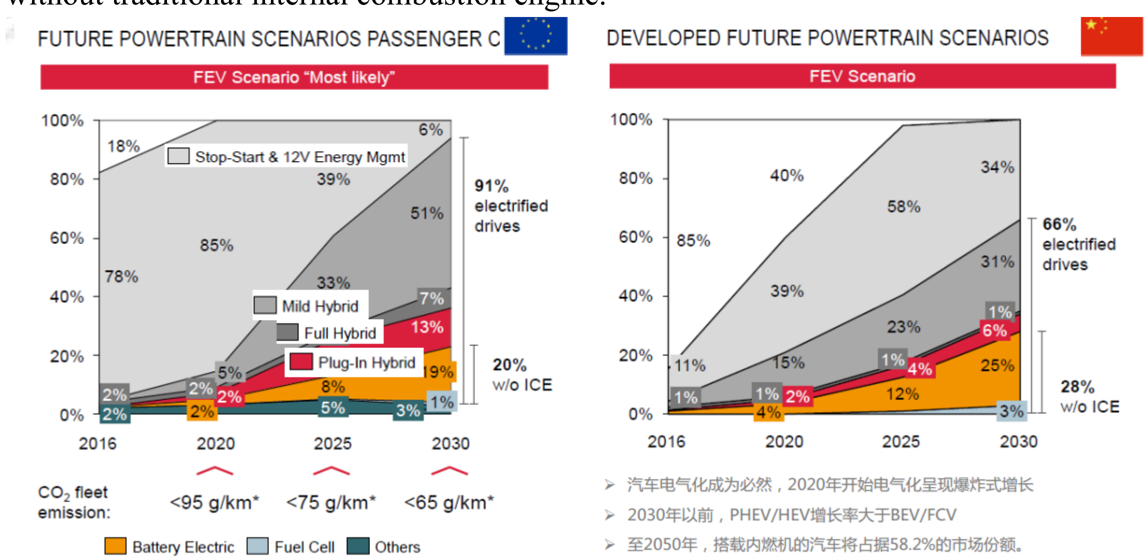


Figure 26. Powertrain Scenario Projected by FEV

5.2 China's NEV Policies

China is the largest motor vehicle production and sales country and also has the largest motor vehicle holding quantity. The rising auto market leads to dramatic demand of fuels. Growing emissions also pose enormous challenge to transportation in China. According to the study of World Bank in 2011[17], urban transportation energy use and greenhouse emission grew between four and six percent per year in major cities of China, such as Beijing, Shanghai, Guangzhou. However, China is one of the largest petroleum importing countries. The Development Report of Domestic and Foreign Oil and Gas Industry in 2018 by CNPC Economics & Technology Research Institute reveals that China's oil import dependency rate has risen up to almost 70% in 2018. Chinese government has been eager to find a way to change the energy structure in order to reduce the reliance on oil, in addition to the strong demand to reduce emissions from transportation. New energy vehicles have apparent advantages in reducing emissions and fuel consumption, while new energy vehicle has been widely debated regarding well-to-wheel greenhouse emission. People argue that new energy vehicle industry shifts vehicle emissions upstream to plants producing electricity and used batteries are significantly harmful to environment. This controversy could vary with countries based on their energy structure. Despite the debate of developing new energy vehicle, Chinese government has been promoting the development of new energy vehicle industry since 21st century. And it is said that China is eager to take a shortcut to become a powerful country in automotive industry by means of its fast development of new energy vehicle industry. Chinese government has made a series of policies in different fields, including tax, science and technology, subsidies to support the national strategy to promote new energy vehicle industry.

Table 9 summarizes the main policies announced by Chinese government in the recent years.

Year	Agency	Policies and Programs
2001	MOST	Key Science and Technology Project of Electric Vehicle under 863 Program in the 10th Five-Year Plan
2006	MOST	Key Science and Technology Project of Energy Saving & New Energy Vehicle under 863 Program in the 11th Five-Year Plan
2009	MOF, MOST	Notice on Implementing Energy Saving & New Energy Vehicle Demonstration Pilot Program
2010	MOST, NDRC, MIIT, MOF	Notice on Extending Energy Saving & New Energy Vehicle Pilot demonstration Program
2010	MOST, NDRC,MIIT, MOF	Notice on Implementing NEV Private Purchase Subsidy Pilot Program
2012	MOST,MOF	Notice on Vehicle and Vessel Tax for New Energy Vehicle and Vessel

2012	MOST	Key Science and Technology of Electrical Vehicle in the 12th Five-Year Plan
2012	State Council	Energy Saving & New Energy Vehicle Medium and Long-term Development Plan
2012	State Council	12th Five-Year Plan The Strategic Newly Arisen Industry Development Plan
2013	MOST	Notice on Implementing New Energy Vehicle Demonstration Pilot Program Phase II
2014	MOST, NDRC, MIIT, MOF	Notice on Adjusting Phase-out Mechanism on Subsidy
2014	State Council	Instruction on Accelerating NEW Promotion
2014	MOF, SAOT, MIIT	Notice on Purchase Tax Free for NEV
2014	MOST, NDRC, MIIT, MOF	Notice on Reward of Infrastructure for Electric Vehicle
2014	NDRC	Temporary Provisions about New BEV Enterprises Investment and Producing Access Management (draft)
2014	MOST,NDRC,MIIT,MOF	Notice on Financial Support on NEV Promotion in 2016-2020
2015	NDRC,NEA, MIIT	Electric Vehicle Charging Infrastructure Development Guide (2015-2020)
2016	MOF	Notice on Adjusting the Fiscal Subsidy Policies on NEV Promotion and Application
2017	MIIT	Parallel Management Regulation for Corporate Average Fuel Consumption and New Energy Vehicle Credits for Passenger Cars
2018	MOF,MIIT,NDRC,MOST	Notice on Adjusting the Fiscal Subsidy Policies on NEV Promotion

Table 9. Policies in New Energy Vehicle Field by Chinese Government

NDRC- National Development and Reform Commission of P.R.C.
MIIT- Ministry of Industry and Information Technology of P.R.C.
MOF- Ministry of Finance of P.R.C.
MOST- Ministry of Science and Technology of P.R.C.
SAOT- State Administration of Taxation of P.R.C.
NGOA- National Government Offices Administration of P.R.C.
NEA- National Energy Administration

In 2001, electric vehicle became one of the key Science and Technology projects announced by the 10th Five-Year-Plan. The developing trend of electric vehicle industry was confirmed. The project specified the technical layout to develop fuel cell vehicle (FCV), hybrid electric vehicle (HEV) and battery electric vehicle (BEV). Besides, vehicle control system, driving motor system and power battery system were major automotive components and systems to be developed. The 'Key Science and Technology Project of Energy Saving and New Energy Vehicle' was approved during the 11th Five-Year-Plan in 2006. More than 400 automotive enterprises, 14.6 thousand scientists and engineers participated in the research. In 2009, the Chinese government initiated new energy vehicle pilot programs in thirteen cities, focusing on the deployment of electric vehicles for government fleet applications such as urban bus transportation and taxies. The program extended from 10 cities to 25 cities in 2010, five of which also started to promote consumer purchase.

In association with the pilot program, fiscal subsidy policy was initiated in 2009. The fiscal subsidy policies if one of the most important incentive policies to promote NEV industry development in China. By the end of 2018, the national government has spent more than 100 billion CNY on NEV subsidies. The fiscal subsidy is not limited to national level. Local governments regulate specific subsidies as per local conditions. The subsidy policy has undergone seven adjustments with reference to the original policy introduced in 2009. Figure 27 illustrated the evolution of NEV fiscal subsidy policies. In 2010, the fiscal subsidy extended to private NEVs. And the subsidy policy was expanded to cover hybrid city buses in non-pilot cities in 2012. Following the further extension of central subsidy to 2013-2015, the first phase-down of national subsidy was announced in 2014 for 2014-2015. In 2015, the fifth adjustment of the fiscal subsidy signified the second phase-down, which was valid from 2016-2020. Shortly after the 2015 policy adjustment, an updated policy was jointly issued in December of 2016 by MOF, MIIT, MOST and NDRC, which means the third phase-down of the fiscal subsidy for NEVs. The 2017-2020 policy adjustment is characterized by tightened vehicle qualification requirements, more robust anti-fraud measures. According to the 2017-2020 adjustment, the subsidy per-vehicle decreases by 20% every two years from 2017 to 2020. The 20 percent rate is also applicable to sub-national subsidy caps [18]. According to the fiscal subsidy policies, consumers can enjoy matching subsidies provided by the sub-national governments in addition to the national subsidies. Before the 2017-2020 adjustment, sub-national governments have autonomy to determine their own subsidy levels according to local conditions. But the 2017-2020 adjustment regulates local subsidy 'caps', which prescribes that total amount of subsidy per vehicle from all sub-national governments cannot exceed 50% of the level provided by central government. The policy adjustment makes an exception for FCVs. In February of 2018, a further adjustment of the fiscal subsidy was issued by MOF, MIIT, MOST and NDRC. As prescribed by the new policy adjustment, the first half year of 2018 is an interim during which new registered passenger new-vehicle cars and buses could enjoy 70% of the per-vehicle subsidy of 2017 while the freight trucks and vocational vehicles keep the same subsidy level of 2017. Moreover, sub-national subsidies will gradually be converted into fiscal support to NEV infrastructures construction and NEV transportation etc.

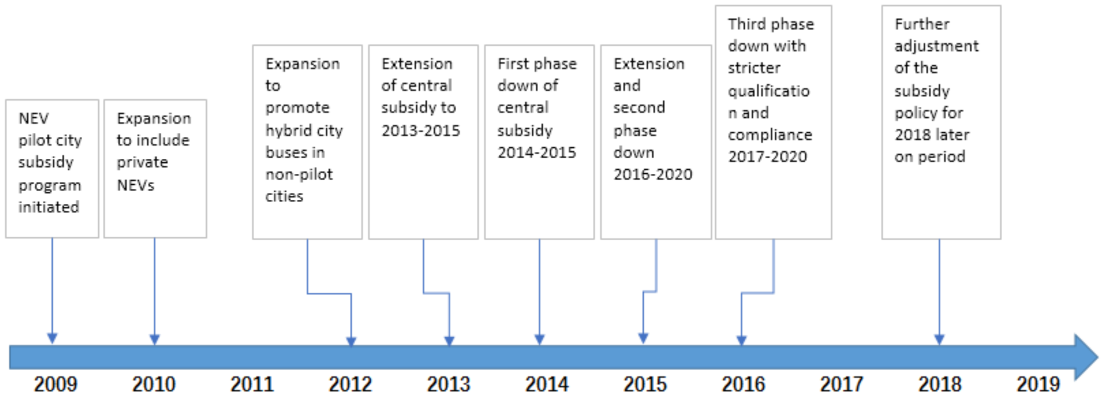


Figure 27 . Evolution of China's NEVs Fiscal Subsidy Policies

The subsidy is applicable to battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell vehicle (FCVs). Besides, vehicles must meet a series of technical requirements in order to be qualified for the subsidy. The requirements aim to keep incentives focused on advanced technologies and omit vehicles with outdated technologies. There are technical thresholds required for these requirements which vary with different types of NEVs. With the adjustments of the implementation of subsidies, qualification requirements for NEVs also update and become more stringent. The magnitude of subsidy is determined by a variety of performance parameters of the vehicles. Taking passenger BEV cars for example, minimum electric range, and max achievable vehicle speed need to be satisfied according to 2016 fiscal subsidy and the 2017-2018 adjustment added the minimum energy efficiency and minimum energy density requirement. Table 10 illustrates the requirements for passenger cars. The energy efficiency requirements designed for BEV and PHEV passenger cars are a function of curb mass and the energy efficiency requirement for PHEV in 2017-2020 is applied on those with electric range no smaller than 80km. But fuel saving requirement in 2017-2020 is only applied on those PHEV having electric range less than 80km. For battery-electric passenger cars, electric range measured in km is used as scaling parameter to determine the subsidy amount while the battery energy density is included as the new scaling factor. The principle of using scaling parameter is that subsidy amount vary with levels of these scaling parameters. For plug-in hybrid passenger cars, there is no scaling parameters prescribed and subsidy amount is identically applied as long as cars meet qualification requirements. The level of subsidy regulated by the 2017-2020 adjustment is scaled with rated power which is a new technical requirement and also as scaling parameter compared to previous policy version. Correspondingly, Table 11 makes a summary of the subsidy amounts for new-energy passenger cars. As regulated by the 2017-2020 adjustment, the subsidies for BEVs and PHEVs are reduced by 20% every two years from 2017. However, the further adjustment in 2018 regulated new subsidy levels which means a more evident phase-down of fiscal subsidy policy.

Vehicle type	Technology	Year	Technical threshold							
			EF[1]	ER (km)	BD (Wh/kg)	BM (%)	CS[2] (C)	SP (km/h)	FS (%)	RP (kW)
Passenger Cars	BEV	2016		≥100				≥100		
	BEV	2017-2020	O[3]	≥100	>90			≥100		
	PHEV	2016		≥50					≥40	
	PHEV	2017-2020	O[3,4]	≥50					≥30[5]	
	FCV	2016		≥150						
	FCV	2017-2020		≥300						>10

Table 10. Technical Requirements for New-energy Passenger Cars

EF: energy efficiency (kWh/100 km for passenger cars)
ER: electric range (km)
BD: battery energy density (Wh/kg)
BM: battery mass as a percentage of vehicle curb mass (%)
CS: charging speed of batteries (C)
SP: maximum vehicle speed (km/h)
FS: fuel saving compared to conventional vehicles (%)
RP: rated power (kW)

Vehicle Type	BD (Wh/kg)	ER (km)	RP (kW)	Subsidy level CNY 10,000/vehicle	
				2016	2017-2018
BEV	90≤BD<120	100≤ER<150	-	2.5	2.0
		150≤ER<250	-	4.5	3.6
		ER≥250	-	5.5	4.4
	BD>120	100≤ER<150	-	2.5	2.2
		150≤ER<250	-	4.5	4.0
		ER≥250	-	5.5	4.8
PHEV	-	ER≥50	-	3.0	2.4
FCV	-	-	10≤RP<30	20	0.6/kW
	-	-	RP≥30	20	20

Table 11. National Subsidy Levels for New-energy Passenger Cars

As a matter of fact, many issues concerning the fiscal subsidy policy happened since it was initiated in 2009, for example, subsidy fraud, inconsistent product quality. Despite the strong stimulus to China's NEV market growth, the fiscal subsidy policy has been widely debated and even criticized due to the negative issues. The frequent adjustments of the subsidy policy imply the decision of central government to close policy design loopholes and making the policies more effectively implemented. For example, the subsidy is released to the vehicle manufacturers only after sales of qualified new-energy vehicles with verification of sales by means of invoices, registration proof etc. instead of the previous rule of checking vehicle operation licenses. And non-private NEVs need to demonstrate a minimum accumulated mileage of 30000 km before their subsidies being paid.

The ‘Energy Saving and New Energy Vehicle Medium and Long-term Development Plan’ and the ‘12th Five-Year-Plan Strategic Newly Arisen Industry Development Plan ‘announced in 2012 specified the target of achieving accumulated sales of five million PEVs until the end of 2020, in addition to the fleet average fuel consumption of 5.0 L/100km until 2020. The Ministry of Finance, State Administration of Taxation and the Ministry of Industry and Information Technology launched the ‘Notice on Vehicle and Vessel Tax for New Energy Vehicle and Vessel’ in 2012. According to the notice, the tax was halved for energy-saving vehicle and vessel, and free tax for new energy vehicle and vessel. In 2014, the ‘Instruction on Accelerating NEV Promotion’ stated the preferential corporation income tax and business tax policies for automotive enterprises manufacturing energy-saving and new-energy vehicles and key parts. Moreover, the ‘Notice on Purchase Tax Free for NEV’ stated that purchase tax of NEVs was free from Sept. 1st of 2014.

Apart from the fiscal subsidy and tax incentives, the Chinese government also issued policies to promote NEV infrastructure establishments. According to the Notice on Reward of Infrastructure for Electric Vehicle issued in 2014, the infrastructure rewards targeted those provinces and cities that had relatively well-established new-energy vehicle charging infrastructures and large new-energy vehicle quantities. The levels of reward were based on the quantity of equivalent pure-electric vehicles in use and other new-energy vehicles were converted to equivalent pure-electric vehicle according to specific conversion rules. As far as the NEVs scale is concerned, those important air-pollution control regions such as Beijing, Shanghai, Shandong, Guangdong need to achieve NEVs new registrations no less than 30 thousand in 2016, 35 thousand in 2017, 43 thousand in 2018, 55 thousand in 2019 and 70 thousand in 2020 in order to obtain the infrastructure rewards. In addition to the requirements for absolute NEVs registrations, percentage of NEVs new registrations with respect to overall vehicle new registrations needs to fulfill specific limits, e.g. 2%, 3%, 4%, 5%, 6% respectively for 2016 to 2020.

In 2017, Ministry of Science and Technology of China launched the Parallel Management Regulation for Corporate Average Fuel Consumption and New Energy Vehicle Credits for Passenger Cars. The regulation is aimed at promoting energy saving and relieving the pressure on environment. The regulation combines the corporate average fuel consumption rules and the policies targeting promotion of new-energy vehicles. The parallel management means that the credits owing to corporate average fuel consumption and credits owing to corporate new-energy vehicles manufacturing are complementary, tradable. For example, if one vehicle OEM designs and manufactures both traditional vehicles and new-energy vehicles, the OEM can use the obtained positive credits by manufacturing NEVs to compensate for the negative credits caused by traditional vehicles when its corporate average fuel consumption doesn't meet the prescribed fuel consumption targets e.g. 5L/100km by 2020. According to [19], 9.94 million positive average fuel consumption positive credits and 2.99 million negative million credits were generated within 2018, which correspond respectively to 19.74% decrease and 77.18% increment. The total amount of NEV positive credits generated in 2018 is 4.03 million. From the perspective of traditional vehicles, it is quite hard to satisfy the average fuel consumption target of 5.0 L/100km by 2020. When new-energy vehicles are taken into consideration, the average fuel consumption of China's automotive industry in 2018 is 5.8 L/100km. The NEVs make a contribution of 12.12% fuel consumption decrease. The influences of NEVs scale is evident for the evaluation of average fuel consumption of the whole automotive industry. This policy and the corporate fuel consumption pressure compel most traditional vehicle manufacturers to produce NEVs in order to fulfill national regulations and avoid penalties. For example, automaker Geely announced an aggressive plan of more than one million NEV sales to be achieved in 2020 in China. As a matter of fact, NEVs need to satisfy some specific technical requirements to be qualified for NEV credits, as is shown in Figure 28.

Vehicle Type	BEV	PHEV	FCEV
Minimum electric range (km)	100	50	300
Range of NEV credits per vehicle	1~6	1~2	2~5

Note: The number of credits per vehicle for a BEV is calculated as: (0.012*electric range+0.8) *efficiency factor. For a PHEV, the calculation is :2*efficiency adjustment factor. For a FCEV, the calculation is: 0.16*FCEV system rated power* efficiency adjustment factor.

Figure 28. Requirements for NEVs Regulated by China's NEV Credit System

The regulation policies and promotion incentives for NEVs adopted by Chinese government indicate the strong determination of China to promote new-energy vehicle industry development and also the fast technical progress in traditional powertrain fields. Along with stimulating consumer demand for NEVs, the intensive efforts by Chinese government have been put to build a full supply chain of domestic NEV industrial sector. The NEV credit mandate is actually an important tool to support this development, which incorporates incentives to stimulate innovation and consolidation of high technologies. In addition to the detailed introductions of China's NEV policies, a schematic summary of NEV policies formulated by other regions is shown in Table 12 for comparison. China, the U.S., Japan, European Union, Canada and India have all promulgated a series of policies to promote NEV development in respective regions. China and Canada are the two countries in the list that have all aspects of policies. A detailed introduction of these policies can be referred to [20].

“The industry forecasts suggest that the global electric vehicle sales will contribute between 2 percent and 25 percent of annual new vehicle sales by 2025, with the consensus being closer to 10 percent. As a result of such a transition, there will be a significant shift in the overall value chain in the automotive industry”. In the following section, detailed economic data concerning China’s NEV industry are demonstrated.

		Canada	China	European Union	India	Japan	United States
Regulations (vehicles)	ZEV mandate	√*	√				√*
	Fuel economy standards	√	√	√	√	√	√
Incentives (vehicles)	Fiscal incentives	√	√	√	√		√
Targets (vehicles)		√	√	√	√	√	√*
Industrial policies	Subsidy	√	√			√	
Regulations (chargers)	Hardware standrads**	√	√	√	√	√	√
	Building regulations	√*	√*	√	√		√*
Incentives (chargers)	Fiscal incentives	√	√	√		√	√*
Targets (chargers)		√	√	√	√	√	√*

Table 12. NEV Development Policies in Selected Regions

5.3 New-energy Vehicle Industry Development in China

In 2018, the global electric car fleet [20] exceeded 5.1 million, more than 2 million’s increase from the previous year. China has the largest motor vehicle production and sales volume in the world. In the sector of new energy vehicle, China is also the largest market followed by Europe and the United States. With the propulsion of a series of policies promulgated by the government, China’s NEV market has been growing with remarkable rate, becoming the largest market since 2015. China has achieved an accumulated production of 3.04 million NEVs between 2009 and 2018, with 2.43 million pure-electric vehicles, 0.599 million PHEVs and 3.4 thousand fuel-cell vehicles [19]. The electric car stock of China was 2.3 million units in 2018, which accounted for almost half of the global electric car stock. It’s necessary to mention that the annual NEV production volume in 2018 is 1.22 million, which signifies the first time that annual NEV production volume exceeds one million in China. Figure 29 depicts the annual NEV production volumes between 2009 and 2018. There was an explosive increment of the NEV annual production in 2015.

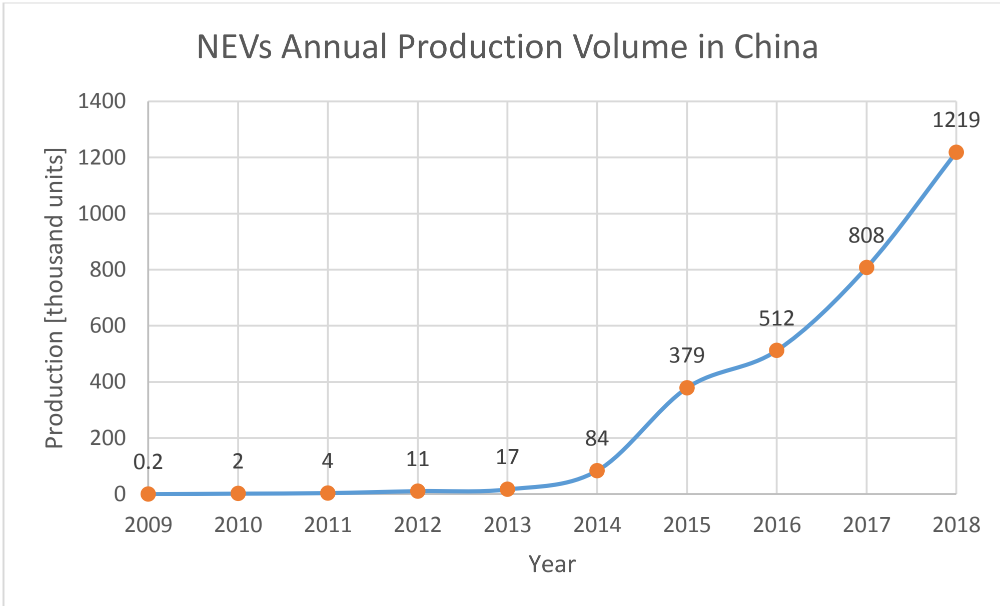
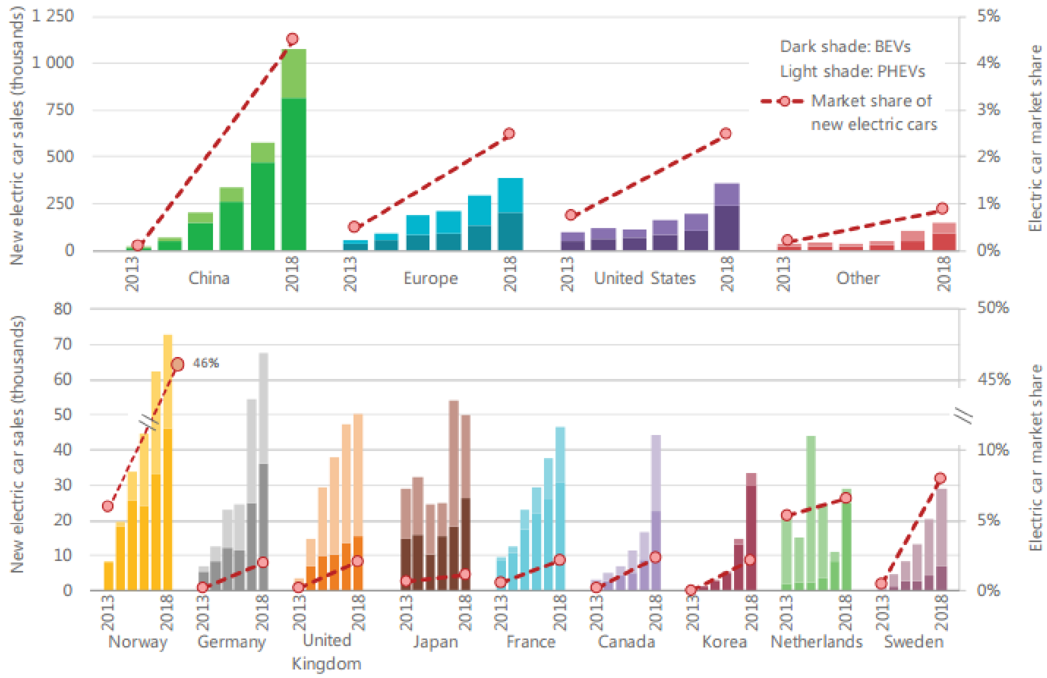


Figure 29. NEV Annual Production Volume in China
(Data Source: CATARC-China Automotive Technology & Research Center)

International Energy Agency made an analysis of the global electric car sales and market share between 2013-2018 as is shown in Figure 30. The data in Figure 30 don't include those of hybrid cars, fuel cell cars, commercial vehicles. Even though China had the largest electric car sales volume in 2018, the market share of new electric car (including PHEV and BEV) was relatively low compared with the value of Norway which achieved 46% in 2018. In terms of light-commercial electric vehicles (BEV and PHEV), 250 thousand units on road in 2018 with a corresponding increment of 47.1% from 2017. In 2018, China achieved the largest electric LCV fleet worldwide with almost 138 thousand vehicles, which made up 57% of the global fleet. It should be mentioned that the reported LCV fleets in China took into account of data of other commercial vehicles such as medium and heavy-duty trucks and buses. Following China, Europe was the second-largest market for electric LCVs, achieving a fleet of 92 thousand vehicles and correspondingly 38% of the global stock in 2018. In 2018, around 54 thousand electric LCVs were sold in China and about 25 thousand in Europe. It was recorded 99% of the electric commercial vehicles were BEVs. As a matter of fact, battery electric city-buses are quite common used in major cities of China, such as Beijing, Shanghai, Guangzhou, Shenzhen etc. Compared to other NEV types, FCEV has a quite small global fleet on road. According to [16], there were totally 11.2 thousand fuel cell passenger cars in 2018, more than half were located in United States. Japan, Korea, Germany and France were other countries that had remarkable deployments of fuel-cell passenger car as of 2018. China has the largest FCEV buses fleet in the world, with more than 400 units by the end of 2018. China has also equipped more than 400 medium and heavy-duty trucks with fuel cell technologies as trail, which signifies the interest of China to apply hydrogen in transportation area.



Notes: BEVs = battery electric vehicles; PHEVs = plug-in hybrid electric vehicles. Europe includes Austria, Belgium, Bulgaria, Croatia, Cyprus,[2] Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom. Other includes Australia, Brazil, Chile, India, Japan, Korea, Malaysia, Mexico, New Zealand, South Africa and Thailand.

Sources: IEA analysis based on country submissions, complemented by ACEA (2019); EAFO (2019); EV Volumes (2019); Marklines (2019); OICA (2019).

Figure 30. Global Electric Car Sales and Market Share in Major Regions

International Energy Agency makes projections of NEVs development based on two scenarios i.e. the New Policies Scenario and EV30@30 Scenario [16]. The New Policies Scenario is based on the impact of announced policies by different countries targeting development of NEVs, while the EV30@30 Scenario corresponds to the pledges of the EVI EV30@30 campaign. According to the former, the global electric vehicles stock will reach 135 million in 2030 and the sales volume is projected to reach almost 15% in 2030. China will keep taking the lead with the highest level of NEV increment over the projection period. The market share of NEVs in new vehicle sale is projected to reach 28% in China, including battery-electric and plug-in hybrid electric passenger cars, buses, trucks. Europe and Japan are expected to achieve respectively EV shares of 26% and 21% by 2030. In the United States, the EV sales share will reach 8% which shows a quite slower pace to deploy battery electric and plug-in hybrid vehicles, but California where adopts more stringent fuel economy and emission regulations is expected to have a higher rate. However, the latter scenario by IEA projects a quite higher global electric vehicle (including battery-electric and plug-in hybrid vehicles) amount on road in 2030, which is almost twice the volume by the New Policies Scenario. According to the EV30@30 Scenario, there will be more than 250 million electric vehicles by the end of 2030 and the sales volume in 2030 will exceed 43 million. In this scenario, China will also maintain the world lead with 42%

EV market share in 2030. Europe and Japan will reach respectively shares of around 50% and 37% in 2030. Besides, the United States is expected to achieve a higher share level compared to the former scenario, that will be 30%, equivalent to that of Canada. Detailed data can be referred to Figure 31.

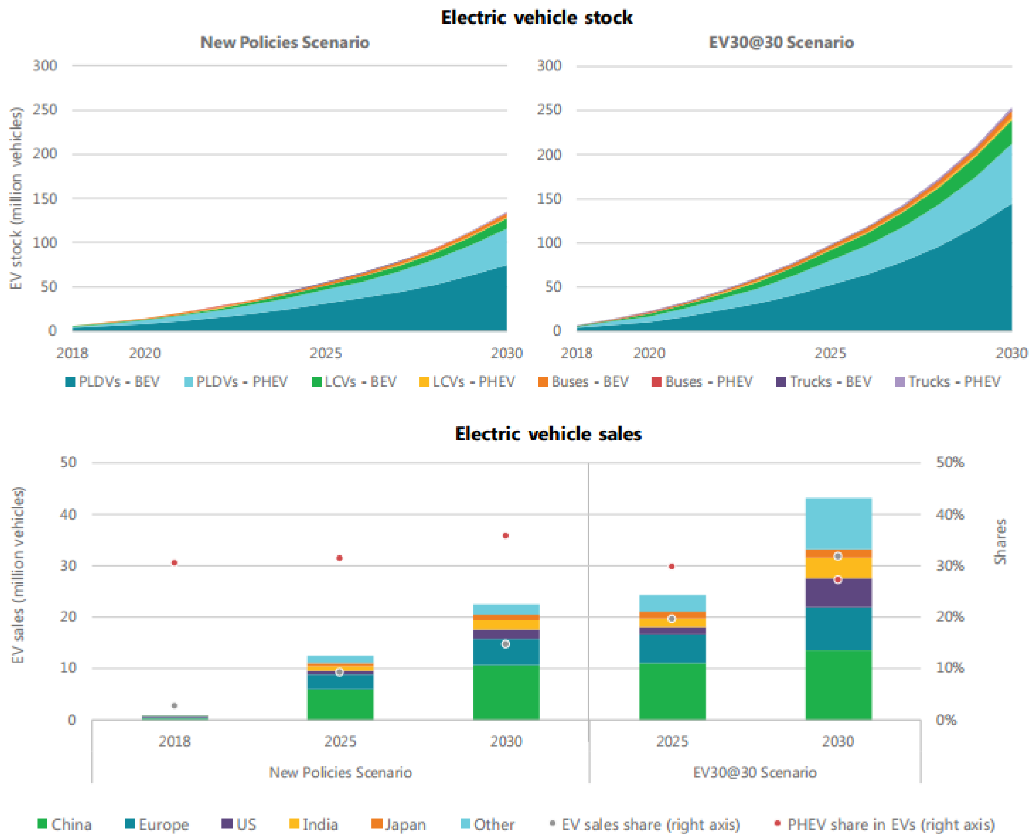


Figure 31. Projections of Global EVs Market by IEA

The global interest of transition to powertrain electrification and series of stimulation policies are reshaping the automotive industry structure. Over the past years, China has made an intensive effort to build a full supply chain of domestic NEV production, from the assembly of vehicles to the production of important vehicle components such as batteries. In correspondence to the developments of policies, automakers announce their electrification strategies. Figure 32 demonstrates the sales volumes of New-energy vehicles of major OEMs in China in 2019. Among the top 15 OEMs of NEV sales volume, there are 12 China's indigenous brands. BYD occupied the first place with a sales volume of 219,363 which accounted for 48% of the total vehicles sales of BYD in 2019. And BYD has maintain the first place in NEV sub-sector for six years in China. Among the fifteen OEMs, BAIC BJEV, SAIC-GM-Wuling, Chery, GAC NE, Great Wall, NIO, XPENG Motors, DFAC DFPV were almost totally focused on BEVs, while BYD, SAIC Motor, Geely, Chang'an had NEV deployments in PHEV sector. The other two joint-ventures SAIC VW and Brilliance BWM only sold their PHEV models in 2019.

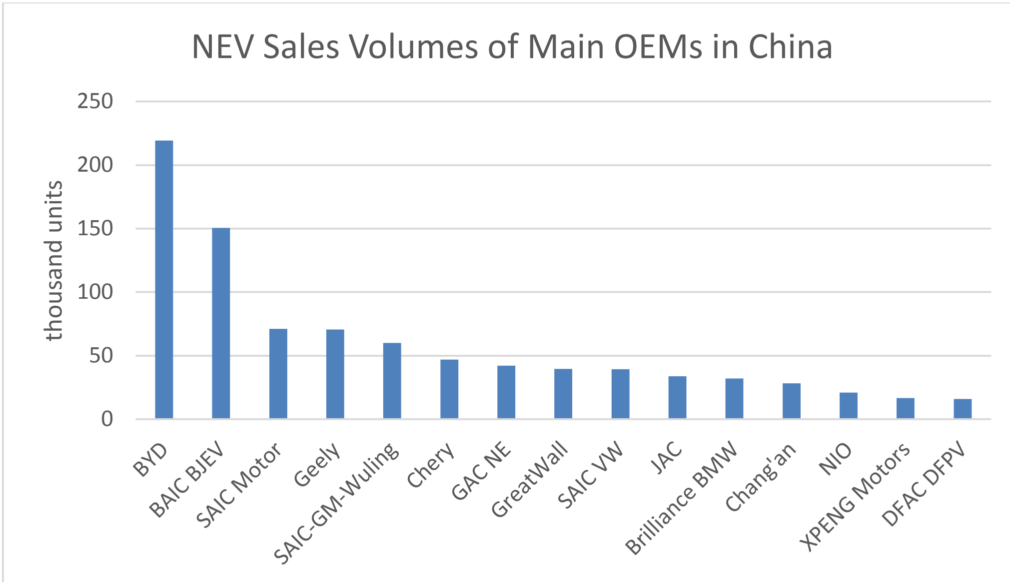


Figure 32. NEVs Sales Volumes of Major OEMs in China

Consumers are increase their positive response to the NEV policies and technology developments, which acts another important stimulating factor for OEMs' technological transition to powertrain electrification. Global automotive major OEMs are putting more efforts to deploy NEVs to extend their products arrays. New-energy vehicle models are expected to increase significantly. Table 13 makes a summary of the recent announcements from global major OEMs concerning NEVs in the following years. As revealed by the analysis of IEA [20], China will remain ahead of Europe and the United States in terms of new-energy passenger models availability. There were almost 32 PHEV models and 120 BEV models across passenger car segments in China in 2018. And there was an increment of 100 BEV models and 70 PHEV models in China's market in 2019. In Europe, the increments of BEV and PHEV models were respectively 60 and 55 within 2019. The scheduled increments of new new-energy vehicle models are in accordance with the market performance of presently available models. In China, almost all indigenous OEMs and OEMs from Europe and US are extending their product diversity with more BEV and PHEV models except that Japanese OEMs such as Toyota and Honda are promoting steadily their HEV products. The difference of OEMs is dependent on their technology advantages and their interpretations of NEV policies of China.

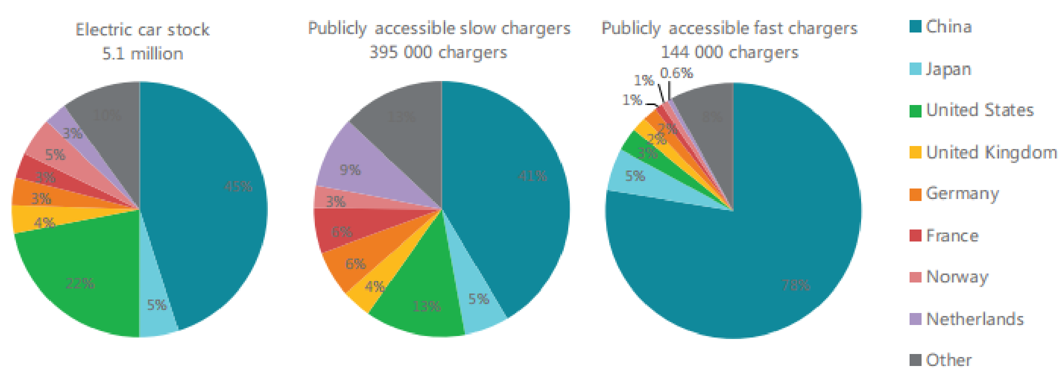
As regards the electrification process of commercial vehicles, most of the activities in electric bus market is in China. Other regions like Europe are also showing increased interest in public transportation tools electrification. Chinese NEV bus manufactures Yutong and BYD have been actively promoting their products in Europe and Latin America. BYD's second European factory in France started production of electric buses and coaches in 2018 and is supplying buses to the UK and Italy. European manufacturers such as Volvo, Scania, Iveco have also been actively involved in the tendency to deploy electrified buses. In the segments of heavy-duty commercial vehicles, OEMs such as Daimler, Volvo announced their plans to electrify their heavy-duty vehicles. BYD has been producing its BEV truck model T9. Tesla launched its BEV truck model Semi with electric range over 500 miles in 2019.

Automotive OEMs	OEM's NEVs Announcements
BYD	0.6 million new-energy car sales in 2020
BAIC-BJEV	0.5 million new-energy car sales in 2020 and 1.3 million in 2025
Chang'an	21 new BEV models and 12 new PHEV models by 2025, 1.7 million sales by 2025
Dongfeng Motor	6 new NEV models by 2020 with 30% electric sales share in 2022
Geely	1 million sales with NEV sales share 90% in 2020
BMW	15-25% of the group's sales in 2025 and 25 new NEV models by 2025
FCA	28 new EV models by 2022
Mercedes-Benz	0.1 million sales in 2020, 10 new NEV models by 2020, 25% of the group's sales in 2025
Volkswagen	0.4 million electric car sales in 2020, 3 million electric car sales in 2025, 80 new EV models by 2025 and 22 million cumulative sales by 2030
Volvo	50% of group's sales to be fully electric by 2025
Honda	15% electric vehicle sales share in 2030
Toyota	more than ten new models by early 2020s and 1 million BEV/FCEV sales in 2030
Hyundai-Kia	12 new EV models by 2020
Ford	40 new EV models by 2022
GM	20 new EV models by 2023
Tesla	Around 0.5 million sales in 2019 and a new BEV model in 2030

Table 13. Announcements by Global Major OEMs Concerning NEV Development

Alongside with the active deployments of electrified product lines by OEMs, deployment of charging infrastructures is of great importance to assist the transition to electrification. Policies play significant roles in the process of enhance charging infrastructure network. The policies generally include minimum requirements to ensure electric vehicles readiness in buildings and parking lots, and the quantity of publicly-accessible chargers in cities or on highway. Charging point operators, manufacturers of hardware and other power sector companies are also actively involved to boost their investments in charging infrastructure.

According to the statistics by IEA [16], there were globally 5.2 million light-duty vehicle chargers by the end of 2018, including 540 thousand publicly-accessible chargers. Among the 150 thousand fast chargers, more than 75% are located in China. Apart from the chargers for light-duty vehicles, there were globally more than 150 thousand fast chargers used for public transportation buses. Figure 33 shows the distribution of publicly-accessible chargers by countries. Table 14 shows the detailed chargers classified by charging standards, usage sites etc. in China. There were totally 1.08 million NEV charging ports in China by the end of 2018, most of which were used in cities with a percentage of 99.3%. Besides, publicly-accessible chargers accounted for less than 30% of the total charging resources, compared to the private sector of 56.5%. From the perspective of charging standards, more than 99% of the chargers comply with the international standards. In addition, Table 15 provides an indication of the distribution of charging infrastructures in China. The top 11 cities accounted for 70% of the chargers in China. Shanghai, Beijing and Shenzhen are the cities that have deployed more than 100 thousand chargers.



Sources: IEA analysis based on country submissions, complemented by Chinabaogao (2019) and EAFO (2019).

Figure 33. Distribution of Publicly-accessible Chargers by Countries

Category	Type	Amount	Percentage
Technical Type	Direct-current	161,200	14.90%
	Alternating-current	918,100	85.10%
Sharing Property	Publicly accessible	276,100	25.60%
	Private	610,000	56.50%
	Special use	193,200	17.90%
Usage Sites	City	1,071,278	99.30%
	On-highway	8,022	0.70%
Standards	International	1,075,314	99.60%
	Non-international	3,986	0.40%

Table 14. Charging Ports as of 2018 in China
(Data Source: CATARC-China Automotive Technology & Research Center)

Major Cities	Charging Ports
Beijing	170,562
Shanghai	197,632
Shenzhen	131,442
Hangzhou	38,030
Guangzhou	52,291
Hefei	26,092
Wuhan	18,016
Xi'an	22,375
Nanjing	21,772
Tianjin	47,221
Qingdao	21,501
Sum of 11 Major Cities	746,934
China Total	1,079,300

Table 15. Charging Ports in China's Major Cities
(Data Source: CATARC-China Automotive Technology & Research Center)

Global major economies are ramping up their determination to expand the construction of charging infrastructures, including promulgating stimulating policies and the active involvement from private sectors. China announced the plan to increase private charging outlets to more than 4 million and 500 thousand publicly accessible chargers by 2020 in order to accommodate the target of 5 million NEVs. Besides, China plans to deploy 12 thousand battery swap stations. As is illustrated by the new adjustment of subsidy policies, China’s government is urging to phase down the subsidies for NEV purchase and spare more emphasis on charging infrastructure deployment. The fast uptake of NEV market should be in line with the fast deployment of charging facilities. In addition to the policies by central government, many cities in China are implementing incentives for private or public charging. Compared to Europe and the United States, most of the plans for deploying charging infrastructures are from stated-owned OEMs [20]. There are four largest charging infrastructure providers in China, State Grid Corporation of China, China Southern Power Grid, Qingdao Teld New Energy and Jiangsu Star Charge. They have a control of more than 80% of China's charging ports. The State Grid Corporation of China announced its target to build 120 thousand charging points in China by 2020. Apart from the plans by power sector enterprises and charging infrastructure hardware manufacturer, some automotive OEMs such as SAIC, BAIC, NIO also announced their targets to get involved to build charging points in China. For example, SAIC plans to build more than 50 thousand publicly-accessible charging ports. NIO and BAIC both set targets of totally more than 4000 battery-swapping stations. Battery-swapping acts as a measure by some OEMs to promote NEV products to mitigate the disadvantages of recharging.

According to the analysis by IEA, the amount of global private charging ports will reach 128 million by 2030 in the New Policies Scenario, while the EV30@30 projects an amount of 245 million [20]. As for the publicly-accessible chargers, the number is estimated to reach 10 million in the New Policies Scenario in 2030 and almost 20 million from the EV30@30 Scenario. From the projections of charging infrastructures' deployments, the global electrification transition is quite evident.

6. Conclusions

In this thesis, the economy of China’s automotive industry is researched from the perspectives of basic introduction of development roadmap, economic significance of automotive industry, the geographical characteristics of automotive industry, the cooperation and competition of indigenous enterprises with foreign invested joint-ventures, and the future development scenario, particularly the new-energy vehicle subsector of automotive industry. At the beginning of the thesis, the development history of China’s automotive industry is presented, including the backgrounds of constructing the first motor manufacturing plant, the development phases in association with the important national policies or targets. The corporate structures of important automotive corporations in China are also presented as a reference of main players in this largest automotive markets. The automotive industry has been seen as the ‘pillar-industry’ of China. The role of the automotive industry in Chinese economy or the economic significance is studied. The economic data of China are demonstrated in order to depict the overall economic situation of China. The annual GDP and its growth compared to other major economies in the world are presented. Besides, the export and import scales of China are summarized, including the data of automotive products. China is ranked as the largest manufacturer in the world. The manufacturing scale comparison is made based on the data from The World Bank. In comparison to the United States and Japan, China shows not only the largest absolute manufacturing scale but also the highest share of GDP. In the past fifteen years, China's manufacturing industry accounts for steadily around 30% of the national gross output in spite of the diminution tendency since 2011. In 2015, the Chinese government announced the 'Made in China 2025' plan. One of the highlighted sectors by the plan is the automotive manufacturing, since automotive production has been continuously within the top ten largest industrial sectors.

The economic significance of the automotive industry is stated from several aspects. The comparison of vehicle production and sales among major economies is made to show the general relation between national economy scale and production or sale of automotive products. Besides, the economic contribution is presented based on how the GDP is calculated. According to the reference data, gross sales in 2018 made a contribution of 76% of the GDP growth in China. Within the gross sales, automotive product sector took up almost 30%. Moreover, the historic data of output value and value-added corresponding to automotive industry, machinery industry and whole industry of China are included in the thesis. With reference to the data, the automotive industry in China made up no less than 20% of the machinery industrial output and maintained steadily the level of 5% in whole industrial output scale. The contribution to employment is another important aspect to evaluate the significance of automotive industry. The employments have been continuously increasing since 2001, which is in accordance with the fast technological progress. From the summarized data, the increment of engineering technical staff is evident.

The breadth of operations of automotive industry extends to many provinces' economies in China. Due to the complex network of industrial operation, individual regions actually show tight linkages alongside the chain of motor vehicle manufacturing. In this thesis, the situations of automotive industries in 34 provincial administrative regions are summarized, including number of enterprises, the employment supported, the output and value-added generated in each region. By comparison, Yangtze River Delta, Beijing-Tianjin-Hebei, Jinlin-Liaoning-Heilongjiang are the top three regions which take high share of automotive industrial scale of China. The detailed conditions of each administrative region can be referred to the summarized data in the thesis. Beijing, Shanghai, Guangdong, Hubei, Shandong, Jilin are the top provinces with large automotive industrial scale from the perspective of output generated. The economic contribution in each region is evaluated similarly from the aspects of GDP contribution and employment supported. Foreign investments have played an important role in China's automotive industrial development. The series of policies made by the government, targeting cooperation and competition between China's indigenous automakers and foreign-invested enterprises, have also produce significant influences to shape the automotive industry. In chapter four, the foreign investments in China's automotive industry are introduced, involving the detailed introduction of several multinational automotive corporations. Besides, the joint-ventures and proprietorships invested by foreign OEMs and parts manufacturers are summarized. The competition between indigenous enterprises and joint-ventures, particularly in complete vehicle manufacturing, is widely researched in the past. In this thesis, the evolution of market share by joint-ventures and indigenous enterprises is presented to show the fierce competition. The performance indicators used in the referred research report is cited as a reference.

In the final section, the future development scenario of automotive industry in China is presented. Since China has remained to be the largest automotive market, how the automotive technologies evolve and how the government policies are involved in are also widely researched topics. The powertrain electrification and new-energy vehicle is not only a critical development orientation in China but also worldwide. The NEV-concerned policies issued by different governmental agencies in China are elaborated. For example, the NEV subsidy policy is seen as one of the most important NEV policies. The evolution map of the policy is listed. In addition to the policies in China, other major countries' incentives targeting electrified motor vehicles are also included as a comparison. Moreover, the historically achieved NEV annual production and sales globally, market shares, projected data by IEA are included. Apart from the automotive products, the construction of infrastructures e.g. charging ports deployment is another critical aspect for the new-energy vehicle development. The situations of charging infrastructures in main cities of China are shown based on the amounts of deployed charging ports. Finally, the projections made by IEA is referred to show the development scenario of this globally-recognized emerging industrial sector.

References

[1] W. M. Morrison, “China ’ s Economic Rise : History , Trends , Challenges , and Implications for the United States,” 2018.

[2] S. P. McAlinden, K. Hill, and B. Swiecki, “Economic Contribution of the Automotive Industry to the U . S . Economy – An Update A Study Prepared for the Alliance of Automobile Manufacturers,” Ann Arbor, Michigan, 2003.

[3] KPMG, “Global Automotive Executive Survey 2017,” 2017.

[4] CATARC and CAAM, China’s Automotive Industry Yearbook 2016. Tianjin, China: China Automotive Industry Yearbook House, 2016.

[5] CATARC and CAAM, China’s Automotive Industry Yearbook 2018. Tianjin, China: China Automotive Industry Yearbook House, 2018.

[6] K. Hil, D. M. Menk, J. Cregger, and M. Schultz, “Contribution of the Automotive Industry to the Economies of All Fifty States and the United States,” Ann Arbor, Michigan, 2015.

[7] H. Wang, “Policy Reforms and Foreign Direct Investment : The Case of the Chinese Automotive Industry,” Econ. Bus., vol. VI, pp. 287–314, 2003.

[8] L. Wei, J. Xiao, and J. Yuan, “Foreign Direct Investment in China ’ s Auto Market : A Welfare Analysis,” 2014.

[9] M. Edwin and R. Anthony, “Technology Transfer to Overseas Subsidiaries by U.S.-Based firms,” Q. J. Econ., vol. 95, no. 4, pp. 737–750, 2011.

[10] S. Girma and Y. Gong, “Putting People First? Chinese State-Owned Enterprises’ Adjustment to Globalisation,” Int. J. Ind. Organ., pp. 573–585, 2008.

[11] Z. Zhao, J. Anand, and W. Mitchell, “A Dual Networks Perspective on Inter-organizational Transfer of R&D Capabilities: International Joint Ventures in the Chinese Automotive Industry,” J. Manag. Stud., pp. 127–160, 2005.

[12] M. Nenovski and K. Pedersen, “Foreign Investments in the Chinese Automobile Industry: Analysis of Drivers, Distance Determinants and Sustainable Trends,” AARHUS University, 2011.

[13] F. ZHANG and G. KHABELASHVILI, “Foreign Automobile Companies in China A Case Study of Volkswagen and General Motors,” Göteborg University, 2002.

[14] Y. Zhao, “Competitiveness Analysis of Chinese Automotive Corporates,” Zhengzhou University, China, 2009.

[15] Y. Huang and D. Lo, “Market and Institutional Regulation in Chinese Industrialization,” China J., vol. 43, p. 196, 2000.

[16] I. E. Agency, “Global EV Outlook 2018 towards Cross-modal Electrification,”

2018.

[17] "The China New Energy Vehicles Program Challenges and Opportunities," 2011.

[18] C. Hongyang, Z. Yang, and H. He, "Adjustment to Subsidies for New Energy Vehicles in China," 2017.

[19] CATARC, Ed., Annual Report on Energy-saving and New Energy Vehicle in China 2019. Beijing,China: POSTS & TELECOM PRESS, 2019.

[20] I. E. Agency, "Global EV Outlook 2019 Scaling-up the Transition to Electric Mobility," 2019.