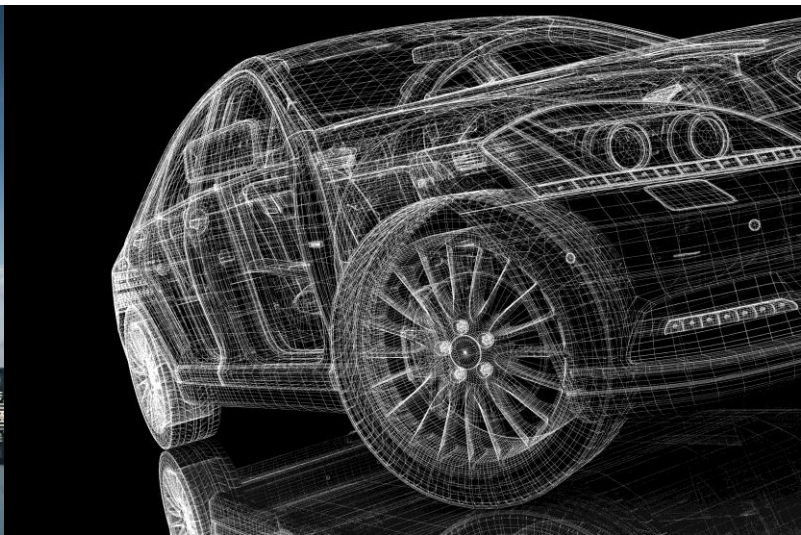


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Leading Edge Cluster Electric Mobility South-West

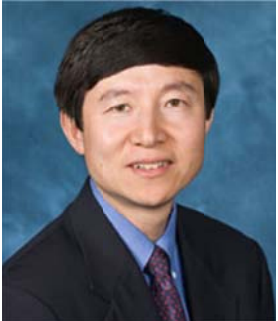
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Map of China

Foreword



Chinese automotive manufacturers have developed rapidly in the recent decade, mostly benefited from joint ventures with global OEMs as well as the establishment of global auto supplier network inside China. Their manufacturing capabilities have been enhanced impressively, and yet their vehicle development capabilities are limited, which is understandable due to the short history of passenger vehicle development in China. Particularly in the areas of powertrain (engines and automatic transmissions), vehicle design (crashworthiness, handling and comfort), and system-level optimal vehicle integration, Chinese OEMs lack core competence, knowledge base and knowhow.

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Is China's Automotive Industry on the run to repeat what Japanese OEM showed decades ago? Will German premium brands be competed? Will China play an important role in terms of innovation? Probably, nobody will be able to answer these questions comprehensively. However, keeping an eye on the market as well as on China's emerging research centers is of overwhelming importance. The following survey aims at giving a concisely glance on the current state of the automotive industry in China.

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Core Findings and Implications

- China's market plays a decisive role in the future of the automotive industry. China rose to become the largest automobile manufacturer and the largest sales market worldwide.
- The Chinese government plays a very important role in promoting the industry. China intends to jump the internal combustion engine technology and to establish one Chinese company among the ten largest car manufacturers in the world by 2016.
- While market growth offers significant opportunities, the automotive industry also faces important challenges.
- The Chinese automotive market is characterized by a complex structure of state-owned manufacturers, relatively independent domestic manufacturers and joint ventures.
- Vehicles of Chinese manufacturers are still unsuitable for the triad markets (EU, US, Japan), so far. Qoros with its Qoros 3 Sedan which was persuading at the Euro NCAP crash test seems to have the best chances on western markets.
- The Chinese government is starting to consider a relaxation of joint venture regulation since no Chinese manufacturer has established an own powerful brand, so far.
- China's days as a low-wage country are counted and a high-tech region is supposed to emerge. Moreover, qualified labor becomes scarce. Therefore, China's automotive industry pushes automation.
- A Chinese lean culture is still in the initial stage; therefore further extensive training and education opportunities are indispensable.
- China records a significant increase in patent applications. Chinese universities and research facilities gain growing attention.
- China's market for safety systems will continue to grow due to rising safety expectations as well as the growing premium market.
- ADAS systems and Telematics are rapidly becoming the norm for Chinese manufacturers but international companies are still the technological leaders.
- New mobility concepts such as car sharing are at an initial stage but feature great potential.
- All manufacturers invest a large amount in ecofriendly, alternative drive technologies. Especially, plug-in hybrid vehicles gain importance in China.
- It remains doubtful whether all-electric vehicles will find a receptive market in the near future. There are still problems which have to be solved such as the lack of charging stations.
- China becomes a major market for lightweight construction but it will be driven by foreign manufacturers in the beginning.
- Western China holds enormous potential for automotive manufacturers as incomes rise. Cities such as Chongqing, Chengdu, or Wuhan are supposed to become automotive hubs.

Initial Situation and Ambition

Due to stagnating demand for vehicles in most mature markets in the face of the global recession, automakers around the world are pinning their hopes on **rising demands in emerging nations** such as the so-called BRIC markets (Brazil, Russia, India, and China).

With increasing purchasing power in the emerging nations more and more people are able to accomplish their desires to own a car. In this case, the existing infrastructure will rapidly reach to or even surpass its limit. However, in **industrial countries** the new generation signals a greater willingness to share a car with others. They favor high flexibility, spontaneity, no traffic jams, and no parking issues over owning their own car.

This is just a small fraction of the issues the automotive industry has to face to satisfy demands of tomorrow's users. Similarly, it is equally important that automotive manufacturers and their suppliers continuously improve their products. **The trend is towards sustainability, a higher level of comfort and safety, lightweight construction, and integration of more advanced driver assistance systems (ADAS).** The aim is to produce cars more economically and at less cost, to scale back consumption and reduce emission levels as well as to support the driver to increase safety. The latter may result in (partially) autonomous driving.

Nowadays, it becomes more and more apparent that especially **China's market plays a decisive role in the future of the automotive industry.** The Chinese automotive market has become one of the most important markets over the last years, not only among the BRIC markets but also in the whole world. In 2009, China rose to become the

largest automobile manufacturer in the world with almost 7.5 million passenger cars and overall 10.3 million manufactured automobiles. At the same time, China replaced the United States of America as the **largest sales market** and maintained its leading position. Not only the absolute figures but also the speed with which the market grows is impressive. China's rapidly expanding automotive industry has outpaced the nation's gross domestic product (GDP) growth rates in recent years. Furthermore, no country in the world has more foreign OEMs and suppliers localized within its borders. [BBVA Research (2012)]

Despite the achieved strong position, the development has not been terminated, yet. China's automotive market still **features the highest growth potential in the world.** According to the latest forecasts, the unit sales of automobiles will reach the mark of 20 million cars in 2015, following 15.5 million cars in the year 2012 in China [Automobil Produktion (2013)].

Therefore, the following issues are **focused on in this research study:**

- What is the current situation on the Chinese automotive market?
- Which domestic manufacturers act on the Chinese automotive market and how successfully do they perform?
- How does the partner constellation of foreign and domestic manufacturers look like in China?
- Which production methods are common in China?

- Which research capacities exist and how are they utilized by automotive manufacturers in China?
- Which are the focus development areas in China's automotive sector?
- What does the geographical structure of China's automotive industry look like and how will it change in the future?



Highway Shanghai

Current State of the Chinese Automotive Industry

2.1 Current State of the Chinese Automotive Market

Until the middle of last century there was no automotive manufacturing facility in China. The first one was built in 1956 in Changchun in the north of China. Until 1978, the Chinese industry development was rather slow due to strict state regulations. For this reason, the Chinese manufacturers produced only three percent of the automotive production worldwide in that year. The subsequent **economic reform** brought many changes and opportunities for the whole industry. Planned economy principles have no longer priority, but rather the production had to focus more on current market requirements [Azza (2009)]. Thenceforth, the Chinese economy, and in particular the Chinese automotive industry, developed in an impressive way which is illustrated in Figure 1.

Nowadays, the Chinese automotive industry

breaks new records. As an important sales market and manufacturing location, the Chinese market is an **integral part of the strategies of the European, American and Japanese automotive industry**. On the one hand China is a very large market with its population of almost 1.4 billion inhabitants. On the other hand the macroeconomic parameters are very fortunate, too. For example, China's gross domestic product (GDP) is increasing steadily followed by growing incomes. Furthermore, China has the largest foreign exchange reserves in the world and, therefore, a very high purchasing power.

The Chinese government plays a very important role in driving the national industry. Every five years the central committee of the Chinese Communist Party convenes to set policy goals for the nation's social and economic affairs. These plans should be observed by all companies that wish to operate in the Chinese market and seek to be successful in the long term. In contrast

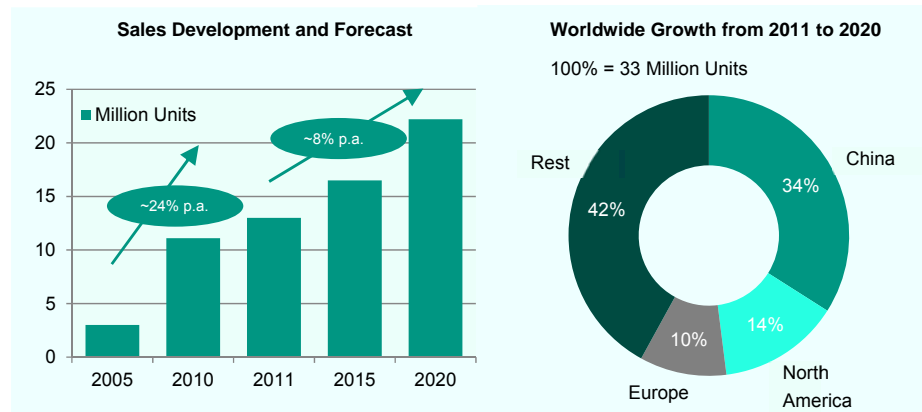


Figure 1: Development of the Chinese automobile market¹

¹ Own figure based on [McKinsey & Company (2012a)].



E-scooter in China

to the situation in Germany, for example, the Chinese government does not consist of several parties holding different opinions. The politics of China take place in a framework of a **single-party socialist republic**. The leadership of the Communist Party is enshrined in the Constitution of the People's Republic of China (PRC) and the party follows long-range objectives.

Nevertheless, this concept is very successful in China, measured by the country's economic growth data. Hence companies may benefit eminently from this circumstance. Based on the five-year plan, for example, the companies may identify which industrial sector will be government-funded by tax allowance or subsidies.

Five-year Plan

The **current 12th five-year plan** agreed by the National People's Congress in March 2011 contains a development program for the years from 2011 to 2015. The main focus of this plan may be summarized as follows: promotion of research and development, strengthening of the private consumption and greater priority to environmental protection and sustainability [Faust/Gang (2012)].

The government aims to detach from its emphasis on export and focus intensively on innovation and China's domestic market. Seven **strategic industries** have been identified in the 12th five-year plan in which China aims to become the global leader [Steward Law (2012)]:

- New-energy automobiles
- power engineering
- machinery and plant engineering
- energy efficiency and environmental protection
- biotechnology

- advanced materials
- information technology (IT)

Especially hybrid and electric vehicles take on an unprecedented level of importance in the 12th five-year plan. The Chinese government proclaimed that China should strive for international technology leadership and become the world's largest electric vehicle (EV) market.

Since Japan, Korea and all the western manufacturers have already a dominant lead in combustion engines, China's aim is to become an early mover and to achieve technological leadership in the field of electric vehicles. With subsidies, requirements and prohibitions **China intend to jump the internal combustion engine technology**. For example, the government recently introduced a new regulation stating that patents by joint ventures for one of the three core components of an electric vehicle (engine, battery, and electronics) have to be applied in China to transfer knowledge of new technologies to China. Using this strategy, the indigenous manufacturers are able to operate on the same level as their foreign counterparts for the first time. Until 2020, the government in Beijing has planned investments about 11 billion Euros promoting EVs. Purchasing incentives were created to scrap old cars to subsidize the purchase of new-energy automobiles. Additionally, investments in the expansion of infrastructure are planned, such as charging stations. [Faust/Gang (2012)]

However, differences between theory and practice can be observed. Until now, only few Chinese automakers have sold meaningful volumes of EVs using advanced technology. Consumers are still discouraged by high prices, limited ranges and a lack of public charging stations. The government in Beijing expects to have **500,000 EVs and plug-in hybrids on the nation's roads by 2015**. But only 11,400 EVs and 1,420 plug-in hybrids were sold in China in 2012 and most cities are lagging behind the construction of charging infrastructure, far short of the target. [Automotive News China (2013a)]

At least 60 percent of the Chinese population can imagine buying an electric vehicle. This number is almost five times higher than in Germany, Japan and the USA. And the examples of **e-bikes and e-scooters** show how consequent and straight-forward new technologies can be implemented in the Chinese market. While western countries electric vehicles can hardly be found, 21 million Chinese people bought one in 2009 alone. [Faust/Gang (2012)]

Premium Car Market

In China, 23 million households will have an income allowing them to buy a premium car by the year 2020. Before then, China will overtake the US market as the world's largest market for premium cars. Up to now, the group of buyers of this segment is only spread over 100 cities in the country, but this group will increase to around 300 cities by 2020. [Industry Journal (2013)]

Foreign brands enjoy an excellent reputation.

Even if they were produced in China, the Chinese people appreciate the quality to be higher than domestic brands. Especially, cars from Germany are highly requested. This is also reflected by the

fact that four of five premium cars in China come from Audi, BMW, Mercedes-Benz or Volkswagen (VW). The 2010 facelift of VWs top model of Phaeton is mostly produced for the Chinese market and BMW sells already every second premium car of its 7-series in China. The situation is hardly any different for the competing brands Audi and Mercedes-Benz. [manager magazin (2013)]

The premium market is **expected to grow from 1.25 million sold units in 2012 to about 3 million sold units by 2020**. Until then, the premium segment will increase by only four and two percent in the USA and in Germany, respectively. In contrast, this segment is expected to grow by twelve percent annually in China. The premium market including cars with a price between 25,000 and 150,000 Euros particularly promises a high profit margin. In the rapidly growing upper class cars, especially western products are considered being status symbols. The common mentality of the Chinese upper class is still that high quality has to be a high price although prices for equivalent cars are even higher than in western countries [McKinsey & Company (2013)]. Figure 2 illustrates increasing demand for premium cars of selected brands from the year 2008 to 2020.

Development of the West

The Chinese market is actually divided in different submarkets being approximately as large as several European countries each. **China's economic power is concentrated along the east coast**, so far. The development status of the large metropolises such as Beijing and Shanghai can already be compared to western metropolis' development status. This is different from the situation in the western provinces of China, which only contribute one fifth of China's gross

domestic product [Faust/Gang (2012)]. In these western regions, there are still many first-time buyers and this category of consumer usually does not buy a premium car. They ask for appropriate small and compact cars at first. Therefore, the automotive manufacturers should prepare to serve those diverse needs in the Chinese market.

Nevertheless, these differences are also **a further opportunity to increase sales volumes**. The coastal regions will still have the highest absolute vehicles sales, but their market share will fall significantly. Moreover, given that the rising automotive industry is very competitive and with rising labor cost in the east, automotive companies increasingly seek for new production facilities and emerging markets in China. This is in the **interests of the Chinese government**, too. They have been

trying to develop the poorer, lagging rural areas of the western part of China with the so-called **“Go West”-strategy** since the 1990's. [Automotive News China (2013b)]

VW already has an assembly plant in the western city Chengdu but an extreme example of this is certainly the new VW plant in Urumqi in the remote northwestern region of China. The region Xinjiang, north of Tibet, populated by the Muslim minority of Uyghur people was considered an unsettled region and poses new challenges for the German automotive manufacture. In Urumqi, there is no automotive industry and scarcely any skilled works. In this plant VW produces the compact car Santana since August 2013. When the press part production and the paint shop are finally completed, the production output is expected to increase to 50,000

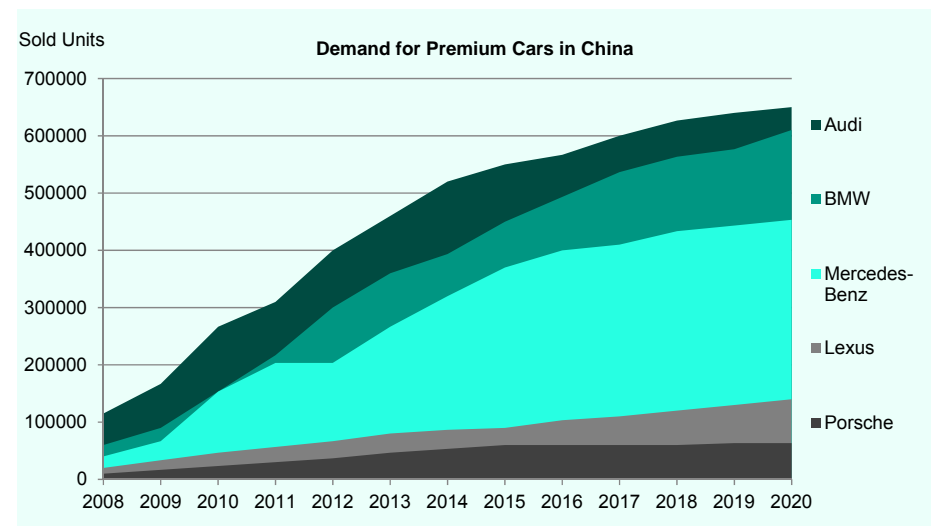


Figure 2: Increasing demand for premium cars²

² Own figure based on [Industry Journal (2013)].

vehicles annually. This venture can hardly be explained on the basis of purely economic reasons. It is more **related to the demographic and economic targets of the Chinese government** and the long-term interests of Volkswagen in China. For experts in the automotive industry, VW had to agree to this situation to obtain permission in return for a new plant in Foshan, in the southwest of China [Wirtschaftswoche (2013a)]. In September 2013, Volkswagen opened a new factory producing initially 300.000 vehicles annually and in the long term twice as many in this secure and well developed region of China. The new factory in Foshan is very important and plays a central role in the plans of Volkswagen. Nevertheless, it is significant how the government in Beijing influences the industry in China. [Wirtschaftswoche (2013a)]

Top challenges

While market growth offers significant opportunities, the companies also face significant

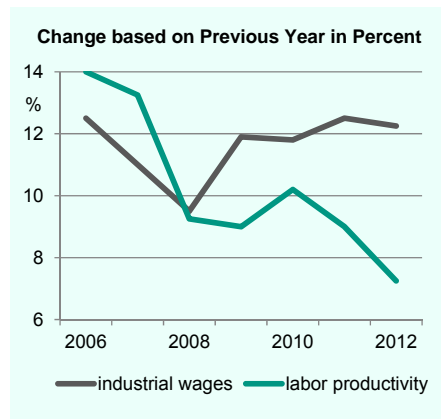


Figure 3: Growing wages and salaries in China³

³ Own figure based on [FAZ (2013)].

challenges that may inhibit the automobile boom in China. In the medium term, China will **no longer be a low-wage country**. According to a study by Deutsche Bank, real wages and salaries in the industrial economy in China grew stronger than the GDP per employee since 2008 (see chapter 322.4). [FAZ (2013a)]

This development is fully intended by the current five-year plan, but it is also due to a **demographic change**. The endless seeming amount of workers ensured low labor costs and has driven China to an extended workbench for industrial companies. The obsolescence is particularly marked in the coastal regions and in the major cities. For example, almost a quarter of the population in Shanghai is older than 60 years [Faust/Gang (2012)]. In 2012, the working population at the age between 15 and 59 has declined for the first time since the 1970s. The **supply of qualified employees on the job market is limited**, too. Therefore, the majority of industrial companies are willing to pay significantly more than the minimum wage [FAZ (2013a)]. As a countermeasure, the government is currently discussing a further relaxation of the one-child policy.

Additional negative consequences of China's growth are the **raising oil price, environmental pollution, and crowded cities**. Again, the government tries to interact with further measures. China did not care about environmental protection for a long time and now starts to suffer under the consequences. **China emits most carbon dioxide worldwide** and in some cities air pollution exceeds the limit value suggested by the World Health Organization by a factor of 40. The government's aim is to reduce the air pollution in Beijing, Shanghai and Guangzhou by 15 to 25 percent until

2017 [Handelsblatt (2014a)]. At present, transportation is responsible for 20 percent of the particulate matter air pollution and, therefore, the automotive manufacturers are directly affected. In Beijing, for example, **the registration of cars is limited and the approvals are granted via lottery**. In addition, car owners are not permitted to drive once a week depending on the last number of their license plates; motorcycles as well as diesel engines are prohibited. An increasing number of cities could pass such laws which could have an active influence on the industry. Furthermore, the National Development and Reform Commission (NDRC) intends to introduce a **maximum fuel consumption** of five liters per 100 kilometers. The date of application of this requirement is supposed to be 2018. This limit cannot be achieved without electric mobility or plug-in hybrid concepts, especially for sport utility vehicle (SUVs) and heavier premium cars. In a corporate group, each group is supposed to be below the maximum. [Faust/Gang (2012)]

Moreover, a further serious challenge is the **risk of a bubble** in China according to several experts. The whole automotive industry invests significant numbers of money to expand their capacities, to be able to meet demand and to secure a greater market share. Therefore, the **number of plants will rise** from just over 120 by 2009 to nearly 160 by 2014. For example, VW Executive Board Chairman Dr. Winterkorn announced an investment of 9.8 billion Euros in China at the Shanghai Auto Show in 2013. BMW opened a new and expensive plant in Shenyang with its Chinese joint venture partner Brilliance, which is considered as one of the most modern plants and one of the most sustainable automotive productions in the world. [Industry Journal (2013)]

"In China it is possible that a financial crisis will take place in the next three years"

Jochen Siebert, Managing Director of the Consultancy JSC Automotive in Shanghai, 2013. [Automobilwoche (2013a)]

These days, the production capacity determines the quantity of sales for many western car manufacturers. By contrast, **the capacity utilization of domestic manufacturers is only about 35 percent** today and in the medium term. One of the reasons for this is that the western brands enjoy a better reputation, but also that Chinese manufacturers are not measured by high profits but rather by the number of workers and employees they have. Due to the total investments, the supply of foreign manufacturers will soon exceed the demand [Faust/Gang (2012)]. Consequently the **risk of overcapacities** is high in China. For this reason, an effective capacity management and focusing on investments in flexible capacities in the future are more important than ever in China. Temporary employments and working time accounts are appropriate means. Especially, high-volume manufacturers will be affected. As a result of a broad range of vehicles and stronger competition on the market, more and more discounts are needed in order to sell cars. [Automobilwoche (2013a)]

For the managing director of the consultancy JSC Automotive in Shanghai, Jochen Siebert, the risk is even higher. He and other rating agencies predict turbulent times for automotive manufacturers and their suppliers. They stated that a financial crisis might take place in China in the next three years.

According to Jochen Siebert, **China is at the crossroads**: On the one hand China can develop into a rich country, but on the other hand China can fall into a so-called **middle income trap**. This means that a country reached a point where on the one hand it cannot compete with low-cost countries due to rising wages any more, but on the other hand it still finds itself behind the advanced economies in higher-value products. An example is the premium segment in Brazil. With a similar development in China, the number of cars would primarily increase from 400,000 in the years 2013 to 800,000 in 2019, but afterwards it would decrease to 200,000 units by 2050. However, if China becomes a rich industrial nation, at first the number of cars would increase at a slower rate in the next few years, but afterwards it would increase constantly to 1.1 million cars in the premium segment by 2050. During the development phase, **rising wages, a decreasing number of workers and a low level of productivity** are the main challenges which must be put under observation in China. [Automobilwoche (2013a)]

2.2 Differences between Global and Local Players

The Chinese automotive market is characterized by a high number of market participants. There are more than **120 whole-vehicle manufacturers and nearly 8,000 automotive parts and system manufacturers** in China. The whole industry is characterized by a complex structure of **large state-owned manufacturers, relatively independent domestic manufacturers and joint ventures** between Chinese and international automotive companies. It is almost impossible for domestic companies to create a consistent unique identity and build consumer retention. In order to

simplification and transparency in the industry, the Chinese government pushes a **consolidation** by supporting individually selected automobile manufacturers. The aim is to establish one Chinese company among the ten largest car manufacturers in the world by 2016. The government plan is to pare the sector down to few major players, thus emulating the Japanese automotive industry, which built a global reputation for engineering and quality with only a small number of companies. Moreover, there are governmental requirements which include that nearly 50 automobile manufacturers will be closed if they are not able to increase their sales volumes substantially [Welt (2013a)]. In 2013, the combined **market share of Chinese brands at their home market shrank** by 1.6 percentage points to 40.3 percent, according to the Chinese Automobile Manufacturers Association (CAAM). Their exports dropped 8 percent which was the first decline in five years.

State-owned Companies

The largest domestic automotive companies are state-owned. Manufacturers such as Shanghai Automotive Industry Cooperation (SAIC), Dongfeng Motor Corporation, First Automobile Works (FAW), Changan'an Automobile Group, and Beijing Automotive Industry Group Corporation (BAIC) are **strongly supported by the government and dominate the Chinese automotive industry**. To support and protect the domestic manufacturers, for example, the government in Beijing listed 400 domestic models of Chinese manufacturers, which should be bought by state employees. So far, they traditionally preferred cars that had been manufactured by Audi [Sueddeutsche (2013)]. Due to the influence of the government, **collaborations with international companies were especially concluded with these manufacturers**.

In spite of the strong support, **no Chinese company could establish the reputation of an own powerful brand**. Foreign brands are still more popular and successful than domestic ones. One of the reasons for this is that they are perceived by the average Chinese consumer to feature much higher quality than their Chinese competitors. A point of criticism is the **organizational structure of Chinese companies** as well. The large state-owned enterprises are controlled by politicians instead of innovators and engineers. They emphasize sheer volume of output over profits, quality and competition [IBTimes (2013)]. Therefore, state-owned manufacturers are operating successfully at their home market in China, but they are still only a smaller participant in the global automotive industry. Figure 4 illustrates

the top ten Chinese players and their sales volume covering both passenger and commercial vehicles. The figure also includes deliveries made by joint ventures. It is evident that the state-owned companies are the largest domestic ones.

SHANGHAI AUTOMOTIVE INDUSTRY COOPERATION (SAIC) is the **biggest and one of China's oldest car manufacturing companies**. The company sells passenger cars, vans, buses, trucks and also spare parts under a variety of brands. Examples are inter alia MG, Roewe and Maxus. The SAIC international strategy includes collaborations with international car manufacturers and company takeovers. **The major Joint Ventures were formed with Volkswagen and General Motors (GM)**. With its successful takeover

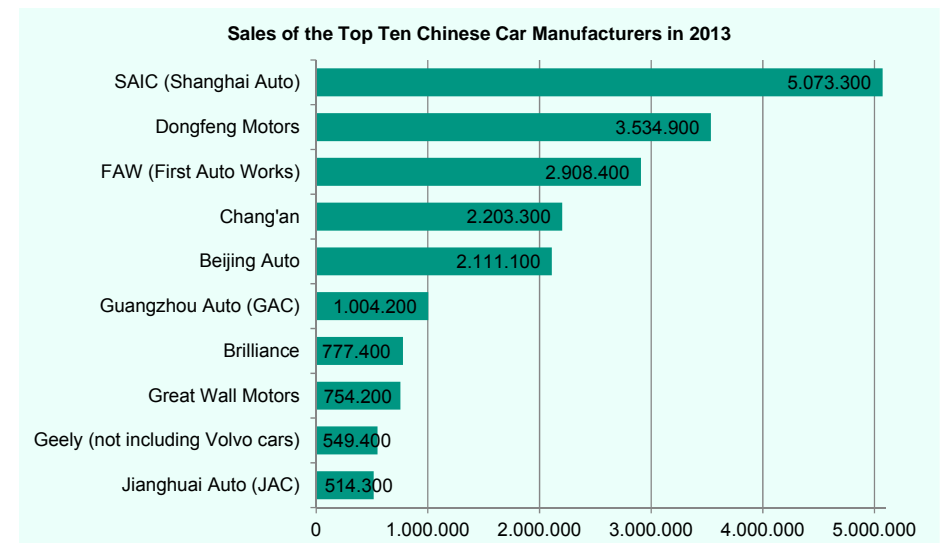


Figure 4: Sales of the top ten Chinese car manufacturers in 2013⁴

⁴ Own figure based on [ChinaAutoWeb (2014a)].

of Nanjing Automobile and the establishment of MG as one of its own brands, SAIC produces and sells also vehicles under the MG brand in the UK to earn some market share in Europe. Due to its growing business, SAIC was ranked number 103 **Fortune Global Top 500** in 2012. Nearly 198,000 workers were employed and five million vehicles were sold in 2013. SAIC is penetrating new markets such as India. The **target of the company is to establish itself as one of the largest automotive manufacturers worldwide** in the near future. [SAIC (2014)]

DONGFENG MOTOR CORPORATION was established under the name Second Automotive Works Co. in 1969 and after some mergers it received its current name in 1992. With more than 3.5 million produced vehicles and 160,000 employees, Dongfeng is the **second largest vehicle manufacturer in China**. The two most important subsidiaries of the company are Dongfeng Motor Group Co. and Dongfeng Automobile Co., Ltd. **Traditionally, Dongfeng was a commercial truck manufacturer**, but nowadays the company sells a wide range of vehicles including trucks, buses, and passenger cars. The company is particularly successful with its truck division. For trucks above six tons load capacity, Dongfeng seems to be the largest producer worldwide, even if there are no exact statistics available [MunichInnovationGroup (2013)]. Dongfeng has **the most joint ventures with foreign companies** in the Chinese automotive industry including Volvo, Honda, Nissan and PSA Peugeot Citroën. The main aim of Dongfeng is to become the number one car manufacturer in China and to establish itself among the top three truck manufacturers worldwide in the long term. In 2012, Dongfeng Motor Corporation **ranked number 142**

among Fortune Global Top 500, an annual ranking of the top 500 corporations worldwide as measured by revenue. [Dongfeng (2014)] [MunichInnovationGroup (2013)]

FAW GROUP CORPORATION was the **first Chinese company operating in the automotive industry**. It was founded in 1953 and at the very beginning it was supported by Soviet Union, which provided production machinery and technical support. **In 1956, the first truck was produced and in 1958 the first car followed.** In 1991, FAW started its first collaboration with Volkswagen, followed by several others e.g. General Motors, Toyota Motor Corporation, and Mazda Motor Corporation. Today, FAW produces cars, buses, truck and automotive parts under a variety of different brands and it has **several wholly or partially owned subsidiaries**. The company employs about 120,000 people around the world and it mainly concentrates on the Chinese market but also sells its products overseas, especially in developing countries such as Egypt, Iraq and Pakistan. The main aim of the company is to meet the demand and requirements of consumers around the world with innovative and valuable vehicles. Therefore, technical innovation plays a key role in the company's strategy. [FAW (2014)] [MunichInnovationGroup (2013)]

CHANG'AN AUTOMOBILE CO., LTD. mainly concentrates on passenger cars but also produces vans and small trucks. Currently, the company has nearly 50,000 employees and owns fifteen vehicle and engine factories producing 2,203,300 vehicles per year. In 1993, the first joint venture was established with the Japanese brand Suzuki, followed by collaborations with the brands Ford and Mazda. However, **joint ventures have become**

"Two or three champions will come out of China, which buy into markets and will reach a dimension. At the end there will be five or six super-competitors: Two will come from the USA, two from China and BMW, Daimler and VW."

Dan Akerson, former Chairman and CEO of General Motors serving from 2010 to 2014. [Handelsblatt (2014d)]

less relevant in the company's strategy. In 2009, Chang'an acquired the automobile manufacturers Changhe, Hafei as well as the engine manufacturers Dong'an. The merger of the companies was one of the largest deals between state-owned brands in the history of China. [Chang'an (2014)]

These days, Chang'an focuses on the development and distribution of its own brands including several hybrid automobiles. For the future, Chang'an has ambitious goals. Since **innovation became one of the major aspects of the company**, Chang'an invests significant amounts of money in research and development (R&D) centers, even outside of China. The manufacturer's internationalization strategy is not based on acquisitions of foreign companies but rather Chang'an tries to cooperate with foreign brands. [MunichInnovationGroup (2013)]

BEIJING AUTOMOTIVE INDUSTRY HOLDING CO., LTD. (BAIC) is a holding company of several Chinese automotive and machine manufacturers. Its principal subsidiaries include the passenger car manufacturer BAIC Motor (Beijing Auto), the

military vehicle and SUV manufacturer BAW and the commercial car and agricultural equipment manufacturer Foton Motor. In the year 2013, Beijing Auto was the **fifth-largest domestic carmaker** with 2,111,100 produced vehicles in China. In 1983, BAIC **established the first joint venture in the Chinese automotive industry** with the American Motor Corporation, which has been acquired by Daimler. Since 2002, the company cooperates with the South Korean manufacturer Hyundai, too. [BAIC (2014)]

Relatively Independent Companies

Since the beginning of the 21st century there is an increasing number of vehicle manufacturers in China, which are **relatively independent from the government**. At that time, the Chinese government relaxed the issuing of licenses to produce vehicles. The largest ones are Geely, Chery, Build Your Dream (BYD), Brilliance, and Great Wall. The dynamic growth of the economy and the booming automotive industry in China enable them to **compete with the large state-owned manufacturers**. Due to limited company size and rapid economic advancement, those companies are called "**young tigers**" by the foreign media. [Luo (2005)]

There have been **three major ways** through which new investors chose **to enter the Chinese automotive industry** which was known as the most profitable industry in China:

1. Using existing overcapacities in China's motorcycle industry and transforming the production knowledge into the automotive sector (Example: Geely).
2. Transformation of automotive parts companies (For example: Chery)

- Funding new companies by investors from other industries (For example: BYD)

There are **differences between the strategies of young tigers and state-owned companies** with their joint ventures. The young tigers have specialized on one car classification, mostly on cheap and less technologically demanding small cars. In contrast to the big state-owned car manufacturers, **all young tigers develop and produce cars under their own brands**. They choose to build their own cars which can generate future value. Thereby, they seek to reduce their non-production costs by ways of joint development with specialized automotive technology companies, R&D outsourcing, and reverse engineering. In addition, since the relatively independent companies are more flexible and autonomous, they were dedicated to export and build new plants in other countries from the very beginning. For Example, Chery Automobile operated already 16 assembly plants overseas in 2011. [Luo (2005)] [Automotive News China (2011b)]

BRILLIANCE CHINA AUTOMOTIVE HOLDING LTD. is a subsidiary of the Huchan Automotive Group and sells cars, mini vans, and automotive components. The company operates in an important joint venture with Toyota. This collaboration **holds market leadership in the minibus sector**. Since 2003, Brilliance established another **joint venture with the German car manufacturer BMW**. The aim of this joint venture is to obtain market leadership in the premium sedan market in China with BMW-branded sedans. In the past, **Brilliance has already sought to export cars to overseas markets** such as Europe. However, this attempt has not been successful. [Brilliance (2014)]

GREAT WALL MOTORS CO., LTD. is one of the biggest car manufacturers in China and China's **leading SUV and pickup manufacturer**. The company is also one of the leaders among the Chinese vehicle manufacturers, especially with its small vans which are even sold in Europe. Great Wall is the **first Chinese manufacturer with a production plant on the European continent**. In Lovech, Bulgaria, passenger cars, SUVs and pickup trucks are assembled for the east European market. In 2009, the company started to export to the Australian market, where no other Chinese automaker had operated before. Up to now, Great Wall Motors has established **no joint venture with a big international car manufacturer** but collaborates with foreign companies such as Robert Bosch GmbH and Siemens AG in the fields of technical assistance, electric systems and transmissions. The development of electric vehicles plays also an important role in the strategy of the company in strengthening and expanding its presence in the industry. [Great Wall Motors (2014)]

GEELY HOLDING GROUP was the **first private automobile manufacturer in China** and is a success story of a rice farmer's son. **Originally, Geely was a producer of refrigerators**. In 1989, it switched to decoration material and in 1992 Geely started to produce motorcycles. Five years later, the company started the automobile production to participate in the growing automotive industry. Nowadays, Geely produces cars, motorcycles, engines and transmissions. It sells automobiles under five different brands. The biggest market for Geely is still China, but it is also pursuing a **dynamic internationalization strategy**. A key milestone was the acquirement of the British car manufacturer 'Manganese Bronze Holdings' which

is well-known for the production of typical London taxicabs. Subsequent to the acquisition, the know-how was provided by the British part of the company and the taxicabs were produced in Shanghai in order to save costs. In this way, production costs could be reduced by half. To establish on international markets, especially Europe, **Geely acquired the Swedish car manufacturer Volvo** in the year 2010. **Environmental awareness and safety are the main focus** in the development of new cars. The model 'Emgrand EC7' was the first Chinese car that got a four stars rating from the European New Car Assessment Programme (Euro NCAP) crash test and hence this car meet the European quality requirements. Moreover, Geely developed the engine '4G18CVVT' which is one of the most efficient engines in the world with up to 57.2 KW per liter. [Geely (2014)] [MunichInnovationGroup (2013)]

CHERY AUTOMOBILE COMPANY LTD. focuses on the production of **cheap low- and middleclass cars** offered by its own four brands. Strengths are a **cost-effective series production in the Anhui Province** by which Chery can underprice its competitor. The company pursues a strategy of imitation of its competitor's cars. In 2006 Chery was already selling cars to 67 different countries in the world. Chery was China's largest passenger car exporter between 2003 and 2011. In the last years, Chery intensified its own research trying to close the technological gap to more international car manufacturer. Focusing on developing countries in Latin America and the Middle East first, it pursues a "bottom up" strategy. The aim is to start cooperating with local producers, followed by the foundation of joint ventures with suitable partners. Thereafter, with the



London Taxi

experience and improved products with higher quality, it is the aim of the company to expand into markets in OECD countries. In 2007, Chery established its **first manufacturing joint venture with the Israel Corporation, Qoros**, to develop a range of premium vehicles for sale worldwide. The company is the **first China-based automotive manufacturer that received a five-star rating in the Euro NCAP** crash test for its first production model, named 'Qoros 3 Sedan'. This compact sedan went on sale in China in November 2013. The brand Qoros **intends to establish itself as a manufacturer for high quality cars**. To achieve its ambitious aims, the company installed internationally **experienced top managers**. For example, in the leading position of the company is the former Volkswagen manger Volker Steinwascher who led VW's business in the United States. Responsible for the design is Gerd Hildebrandt who was head of design of the BMW subsidiary Mini until the end of 2010. Qoros does not only seek to conquer the Asian market. Eastern Europe is the primary target and in Germany the start of sales is planned for 2015. [Spiegel (2013)] [Qoros (2014)].

Additionally, Chery formed a 50:50 joint venture with Jaguar Land Rover for the production of Jaguar and Land Rover cars in China. The joint venture received regulatory approval in September 2012 and production is scheduled to start in 2014 [Chery (2014)].

BYD AUTO COMPANY is a wholly owned subsidiary of Build Your Dreams (BYD) Company, which is the largest supplier of rechargeable batteries in the world. The company was founded in 1995 to compete against Japanese imports and operates in three major fields: IT, new-energies and automobiles, nowadays. In 2003, the automotive division BYD Auto Company was founded, following BYD Company's acquisition of Tsinchuan Automobile Company. In this subsidiary, BYD focused less on technical know-how, but rather on acquisition of the license to produce vehicles in China. BYD Auto Company **focuses on electric cars, but also produces gasoline-powered vehicles, plug-in hybrids, and rechargeable batteries for electric devices.** The company was the sixth largest automotive manufacturer in China by units sold in 2010. However, BYD did not manage to secure a stable growth. Because of losses at its photovoltaic business, a decline in global battery demand and quality issues, the company had to register a strong profit decrease. At the end of the year 2013, Chairman Wang Chuanfu completed a **three-year reorganization**, during which he reduced the number of dealerships and narrowed losses of its solar business. In the year 2013, the sales of the automotive company rose 11 percent to 506,000 sold units. [MunichInnovationGroup (2013)] [BYD (2014)]

Nevertheless, the forecast for the future is optimistic. Due to the growing automobile market and the increasing environmental pollution in China, the need for electric vehicles in China is obvious. BYD Auto Company has ambitious goals and plans for the next years. **The company's aims are to become China's leading automotive manufacturer by 2018 and a major global player**

by the end of 2025. The company plans to strengthen its presence in the whole world. [BYD (2014)]

The company mainly focuses on its **"Green City Solution" concept with its electric car 'e6' and its electric bus 'K9'**. Thereby, BYD describes a concept in which its all-electric vehicles replace current conventional taxis and buses to reduce emissions and cut down the operational cost of buses and taxis, too. According to the company, the range of its busses is up to **250 kilometers in city driving.** BYD has already undertaken test-trials of the electric bus, which runs on lithium iron phosphate batteries in different cities all over the world. For example, BYD has already been trialed its e-bus in several **cities such as Paris, Bremen, Bonn, Madrid, Barcelona, and Salzburg.** Amsterdam's Schiphol airport has even ordered 35 electric busses. Since December 2013, two pure electric e-buses of the manufacturer operate on the two central routes 507 and 521 in London. In China, BYD electric vehicles have been operating in about 10 cities. But according to BYD, it is easier for the company to sell its electric vehicles overseas than in its home market China. For example, the company **failed to qualify for local inventive in Shanghai and Beijing** because it is based in Shenzhen in southern Guangdong Province and the local governments in Shanghai and Beijing would prefer their own local automobile manufacturer [Automotive News China (2014d)]. By reason of high costs of the electric vehicles and charging stations, government subsidies are mandatory to increase sales volumes. [BYD (2014)]

In its automotive division, BYD also operates in a **joint venture with Daimler AG.** This collaboration

is mainly established to produce an all-electric vehicle under the new Denza brand. The car is produced in China for the Chinese market and will be introduced in the year 2014. [Automobilwoche (2013d)]

Future Outlook

Up to now, only a few people in Europe or the United States know Chinese automotive manufacturer such as Dongfeng, Geely, and Chang'an and it is predicted to remain this way in the near future. According to a study by the consulting company Ernst&Young in which 150 Chinese automotive manufacturers and suppliers were asked about the most attractive markets worldwide, **the home market China remains the most interesting one** with 78 percent of nominations. For four of five Chinese managers surveyed, China is the most popular investment location. North America ranks in second place with 26 percent followed by Germany with 19 percent. However, the study also states that two thirds of surveyed managers expect Chinese manufacturers and suppliers to become increasingly important in the international automotive industry in the next few years. [Handelsblatt (2013a)]

For Chinese automotive managers, **cooperation with foreign automotive manufacturers is the key to expansion and success.** So far, especially the **western companies benefit the most from the collaborations in China.** Currently, the business outside the collaborations is little more than seven percent for the largest Chinese enterprises SAIC and Dongfeng. Therefore, the Chinese efforts have been limited to the home market and emerging countries, until now. In the Chinese automotive industry, the **imports clearly outweigh the exports** in an impressive way. For



E-bus in London

example, Germany exported vehicles and motor vehicle parts worth about 19.3 billion Euros to China in the year 2012. By comparison, the Chinese exports to Germany only amounted to 0.9 billion Euros in the same year. [Handelsblatt (2013b)]

The central government in Beijing also plays a decisive part and has ambitious plans in the area of future development. According to the government, the Chinese automotive industry is supposed to be **world export champion and at least one Chinese manufacturer is supposed to be among the top ten automotive manufacturers worldwide by 2016.** In implementing this Chinese internationalization strategy, the government and the manufacturers attempt to close the technology gap with **further joint ventures as well as takeovers** in order to spread their know-how. For this purpose provincial governments in China promote Chinese companies with substantial financial supports. However, the efforts have suffered a setback. According to CAAM, the **exports of Chinese automotive manufacturers fell** significantly in 2013. Passenger car exports fell by 9.8 percent to less than 600,000 units. Including light commercial vehicles, the decline was 9.5 percent to 977,300 units. The largest exporters have been Chery with 130,136 vehicles and Geely with about 120,000 vehicles. The reason for the sales decline was high import duties for vehicles that are not produced in the respective home country. Chinese companies have been seriously affected by import duties' increase of 35 percent in

Brazil. However, due to these import duties, Geely, JAC, and Chery are planning to build up production facilities in Brazil. They want to serve the growth markets in South America with vehicle supplied from Brazil. In the first eleven months of 2013, the **three largest export markets for Chinese automobile manufacturers** were Algeria (112,100 units), Russia (84,100 units) and Chile (71,600 units). [Automobil Produktion (2014)]

Premium carmakers such as Daimler or Audi would hardly notice a Chinese sales campaign. If Chinese cars edge into western markets, they initially attack brands such as the Romanian car manufacturer Dacia and the South Korean Kia in the **low-priced mass segment**. Medium-priced brands such as Ford and Opel would be the next ones. **Qoros with its Qoros 3 Sedan seems to have the best chances** to compete effectively on western automobile markets. Jiangling Motors tried to enter the European market with its SUV Landwind, but it failed completely. In 2007, the joint venture partner of BMW Brilliance sought to enter the European market with two mid-range cars, but they only received a one-star rating in NCAP. Most **Chinese vehicles are unsuitable for western markets** not only in terms of quality issues, but also Chinese engines go beyond the European exhaust emission standard. **Acquisitions and takeovers** are supposed to help improving the quality and to get access to western markets. BAIC seek to produce vehicles of higher quality by the use of patents and facilities of Volvo. By contrast, Geely pursues a different strategy and seeks to use the truck division of Volvo as a springboard for internationalization. The **commercial vehicles division of Dongfeng also features favorable international opportunities** and is at the beginning to become a global player. Together with

the independent commercial vehicle division of Volvo, Dongfeng is able to become the largest commercial vehicle manufacturer worldwide, in total and not only for trucks above six tons load capacity. Therefore, take over the leading position from Daimler. Although, a market entrance in Europe is not planned yet, according to Dongfeng, the company will consider it carefully. Especially western markets such as the European one are very attractive to commercial vehicle manufacturers offering higher profit margins than emerging markets. [Handelsblatt (2013c)]

Several companies have already planned new factories in Brazil, Russia, and Iran. Here in particular, Chinese companies have good chances to expand. But in addition to developing countries in Asia and South America, **China is focusing more and more on Africa**. China already seeks to capture markets shares in Africa for several years. Until today, the building industry has invested large amounts of money in different African; the Chinese automotive industry may follow shortly. Tanzania is just one example. A Chinese company is supposed to build the port of Bagamoyo for 8 billion Euros and China constructs an economic zone next door. The stadium of the city Daressalam is even finished, for which the Chinese government covered half of the amount. The Chinese government has also cancelled the debt of 32 African countries in the amount of about 8 billion Euros. The **volume of trade passing between China and Africa** amounts to 145 billion Euros in 2012. More than 200 Chinese companies have already established themselves in Africa and more than one million Chinese people currently live in Africa. [Berliner Zeitung (2014)]



Qoros 3 Sedan

Africa features 40 percent of reserves of raw materials in the world and, therefore, the Chinese engagement is well justified. It can be assumed that that China seeks to secure the flow of raw materials for itself by concluding long-term agreements for raw materials, which the country urgently needs to proceed on the path of economic growth [Wirtschaftswoche (2014a)]. For example, the crisis country South Sudan has become one of the most important oil suppliers of China. Nevertheless, Africa has also a population beyond one billion people with **increasing purchasing power**. Experts **even compare this situation with China 20 years ago**. For instance, at that time there were only a few German investors in China,

but exactly those ones such as Volkswagen are very successful in China's automotive market the today. In contrast to Europe and the United States still questioning corruption, human rights and the governance in Africa, China regards Africa more as an investment location. **The African market could be an opportunity** for the Chinese automotive industry **to expand and to open up possible future markets**. [Wirtschaftswoche (2014a)]

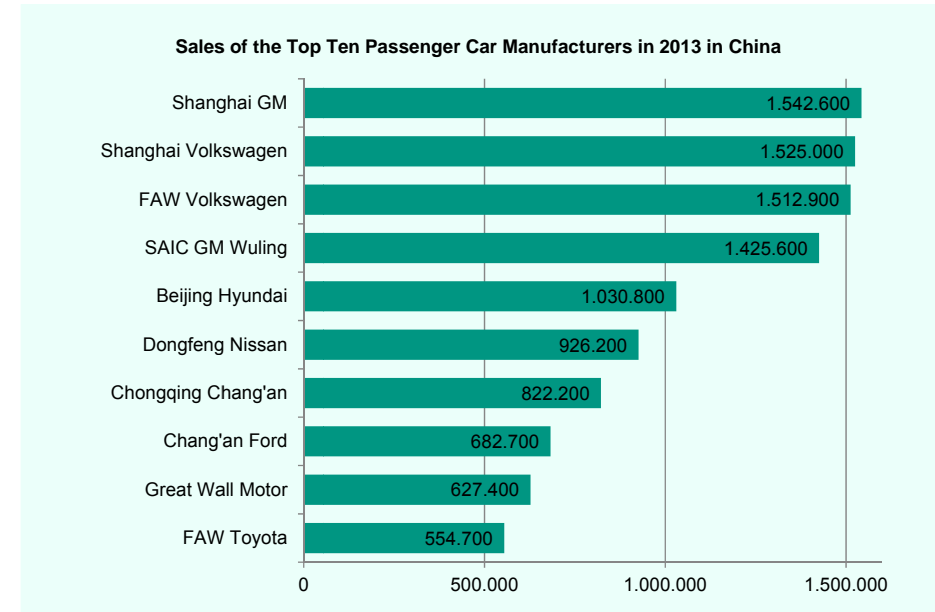


Figure 5: Sales of the top ten passenger car manufacturers in China in 2013⁵

⁵ Own figure based on [ChinaAutoWeb (2014a)].

Figure 5 illustrates the top ten passenger car manufacturers and their sales in China for the year 2013. The joint ventures with international companies dominate in an impressive way. Nine of ten manufacturers operate in a joint venture. Only the relatively independent Chinese manufacturer Great Wall was listed among the **top ten manufacturers** in 2013. [ChinaAutoWeb (2014a)]

2.3 An Overview of the Current Status of Joint Ventures

As part of the economic modernization, the Chinese government allows foreign automobile manufacturers to invest in different ways in China, but the local production of vehicles **requires that the international manufacturers set up a joint venture with a Chinese company**. This differs from the regulations for automotive parts and systems. A large number of foreign automotive manufacturers and suppliers have already started business activities on the Chinese market in the 1990s. Foreign companies may have a **maximum holding of 50 percent in the vehicle joint ventures** and can only enter into **joint ventures with a maximum of two Chinese partners** in the passenger car or truck market. The joint venture policy is designed as a way for Chinese automakers **to learn from their more established global competitors** to support innovations and to increase the product quality of Chinese cars. [MunichInnovationGroup (2013)]

In the beginning, **only completely knock-down (CKD)** kits were imported and assembled in China. Afterwards a minimum of 40 percent Chinese production share was required. In 1983, the American Motors Corporation (AMC) made the first steps into the Chinese market by collaborating with

BAIC. Since its founding, the joint venture has kept the same Chinese co-owner but has had several foreign co-owners. Currently, it is officially called Beijing Benz Automotive Co., Ltd. and it is a joint venture between BAIC and Daimler AG. Two years later, in 1985, **Volkswagen became the first foreign car company which constructed an own plant** in China, when it joined with SAIC. This plant was built to produce a sedan called **Santana**, which was based on the VW Passat and is still **amongst the best-selling cars in China**. The main reason for this is the statutory minimum size of engine displacement of 1.6 liter for taxis in certain provinces. The Santana fulfills this criterion and still provides an appropriate vehicle body which is also essential for the taxi industry. [FAZ (2013b)]

Those collaborations set the stage for a series of joint ventures backed by the Chinese government between western and Chinese automobile manufacturers. Particularly, Volkswagen has made sustainable profit within a short period of time. Nowadays, **every major European, Asian, and American automobile manufacturer** is collaborating with one or two Chinese counterparts. In 2013, Renault as almost last major western automaker entered in a joint venture with Dongfeng and is now able to produce locally. Before then, Renault has only acted as an exporter to the Chinese market. [Automobilwoche (2013b)]

Despite the risks to lose know-how, western carmakers are optimistic to bring most advanced technologies with them. Actually, they do not have a choice considering the vast potential of the Chinese consumer base. While China is the largest auto market worldwide, the country has still plenty of room to grow as the number of vehicles on its

streets account for only about six percent of the population. By comparison, in the United States 80 percent of the population use their own cars. Nevertheless, joint venture agreements have also **advantages for Western automobile manufacturers**. Since **close contacts** to potential customers and **public authorities** are still very important in China, it can be advantageous to have a good and reliable Chinese partner. Moreover, it is a quite elaborate strategy to **supply the ASEAN** (Association of Southeast Asian Nations) such as Indonesia, Malaysia, and the Philippines from China.

Foreign lobby groups such as the European Chamber of Commerce in China (EUCCC) have long been calling for **abolition of dictated joint ventures or at least of prohibitions of controlling interests**. But now, the Chinese

government is starting to consider about a **reformation**, too. The Chinese Automobile Manufacturers Association (CAAM) is an obvious opponent and rejects a relaxation to protect Chinese manufacturers. So far, the regulations would not have deterred foreign automobile manufacturers and the joint ventures are essential for the Chinese automotive manufacturers according to the CAAM. Joint ventures earn the majority of profits of Chinese companies and technology transfer is significant for the Chinese companies.

In October 2013, the Chinese trade ministry has acknowledged publicly for the first time ever that a **reform is actually on the agenda**. As reasons, it is stated that other countries also do not require joint ventures. Furthermore, the government stated that **no Chinese manufacturer has established an own powerful brand, yet**. According to the government, not only the foreign companies will benefit from a relaxation. Again, the acts of the government in Beijing are of special importance and high relevance for the whole industry. Figure 6 illustrates the largest foreign automotive manufacturers in China in 2013. [Automobilwoche (2013c)]

VOLKSWAGEN AG is the **largest, and the most successful international partner** in China's automotive industry. Because of the early collaboration with the Chinese manufacturer SAIHC in 1985, VW has a leading position in the Chinese automotive market. VW's locally manufactured and imported vehicles are sold under **various brands** such as Volkswagen, Audi, SEAT, Skoda, Bentley, and Lamborghini in China. Its first joint venture in China, **Shanghai Volkswagen Automotive Co., Ltd.** was established in October



Figure 6: The largest foreign automotive manufacturers in China, 2013⁶

⁶ Own figure

1984. The second joint venture, **FAW-Volkswagen Automotive Company Ltd.** was followed in February 1991. Volkswagen Group China has **16 subsidiaries** with SAIC and FAW being the two major Chinese partner companies. Nowadays, Shanghai Volkswagen Automotive Company produces cars of the brands VW and Skoda including the success model Santana. FAW-Volkswagen produces VW and Audi vehicles. The top-selling FAW-Volkswagen car is the model Jetta. **Both models, Santana and Jetta, are amongst the most successful cars** on the Chinese market. The Santana was sold almost 4.2 million times in China since 1983, although the car was not successful in Volkswagen's home market Germany. The European production ended in 1988. Since the beginning of 2013, VW has launched the latest version of the success model Santana. [FAZ (2013b)]

Both joint ventures have developed a **brand name of their own for electric vehicles**. Under the brand name **Tantos**, Shanghai Volkswagen produces its electric vehicles. The e-car brand **KaiLi** is produced by FAW-Volkswagen. The market launch of electric vehicles of both brands was scheduled to be in 2014. The model Carelay of the KaiLi brand is already entirely developed but VW deferred the production launch. It's a similar story for Tantos. There is a lack of buying interest and adequate electric charging network. In 2014, VW sold at least **3.27 million vehicles** in China according to delivery figures released by the German automakers VW, Porsche, Audi and Skoda brands. Therefore, the German vehicle manufacturer has sold more vehicles than General Motors **for the first time in nine years in China**. Actually, VW already considers itself the largest passenger car manufacturer in China for a long

time. In contrast to GM, Volkswagen does not include light commercial vehicles. In this segment General Motors clearly leads with its brand Wuling. Otherwise, VW figures count Hong Kong which GM does not include when it released official figures for the enterprise. Among the biggest driver for VW in 2013 in China was the **top-selling premium car brand Audi**, whose sales rose 21 percent last year. **Porsche recorded large growth**, too. But the **sales of Skoda and particularly SEAT declined**. [FAZ (2013c)] [Volkswagen (2014)]

Even if brands are considered, Volkswagen dominates even more the Chinese market. In 2013, **Volkswagen sales rose nearly by 17% to 2.4 million units**. The Korean brand Hyundai ranks second among the brands with 1.030.708 sold units. Figure 7 illustrates the five top-selling brands and compact sedans in China in the previous year. The top eight brands are foreign brands. The leading domestic brand was Great Wall in ninth place followed by BYD (11th), Chery (13th) and Dongfeng (16th). [Automotive News China (2014a)]

For the future, VW is planning **investments of 18.2 billion Euros (151 billion RMB) in China by 2018**. According to the company, that would help VW to increase the number of offered passenger cars, SUVs, vans and commercial cars from the **current 70 models to 90 models by 2015**. Seven of VW's ten new plants worldwide will be built in China. The company intends to expand its production capacity to four million vehicles per year [Volkswagen (2014)].

At the 13th Beijing International Automobile Exhibition in April 2014, VW announced that the company will decide about the launch of VW's very low-priced **"Budget car"** designed for growth and

emerging markets. The price of the car is supposed to be around **7,000 Euros and it is supposed to be introduced in 2016/2017**, initially only in the Chinese automotive market. The car will be built in collaboration with one of Volkswagen's joint venture partner, SAIC or FAW, and the localization level is supposed to be 100 percent. However, the new cheap car will be **not offered under the main label**. There will be a **totally new brand**, even with an own distribution channel. Afterwards, new models such as a SUV and further markets such as India are supposed to follow. The aim of the **"Budget car" is to attract new groups of buyers and to increase the company's output**. According to Volkswagen, the world market for very cheap cars is about 10 million units per year and China accounts 3 million units of those. [Automobilwoche (2014a)]

Beating GM in the most important market China puts VW a step closer to its goal of becoming the **world's largest carmaker by the year 2018**. Similarly, at the worldwide level, Volkswagen and

General Motors compete in a neck-and-neck race. Including trucks of the MAN and Scania brand, Volkswagen sold **9.7 million vehicles worldwide in 2013**. In the same period, GM sold 9.71 million vehicles. World market leader remained Toyota with 9.98 million sold vehicles in 2013 according to estimates. [FAZ (2014a)]

GENERAL MOTORS COMPANY operates in China through 12 joint ventures and two fully owned foreign enterprises. It has more than 55,000 employees in China and **three major joint-ventures** called **Shanghai GM, FAW-GM, and SAIC-GM-Wuling** with its two Chinese vehicle joint venture partner SAIC and FAW. The joint ventures are selling products under the Buick, Cadillac, Chevrolet, Opel, Baojun, Wuling, and Jiefang nameplates. For the year 2013, General Motors quoted a sale of 3.16 million vehicles in China. General Motors is the **second largest seller** of vehicles behind Volkswagen. Nevertheless, the increase of GM's sales of 11.2 percent grew less than market growth (14 percent). Around half of

1. Volkswagen 2,395,695 Units	1. Ford Focus 403,640 Units
2. Hyundai 1,030,708 Units	2. Volkswagen Lavida 374,056 Units
3. Toyota 857,749 Units	3. Buick Excelle 296,183 Units
4. Nissan 842,847 Units	4. Toyota Corolla 294,401 Units
5. Buick 807,769 Units	5. Chevrolet Sail 276,242 Units

Figure 7: Top five brands and compact sedans in China in 2013⁷

⁷ Own figure based on [Automotive News China (2014f)]

General Motors' sales come from the Wuling brand. However, the demand of the Wuling models declined since the government incentives for agricultural regions have expired. [FAZ (2014)]

The first joint venture with the Chinese company Shanghai Automotive Industry Corp. Group (SAIC) is called **Shanghai GM** and was created on March 25th, 1997. Shanghai General Motors began assembling the venture's first Chinese-built vehicle, the Buick Regal, in Shanghai in 1999. The joint venture manufactures a **comprehensive range** of Buick, Cadillac, Chevrolet, and Opel products in several manufacturing bases. In 2013, Shanghai GM had the record of domestic sales of 1,542,600 vehicles and thus it was the largest automobile manufacturer in China. **The success model Buick** was delivered over 800,000 times in China in 2013. [General Motors (2014)]

The **SAIC-GM-Wuling Automobile (SGMW)** is a joint venture between SAIC Motor, General Motors and Liuzhou Wuling Motors Co., Ltd. and sells mini-trucks and minivans under the Wuling brand and a growing family of passenger cars under the Baojun brand. SGMW is **one of the largest manufacturers of minivans** in China. The Wuling Sunshine is one of its most popular minivans and it has been the best-selling vehicle in China for nine consecutive years. The Baojun brand was established in 2010 and aims to sell to consumers in third and fourth tier cities in China. Such large- and medium-sized Chinese cities are not counted among the top cities in terms of population and economic contributions. In 2009, SAIC and GM **also set up a joint venture in India**. That was the first time an international OEM collaborates with a Chinese OEM **without governmental mandatory requirements**. GM obviously has seen SAIC as a

very important partner for emerging markets such as India, which has the potential to become the next large market for the automotive industry. The third joint venture FAW-GM Light Duty Commercial Vehicle (FAW-GM) is a commercial vehicle manufacturing company between GM and FAW. It was launched in 2009 and it is focused on the production and sale of light-duty trucks and vans. In 2012, FAW-GM sold 55,609 vehicles in China. [General Motors (2014)]

GM led global sales for 77 successive years from 1931 through 2007, longer than any other automaker. The worldwide largest automotive market plays also an important role in GM's future. General Motors will face the challenge of regaining the eight-year lead it held in China. Matthew Tsien, the new company's country head in China announced that General Motors **plans to invest about 11 billion USD** (66.5 billion RMB) in China until 2016. Four new production facilities are planned to expand the capacity to five million vehicles per year. These plans also include the expansion of the portfolio of vehicles for the low-cost Baojun brand and also to launch four Chevrolet models in Chinese market this year. [General Motors (2014)]

According to companies figures **NISSAN MOTOR CORPORATION** followed in **third place** behind General Motors and Volkswagen regarding sales in 2012. The Japanese automaker's sales climbed to **1.27 billion units in 2013**. Nissan's aim is to capture ten percent of the Chinese automotive market. In 2003, Nissan established its **joint venture with Dongfeng Motor**. The joint venture sells a complete series of trucks, buses, light commercial vehicles, and passenger vehicles. The Dongfeng brand is used for its commercial vehicles

and the Nissan brand is used for passenger vehicles. The company is also in a close alliance with the French car manufacturer Renault. Due to the rising premium market in China, Nissan sees major opportunities for its **luxury brand Infiniti**. Infiniti plans to attract especially younger Chinese buyers. It is targeting **ten percent of the world premium market by 2020**. In the year 2013, the company started local production and expects an increase of about 50 percent in 2014. Previously, the Infiniti brand imported all models that have been sold in China. The aim is to sell more than 100,000 units in China within the next five years. [Automotive News China (2014b)]

However, the **future of Japanese automakers in China remains blurry** because of the sales crisis that hit Japanese brands led by Nissan Motor Company, Toyota Motor Corporation and Honda Motor Company in the fall of 2012 and lingered through the year 2013. In 2012, Japan nationalized a **group of islands** in the East China Sea called the Senkakus in Japanese (and the Diaoyu in Chinese) by buying them from private owners. **China and Japan both claim the islands** because they are close to important shipping lanes, offering rich fishing grounds and lie close to potential oil and gas reserves. **Political Tensions** led to violent protests and a **boycott of Japanese products**. During nationwide street protests at the beginning of the issue between the North Asian neighbors in 2012, demonstrators torched dealerships and vandalized cars associated with Japan. In this year, Toyota and Nissan stated their first annual sales declines in China. According to the consultancy LMC Automotive, the collective **Japanese market share of the Chinese passenger car market declined** to 16.6 percent in 2013 compared to 23 percent in 2011. Although,

sales on a monthly basis of Japanese companies recovered to pre-crisis level toward the last months of 2013, the **political tension between Beijing and Tokyo is likely to continue**. The diplomatic disputes did not lead to vehement protests as they had done in 2012, but the tension flared again after China created an air-defense zone including the islands. Therefore, the Japanese automotive manufacturers **remain strongly dependent on the relationship between Beijing and Tokyo**. To reverse this trend, Japanese brands are planning to launch new and redesigned models. [Automotive News China (2014b)] [BBC (2013)]

Fourth place went to the South Korean automaker **HYUNDAI MOTOR GROUP**, whose sales rose 21 percent in the last year to exceed one million vehicles for the first time; Hyundai sold **1.03 million vehicles** in China. The company operates in a joint venture with Beijing Automotive Industry Group Corporation (BAIC), which is called **Beijing Hyundai** and is headquartered in Beijing. This year, the collaboration aims to expand in the market and to sell more than 1.13 million vehicles in China, supported by a capacity increase at its third Chinese plant and a new fourth assembly plant in China. Beijing Hyundai produced most of the taxis used in Beijing. Unlike most other Chinese cities, where taxi companies are privately-owned, the Beijing government still runs the city's largest taxi operators and the local government still distribute business to related companies. [Automotive News China (2014a)]

In beginning of the year 2013, Hyundai established another joint venture, named **Sichuan Hyundai**, with Sichuan Nanjun Automobile to produce **commercial vehicles and engines**. The plant is located in the southwest city of Ziyang, in the

Sichuan Province and is designed to roll out approximately 160,000 trucks, 10,000 buses, and 20,000 heavy-duty engines annually. The long-term aim of the joint venture Sichuan-Hyundai is to increase production capacity to 700,000 vehicles a year and to become a major commercial vehicle manufacturer in China by 2017. [Automotive News China (2014e)]

FORD MOTOR COMPANY overtook Toyota to become the **fifth largest manufacturer** among foreign automotive companies. Although Ford was a latecomer to the world's fastest growing auto market, it achieved very strong growth in China. In 2013, Ford delivered a record of 935,813 units with its local partners and its sales rose by around 49 percent in the last year. Like Volkswagen's Santana and GM's Buick, the **Ford Focus is also one of the best-selling cars** in China. In 2013, it even was the best-selling car in China according to CAAM. Ford's **passenger car joint venture** with Chang'an Automobile Company, named **Chang'an Ford**, was formed in the year 2001 and produces and sells Ford's portfolio of sedans and SUVs. Chang'an Ford produces vehicles such as the Ford Mondeo, Focus, and EcoSport in the southwest China municipality of Chongqing. Ford also operates in a **commercial truck joint venture** with Jiangling Motors Group, named **Jiangling Motors Corporation (JMC)** that produces the Ford Transit commercial van and its SUVs, pickups, vans, and light trucks under the JMC-brand in the east China city of Nanchang. [Automotive News China (2013c)]

By 2015, the number of powertrain and assembly plants in China will grow to 24 and Ford will have the capacity to produce more cars and trucks in Asia than it manufactured last year in its home

market North America. However, Ford operated 14 plants in China in the year 2012. Ford is likely to benefit a lot from the relatively strong growth in the Chinese automobile market. The company is still lagging far behind Volkswagen and General Motor but a portfolio of new and revamped vehicles helped Ford to the **rapid growth**. Ford launched a couple of small sport-utility vehicles and the redesigned Focus and Mondeo model. An additional reason for the sales increase was the territorial dispute between China and Japan which was an advantage to Ford. [Automotive News China (2014c)]

In 2013, sales of *TOYOTA MOTOR CORPORATION* increased to **917,500 vehicles** and by nine percent compared with the previous year's sales. The Japanese company operates three joint ventures in China. The first one, named **GAC Toyota Motor Company**, was founded in 2005 and began production in 2006. It is an automobile manufacturing company headquartered in Guangzhou and a joint-venture between Guangzhou Automobile Group and Toyota Motor Company. The second and third joint ventures are called **Sichuan FAW Toyota Motor Company** and Tianjin **FAW Toyota Motor Company**. Both are joint ventures between Toyota Motor Company and FAW. In 2012, the technology departments of both joint ventures were merged to FAW Toyota Research & Development (FTRD). The FTRD develops vehicles especially for the Chinese market, for example vehicles of the Ranz brand originated from the joint venture. It was also built to support Toyota to reduce the gap to Volkswagen and General Motors in China. On the world market, Toyota is at the same level as the two competitors, but in China the company is far behind them. Toyota said it aims to sell more than 1.1 million

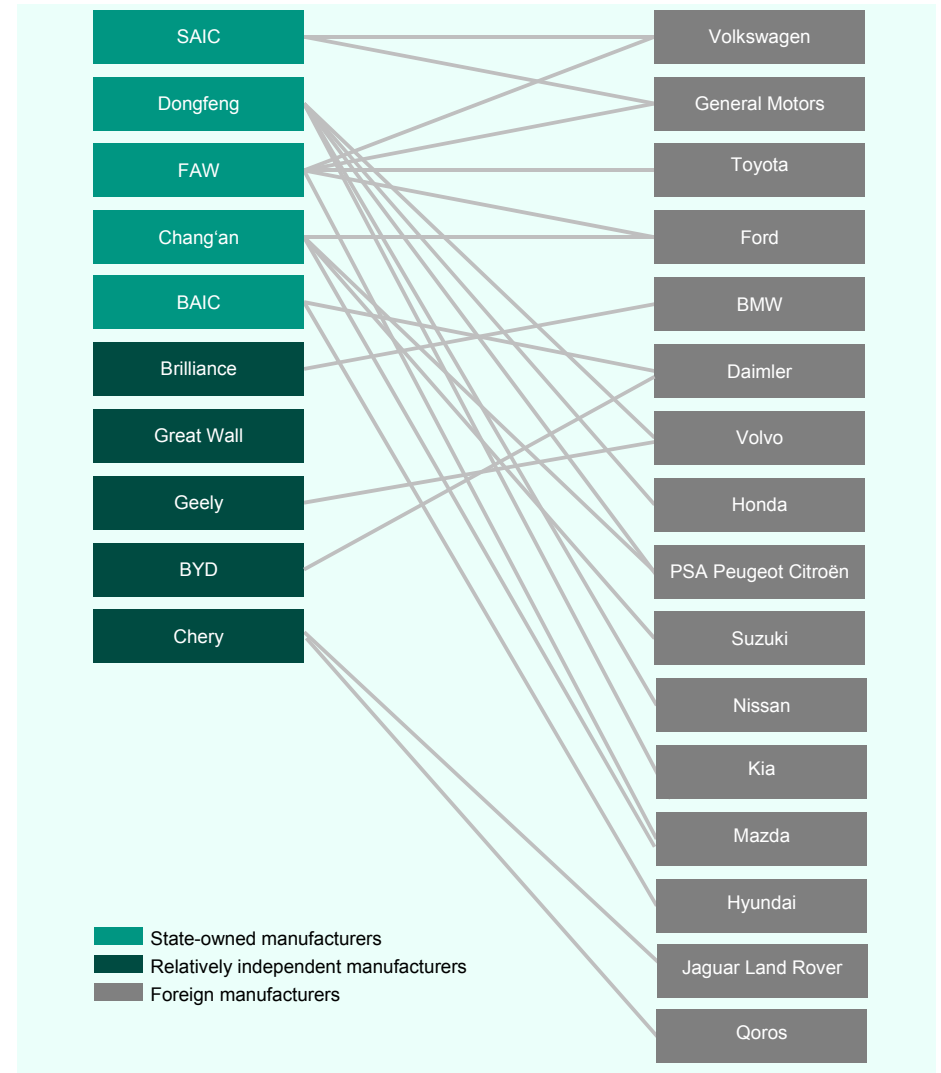


Figure 8: Overview of joint ventures in the Chinese automotive industry⁸

⁸ Own figure.

vehicles in China this year. That is a milestone the company has already been trying to reach for quite some time. Toyota has entered late into the Chinese market. The company has concentrated on its home market as well as the US market in the last decades instead of entering the Chinese market at an early stage. Furthermore, they are forced to contend with political tensions between China and Japan. [Toyota (2014)]

2.4 Production Methods

Since more than 20 years, China has been considered as the **'workbench of the world'**. Due to a vast number of young workers, low wage costs have resulted in competitive advantages. Huge **foreign direct investments** have ensured financing of factories in China which have covered the demands of low-priced goods worldwide. According to data of the United Nations (UN), 654 billion Euros have been invested in Mainland China in the last years. This investment has certainly been contributing to the outstanding **success in economic growth**. The GDP of China rose from 357 billion USD in 1990 to 9.3 trillion USD in the

previous year, which corresponds to an increase by a factor of thirty. But China's **days as a low-wage country are certainly counted**. Yet, the world's manufacturing powerhouse has other, far more ambitious plans. Meanwhile, China is manufacturing more and more sophisticated products. The government in Beijing rather wants to produce high-speed trains, computers, machinery, and vehicles. The extended benchmark is supposed to move backwards and a **high-tech location should emerge** in China. At the same time, the productivity is below the level of the USA, for example. The result is a process of adjustment regarding unit labor costs, i.e. the relationship between wages and labor productivity per person employed. In China, **wages and salaries grow** between 10 and 20 percent annually. Engineers and skilled workers register even higher salary increases. In comparison to 2000, they have been tripled. Figure 9 illustrates the development of wages in China from 2005 to 2011. This growth has several reasons. On the one hand **the government constantly increased the statutory minimum wage** to prevent an income gap from becoming too large. In 2012 for instance, in

Shanghai the statutory minimum wage was increased by 13.3 percent to 1,450 Renminbi Yuan (RMB). In 1993, when it was introduced in this metropolis, the statutory minimum wage was at 210 RMB. The situation is similar in nearly all provinces and cities in China. On the other hand **qualified labor is becoming scarce** in China. Whereas the economy of China continues to boom, the population shrinks in China. In 2012, the **working population aged 15 to 59 declined** by 3.5 million people compared to the previous year. The change is also reflected in the population's desire. Previously, the money was the key factor and it was normal that the workers lived in residential homes far away from their families. Nowadays, the workers seek to earn good money and the close proximity to their families plays a more important role. [GTAI (2013)]

But with growing affluence in China the **costs for companies increase**. In addition to rising wages, the social security contributions and rents increase for companies. Moreover, the appreciation of the national currency tends to increase the price of Chinese goods on the world market. In these times of change, when low labor costs are no any longer an advantage in many industries, other **concepts and methods** become more interesting in order to obtain competitive advantages. Only the companies with the **highest productivity, the most efficient processes, the highest quality and the best customer orientation** may prove themselves sustainable, particularly in a market environment characterized by a large amount of competitors. In addition to cost efficient processes, material flows are important to realize rapid economic growth. An annually increase in sales by double-digit percentages in the automotive industry led to **capacity bottlenecks and delays**. With the

rapidly rising demand for vehicles, many manufacturers reach their capacity limits. Many companies would have been able to sell more vehicles if more were produced.

Initially, Chinese companies primarily reacted with **relocations** of production from the east to the west in China in order to be successful at international level. But in these rural regions the labor costs also increase now and in combination with increased transport costs to the ports in the east the labor costs equalize a large proportion of the cost savings of such location shifting. In contrast to companies, the **government in Beijing welcomes the wage increase**. It would like to base its economic growth rather on domestic consumption than on export of cheap goods. Therefore, **Chinese industry seeks to keep up with international competition** in all respects. One example is the new emission standards being introduced in different cities in China. These reforms are intended to reduce emissions and, thereby, to protect the environment but with consistent engine power. This development requires high quality components produced by cutting-edge methods and machines. [Produktion (2013a)]

Level of Automation

When wages and salaries are low, it is not worth to purchase expensive machines or special robots. However, those times are definitely over. In China, **personnel placement and economy of manual labor** are playing a more important role than in the past. The 12th five-year plan of the Communist Party of China also includes the **aim to further automate its production**. Companies switching from manual labor to machine-based production in their factories receive **government aid**. Especially,

Development of Wages per Month in China

	2005	2006	2007	2008	2009	2010	2011
Nominal (in RMB)	1,530	1,750	2,078	2,408	2,687	3,045	3,483
Nominal (in USD)*	187	220	273	347	393	446	532
Change (in % and on a RMB basis)	14.6	14.4	18.7	15.9	11.6	13.3	14.4

* Translation at the annual average exchange rate of each year

Figure 9: Development of average gross monthly wages of urban workers⁹

⁹ Own figure based on [GTAI (2013)].

key industries such as the automotive industry are supposed to be equipped with modern and efficient machines. The coastal Zhejiang Province in the east of China announced to support, for example, companies that will purchase industrial robots over the next five years. This development plan shall contain about 50.35 billion Euros. [IFR (2013)]

The speed that Chinese companies show in automating their factories is just as impressive as the economic growth in the country. Nowadays, China is already the **largest sales market for machine tools**. More than one third of all machine tools produced worldwide are sold in China. With continuous improvement pressures and the recent economic slowdown China's automotive industry drives automation forward and, in particular, robotics. More and more Chinese workers struggle against **social inequality** and after a series of strikes in 2010, significant increases of wages could be enforced in the automotive industry. Many of the automotive industry's suppliers but also manufacturers such as Honda and Hyundai were affected by the strikes. For example, Honda had to shut down its production plants for a period of several weeks. But in the meanwhile, it is even more than just working hours and wages in China. In addition, there is also a higher quality, which China has to provide if it seeks to reinvent and establish itself as a **high-tech location**. The products must not only meet minimum standards. Since the Chinese companies even started to produce and market their own brands globally and have launched manufacturing bases in western countries, competitiveness is crucial. In this respect, automation helps to **ensure a higher quality and to manufacture better products**. Moreover, more and more Chinese companies accelerate to export their products in recent years. This also increases

"With automation, we can reduce our head count and save money. Within three years, this cost will be completely paid for in savings from reduced worker wages."

Hao Jianjun, General Manager of Great Wall, 2012. [Bloomberg (2012)]

the quality demands on the components especially in western markets. A further reason for a higher level of automation is the opportunity of achieving **more stability and planning certainty** in the production. The mentioned skilled worker shortage and the still relatively high level of staff turnover are serious problems for many companies in China. [Produktion (2013a)]

The rising interest of the Chinese automotive manufacturers in automation is also recognizable by the huge rush at the opening at the last China International Machine Tool Show (CIMT) in Beijing in April 2013. Nowadays, CIMT is one of the largest and most influential machine tool shows in the world. All well-known machine tool manufacturers take part in the exhibition in order to display their most advanced manufacturing technology and equipment. Currently, **Japan and Germany are the biggest suppliers for automation engineering** in China. But like other sectors before, it can be assumed that China might soon produce a large proportion of its machine tools in the near future. Meanwhile, China is the largest manufacturer of lathes and milling machines in the world. However, the **industrial robots industry** will still be dominated by Japan and Germany for extended periods of time and robotics sales are still heavily dependent on the automotive industry with

about 60 percent of the robotics demand in China. Figure 10 illustrates the annual supply of industrial robots to China from 2005 to 2016. [Wirtschaftswoche (2013b)]

According to Great Wall's general manager Hao Jianjun, the Chinese automobile manufacturer invested 161 million USD into installation of 1,200 industrial robots in four plants in 2012. As a result, the number of workers at Great Wall's factories dropped from 1,300 to around 400, after the robots were added. And additionally, the **expenses will be amortized** within three years. It is to be noted that 50,000 USD was the average price of one robot for this Chinese car manufacturer. [Bloomberg (2012)]

Nevertheless, the **potential of automation** still remains very high in the China's production industry. In comparison to highly industrialized countries such as Japan or Germany having a robot density between 270 and 400 robots per 10,000 employees in the manufacturing industry, the robots density in China is comparatively low at 20 robots. Therefore, China has still the **immense backlog demand**. Over one million industrial robots would have to be installed over the next years to achieve such a high level. For 2014 to 2016, the **rising sales will continue** and gain momentum. These developments lead to the expectation that the supply of industrial robots to China will increase to 38,000 in 2016 with an annual growth forecast of 15 percent. Figure 11 compares the estimated operational stock of multipurpose industrial robots in selected countries. [IFR (2013)]

However, there are also some risks because a quick automation does not only cause benefits. For



example, faced with an overly fast automation, difficulties may arise if a shortage of qualified employees exists, which are able to maintain and repair advanced machinery. Therefore, investments in employee trainings play a crucial role and will also be needed.

In a certain sense, experts **compare the current situation in China with the developments in Japan** during the 1980s. At that time, Japan had the same level of automation such as China today and could therefore provide more information about the impact of automation on a capitalist economy. Following a period of rapid growth and expansion, the Japanese economic miracle collapsed in an asset price bubble in the late 1990s in which real estate and stock market prices were inflated. Since the early 1990s, the most automated economy in the world remains in deflation and economic stagnation. [Produktion (2013a)]

In general, the automotive manufacturers are best advised to implement a **sustainable automation**. Process optimization methods such as Lean Management and a better involvement of employees and managers are necessary for enhancing productivity. [Produktion (2013a)]

Lean Production

The contrast between big cities in the east and rural regions in the West also reflects the corporate landscape on the ground in China. From a state-of-the-art factory to a small workshop, all kinds can be

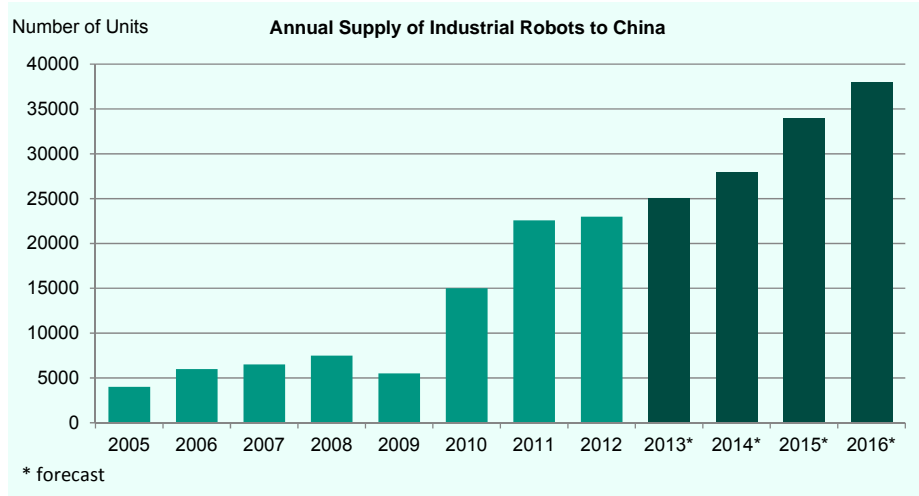


Figure 10: Annual supply of industrial robots to China¹⁰

	2011	2012	2013*	2016*
Brazil	6,971	7,576	9,170	17,400
China	74,317	96,924	121,200	215,800
India	6,352	7,840	9,300	16,300
North America (Canada, Mexico, USA)	184,679	197,962	215,650	260,800
Germany	157,241	161,988	165,800	177,900
Japan	307,201	310,508	309,400	312,900
Republic of Korea	124,190	138,883	155,300	201,700

Figure 11: Estimated operational stock of multipurpose industrial robots in selected countries¹¹

¹⁰ Own figure based on [IFR (2013)].

¹¹ Own figure based on [IFR (2013)].

in the Chinese industry. Under the increasing pressure, gaining and applying effective production practices such as lean production may be essential to survive in a globalized economy characterized by numerous competitors. Ignoring this need would most likely force companies to disappear from the market. Sustained rise of wages and increasing competition feature consequences, particularly as it is more important to operate profitably than ever before. In concrete terms, this means that in China the **production needs to be organized efficiently, stocks have to be reduced and waste has to be eliminated**. Lean production or lean manufacturing is a set of principles, which among others describes an elementary basis for modern and competitive flow of material, thereby, steadily eliminating waste in the production system. For instance, these principles include pull processing, waste minimization, continuous improvement, flexibility, building and maintaining a long term relationship with suppliers as well as production flow and visual control. **The core idea is** to create more value for the end customer while minimizing waste and resources. It became mostly known as the Toyota Production System (TPS) by Taiichi Ohno. In 1980s, the methods were essential for Toyota to overtake the European and the North American market from its international competitions [Taj (2008)]. Nowadays, the situation for many companies, particularly in China, is comparable. Even small firms compete in the global market place. There is **great potential** for companies, but also the constraint to be profitable. To remain competitive, companies have to organize their factories more efficient and 'lean'. Despite the wide knowledge, many manufacturers struggled to implement lean production, yet.

The basic concept of lean production is identical in

"In China many companies are at an early stage of implementation – a real lean culture can mostly be found in foreign companies. Most of the large state-owned still work completely traditionally."

Wilhelm Goschy, Executive board of Staufen AG, International lean management consulting company, 2013. [Produktion (2013b)]

each country. But conditioned by local legislation and different regional characteristics (e.g. culture) the **implementation of lean production strategies differs from country to country**. Lean thinking will help Chinese companies making great progress with production and innovation. **First applications of lean production in China** started in the late 1970s in the automotive industry, much earlier than in the USA or Europe. The Chinese manufacturer First Automotive Works (FAW) and its first automotive plant in Changchun introduced the TPS in 1977 even with the help of Taiichi Ohno. He was very crucial to the mass production at FAW and changed the whole layout of the production line to reduce waste. FAW also sent a team to Japan to visit Japanese automotive companies to learn more about lean production. In the late 1980s, FAW opened a new transmission plant with assistance of Mr. Ohno which was regarded as **one of the best manufacturing plants** in the world. Afterwards, FAW continued with spreading its lean production knowledge to its other manufacturing facilities. [Taj (2008)]

In the meanwhile, especially in the Chinese automotive industry with its various international collaborations, lean production principles were

implemented but in general in China a sustainable lean culture is still in the initial phase. Especially at international companies, the lean production concept works because of well trained and internationally experienced employees. In these companies the spirit is implemented in accordance with international standards. Because they have already implemented lean principles in developed countries such as Germany or the USA they are able to transfer these principles to China. In contrast, **at the large state-owned companies** work is partially still done in a traditional way with traditional mass production. New and innovative production practices are only used rarely. Chinese companies always **focused just on economic indicators**. Process and product quality as well as reduction of waste were frequently neglected. This indicates a large gap in terms of lean production among manufacturers in China. One reason is why lean exercised infrequently were very low labor costs in the old days so that further reduction of labor costs would not have had a significant impact on total costs. In line with the philosophy that products only have to fulfill current minimum requirements of customers Chinese companies **still have a backlog demand** in implementing innovative production practices. [Produktion (2013b)]

Even though China is an excellent manufacturing base, implementation of lean production can be difficult due to **political, economic and cultural differences**. The methods must also be adjusted to suit the cultural identity of China. For example, in China the employees rarely take the initiative to solve problems. Chinese workers are used to get direct instruction from their superiors. Also unusual is that the employees communicate openly in the workplace. The **Chinese society** is organized

hierarchically and individualism plays a secondary role. In a culture where 'losing face' is one of the most terrible consequences, a defective test run may create problems. Instead of an useful and open communication employees most likely choose to be silent. But a successful implementation of lean concepts particularly includes a critical attitude as well as creativity, individual initiative and communication. An active participation, a focus on improvement of processes and elimination of waste are core tasks of each individual staff member. Shortages in skilled staff reduce the chances of success of an introduction of lean production. Especially workers from regions which are heavily influenced by agriculture often lack knowledge and key qualification to identify and avoid waste. The **middle and senior management** also plays an important role. The behavior of supervisors is crucial for successfully implementing lean production principals in China. As long as the management is not ready for modification, it is considered that new methods won't be implemented. But with the right managers on-site Chinese employees may follow their example. In addition, **management continuity** is one of the keys to establish lean production strategies. Employee fluctuation is still very high in China and, therefore, standards have to be defined to ensure that quality remains consistently high in case of frequently changing staff. Chinese people also have a marked urge for **improvisations** and just a few weeks after implementation of measures it may occur that they deviate from standards, especially following a change of their leadership. Visualized and standardized processes may help in these phases. [Jochem/Iacovelli (2011)]

Moreover, many Chinese manufacturers produce in a traditional way of mass production and usually

produce their products in large lot sizes and generate high levels of inventory. This situation increases the risk of damages to the products. This may result in higher total production costs. Furthermore, poorly defined processes between the individual production steps often cause bottlenecks in China. As a result, an increase in waiting time arises because of prior delays in the process flow. In addition, a successful implementation of lean production requires **machinery, plants, and tools with a high level of quality and stability**. The progressive automation in manufacturing in the Chinese automotive industry is conducive to a further implementation of principles of lean production. [Faust/Gang (2012)]

All in all, the impression remains that further extensive training and education opportunities are indispensable. In order to stay competitive, Chinese automotive manufacturer should improve their production operations. A change of culture in terms of developing **own problem-solving skills** would be helpful. It is a management task to motivate employees continuously to actively contribute their suggestions as to how the company may work even more effectively. A **standardized system for China** may also originate from integrating cultural differences into the lean principles. If the Chinese government is convinced and it believes that lean production is essential for the establishment of Chinese automotive manufacturers as one of the world's largest vehicle producers a nationwide implementation may be rapidly pushed ahead. There are already some provincial governments funding individual lean projects. However, an implementation of the lean culture is **not a short-term proposition**.



Automation

Research Capacities in China

In 1994, the Chinese government invited a number of international automotive manufacturers to submit concepts for a new family car. Foreign manufacturers regarded this task as a serious chance to capture the promising Chinese automotive market. For example, even Porsche developed a four-door compact sedan called C88 which was totally different to any other Porsche model. The development was completed in only four months by Porsche engineers and the car was showed to the public at the **Beijing Auto Show in 1994**. With an eye on the specific characteristics of the market, Porsche included Chinese engineers and the C88 was designed with only one child seat reflecting Chinese population control policy. How serious this project was for Porsche was shown in the fact that the prototype was presented by Wendelin Wiedeking himself, at the time Chairman of the Board of Management, who even gave his speech in Mandarin. However, the Chinese government decided against the continuation of the tendering. Therefore, there was no winner and no concept of an international manufacturer which was actually implemented. It was obvious to the foreign companies that the Chinese government regarded the submitted concepts **rather as inspiration than as a quotation**. [Focus (2014)]

This frugal approach represents the previous course of Chinese vehicles manufacturers and that they have **spent less than their competitors on nurturing innovative engineering and design**, even in their joint ventures. Instead of creating a car from scratch, which would allow them to claim some patent rights, Chinese joint venture partners **took existing foreign vehicle blueprints**, made a few changes and then sold it as a new joint venture car. GM and SAIC's first joint venture car, Baojun 630, is based on the old Buick Excelle series,

while Dongfeng and Nissan's first Venucia vehicle was produced based on to Nissan's Tiida. Consequently, Chinese companies are remote from their foreign competitors in the matter of sales, quality and innovation. In recent years, **things started to change** and China is on its the way to become a powerful location for innovation. To become a global player in the worldwide automotive industry is the goal of numerous Chinese companies. In other sectors like the electronic industry companies such as the Chinese multinational networking and telecommunications equipment company Huawei have already succeeded. One reason for this is the fact that the **level of innovation has risen** significantly. China has made great progress in its move to catch up with industrial countries regarding R&D. Figure 12 illustrates the **gross domestic expenditure on R&D (GERD)** of years 2011 and 2001. GERD are the expenditures on research and development of the sectors' business enterprises, the government, and higher education institutions. [EFI (2014)]

China catches up not only in terms of quantity but also **quality improves rapidly**. China also records a significant increase in patent applications. Since the late 1990s, **the highest growth rates** are shown by China and Korea. Figure 13 points out intensity, growth rates, and absolute number of transnational patent applications in high technology for selected countries in 2011. The high-tech sector covers industries which invest more than 2.5 percent of their turnover in research and development. This also includes the automotive industry. The intensity is the number of patents per million citizens. This development of patent activities also shows that the value of intellectual property is increasingly recognized by Chinese companies and the government. [EFI (2014)]

International manufacturers recognized at an early stage that **it is essential to research and develop in China** and it is not sufficient to only adjust the products slightly compared to the products sold on their home markets. Carmakers such as General Motors, Volkswagen, and Toyota are outspending

Chinese brands on research and development and lead in terms of engineering technology. Therefore, foreign companies increase not only their local production volumes; they also consider China more and more as **research and development location** [Bloomberg (2013a)]. For example, many German

**Distribution of Gross Domestic Expenditure on R&D by Implementing Sectors
2001 and 2011**

	2001					2011				
	GERD In Mio. USD ¹	conducted by... (in %)				GERD In Mio. USD ¹	conducted by... (in %)			
		Eco- nomy	Uni- versity	State	Un- known		Eco- nomy	Uni- versity	State	Un- known
GER	54,426	69.9	16.4	13.7	-	93,987	67.7	17.8	14.5	-
FR	35,804	63.2	18.9	16.5	1.4	51,891	63.4	21.2	14.1	1.2
GB	29,179	65.5	22.7	10.0	1.8	39,627	61.5	26.9	9.3	2.4
US	278,239	72.6	12.1	11.3	4.0	415,193	68.3	15.2	12.1	4.3
CN	31,744	60.4	9.8	29.7	-	208,172	75.7	7.9	16.3	-

¹2000 instead of 2001 and 2008 instead of 2011

Figure 12: Distribution of Gross Domestic Expenditure on R&D by implementing sectors¹²

**Intensity, Growth Rates and Absolute Number of Transnational Patent Applications
in High Technology in 2011**

	Absolute	Intensity	Intensity High Technology	Overall Growth in % (2001=100)	Growth of High Technology in % (2001=100)
GER	29,035	731	412	116	113
FR	11,028	428	253	128	136
GB	7,384	254	151	96	98
US	54,887	392	259	109	111
CN	18,496	24	17	1,701	2,098

Figure 13: Intensity, growth rates and absolute number of transnational patent applications¹³

¹² Own figure based on [EFI (2014)].

¹³ Own figure based on [EFI (2014)].

companies already invest in innovations in China as much as in Germany in terms of turnover. A range of foreign manufacturers shift their **research and development centers** to China and for this reason China is already an important research and development location. The R&D capacity building occurs for market-oriented reasons. The proximity to important market and customers is crucial factor. Cost benefits due to a reduction of labor costs are less significant although the percentage of personnel costs of the total R&D budget is relatively low at about 45 percent (compared to about 70 percent in Europe). Technology-orientated reasons play only a minor role in R&D efforts in China so far. At the beginning of their research activities, foreign companies installed only smaller R&D centers in which they only adapted products to local legislation and requirements. Nowadays, they have intensified their efforts in the area of research and development. They also **develop entire products for the Asian market in local development centers**. However, global research centers in which global R&D activities were implemented are not operated by international manufacturers. [Bielinski (2010)]

There are **several examples of research and development activities** in China, for example GM produces and develops engines together with its Chinese partner SAIC. In China and in cooperation with BAIC, Daimler maintains its only engine plant outside Germany including a development department. Audi opened a new R&D center in Beijing in 2013. In cooperation with its partner FAW-Volkswagen, Audi especially seeks to react to increasing requirements of Asian and especially Chinese customers. The number of developers rose from 40 to more than 300 originated by the new opening. They are employed in the fields of

engine, battery, electronics and vehicle body development. The design of Audi is also part of the new center. Designers are supposed to identify trends in Asia and share them with Germany, where the **global responsibility** for the Audi design remains. The foreign parent company of foreign manufacturers is mainly responsible for all processes of research and innovation in China. Foreign managers mainly decide about product and service innovations. [DAAD (2014)] [Automobilwoche (2013e)]

External collaborations of Chinese R&D locations still play a minor part in innovation in comparison to other countries but local partners such as Chinese universities and research facilities gain growing attention. However, it is advisable to rethink and **to rely more on local partners and research facilities**. **Chinese scientists and universities** steadily manage to improve the quality of their work. Therefore, automotive companies should rethink their research strategy and start collaborative research projects with higher education institutions. Figure 14 illustrates shares of all publications of 'Web of Science' in selected countries and regions. China in particular almost managed to triple its share from 3.9 to 11.6 percent from 2002 to 2012. The database "Web of Science" records publications in selected scientific journals and citations of those publications worldwide [EFI (2014)]. In addition, Figure 15 illustrates the distribution of scientific articles with different search terms of the database 'SCOPUS'. The abstract and citation database of peer-reviewed literature covers almost 53 million records, 21,915 journals as well as 5,000 international publishers and delivers the most comprehensive overview of the world's research output. [SCOPUS (2014)]

In general, the **Chinese research landscape** is very centralized in its lead. The Ministry of Science and Technology (MoST), the Chinese Academy of Sciences (CAS), and the Ministry of Education (MoE) are responsible for strategy and implementation. Research facilities such as **universities, research institutes and companies** are subordinate to them. CAS is the largest institution for research in natural sciences in China. Automotive companies maintain R&D collaborations with institutions of CAS. By national development plans, such as the **'211'-project** which was started in 1995, 112 universities were funded to become **first class universities** in China. Nowadays, about 70 percent of all master's degrees and 80 percent of all doctorates in China are taken at these 112 universities. The

'985project' particularly funds 39 selected universities of the "211"-project". They are the most heavily funded universities in China. Projects with automotive companies, especially foreign companies, have different characteristics and motives. As outlined in chapter 2.4, the demand for skilled employees is very high and the access to them is a bottleneck at present in China. **Collaborations with universities** are, therefore, a very good opportunity to find future employees. But the major aim of these collaborations remains the generation of new knowledge. One of the **main focuses of research** of all automotive companies in China is the development of alternative powertrains. To benefit from China's ambition to jump internal combustion engine technology and become a leader in electric-vehicle technology several companies have started developing R&D capacities in this field. In addition to collaborations with universities and research facilities, companies in the automobile sector develop more and more R&D projects **with their suppliers and customers**. [Bielinski (2010)] [DAAD (2014)]

Since success and future development of Chinese companies are **heavily dependent on research and development**, the government in Beijing actively promotes R&D in their country. In China, there is an **extensive system of tax deductions** for R&D efforts including tax exempt amount, perks as well as easier depreciation opportunities. In the current five-year plan the government seeks strategic alliances between companies, universities and research facilities out of which centers of innovation are supposed to grow with a prime international reputation. These centers are called **industrial parks and development zones**. Due to directives of Mao Zedong which were originally issued in the early 1950s, aggregation of certain

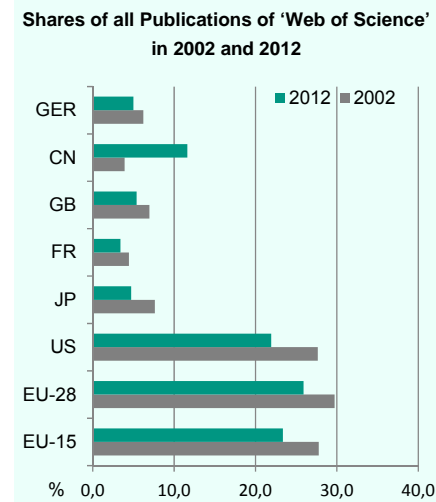


Figure 14: Shares of all publications of 'Web of Science' in selected countries and regions¹⁴

¹⁴ Own figure based on [EFI (2014)].

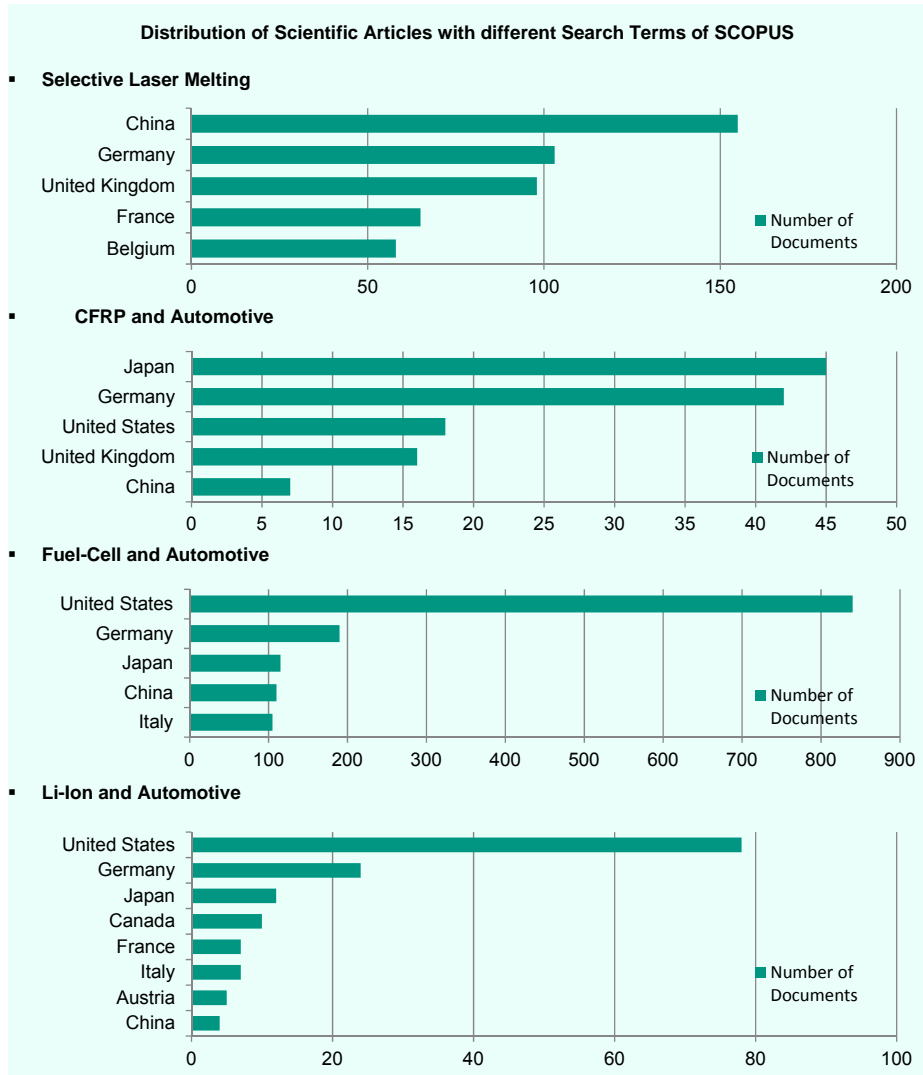


Figure 15: Distribution of scientific articles with different search terms of SCOPUS¹⁵

¹⁵ Own figure based on [SCOPUS (2014)].

industries to certain locations already began in China very early. Key industries should be better protected from any attacks during the Cold War. Nowadays, the areas are mostly provided with **good transportation access** and are planned for the **purpose of industrial development**. In China, industrial parks are operated at a national, provincial, and local level. They are established by the government with the aim to promote industrial and economic development. The attractive incentive packages differ from city to city and from the different operating levels. Today, China is the country with the **highest amount of industry parks** in the world and in recent years, cities such as Shanghai, Beijing, Changchun, Chongqing, Wuhan, and Xi'an and their major automotive production bases also established specialized automotive industry parks. Due to the long industrial chain in the automotive industry, the close proximity of suppliers within the automotive clusters is highly beneficial for each manufacturer. Since competition became tougher **automotive industry clusters** and close R&D collaboration within clusters have become an important way to improve the competitiveness. [Qianzhan Industry Research (2013)]

One well-known automotive cluster is Anting in Jiading District in Shanghai. It is called '**Shanghai International Auto City**', and it is one of the centers of the Chinese automotive industry. Anting is the home of the headquarters of Shanghai Automotive Industry Corporation (SAIC) and includes the German/Chinese joint venture: Shanghai Volkswagen Automotive. Starting with vehicles which were manufactured entirely out of imported parts, a cluster has developed with a **large number of Chinese and international parts suppliers**, automobile trade and marketing

"Technical innovation is lagging behind the rest of the world in maturity. The country is trying to get there as quickly as it can but doesn't have the deep graduate research capability that the rest of the world has."

Kevin Wale, former President and Managing Director of General Motors China, 2012. [McKinsey & Company (2012b)]

companies as well as automobile testing organizations. In addition to the existing automotive industry, the **Tongji University** established its own automotive engineering faculty nearby to research and to develop in collaboration with automotive companies as well as to train excellent engineers. Among its various departments, Tongji University in Shanghai is especially **highly ranked in engineering** and its automotive engineering department is also one of the best in in the People's Republic of China. [Bode (2009)]

Remarkable is the fact that almost all automotive manufacturers and also a number of major suppliers such as Robert Bosch GmbH or Continental AG have established **endowed professorships** at leading Chinese engineering universities to build up long-term cooperation. For example, the College for Graduate Study at Tongji University opened in 1998 and has 30 endowed chairs supported by over 20 international companies now. Volkswagen alone has set up three endowed chair at Tongji University in Shanghai. In 2000, the VW-Tongji Automotive Institute was founded and Volkswagen was the first manufacturer to launch a crash research project in China together with Tongji University in the year

2005. In addition, the ‘**Volkswagen Education Foundation**’ was set up in 2007 and was commended by the Chinese Ministry of Education for its practice-oriented higher education program. In 2011, both partners strengthened their collaboration and set up an endowed chair for human resource management to support the training of young scientists. The first two endowed chairs are engaged in vehicle technology research. [Volkswagen AG (2011)]

In an international comparison, most of Chinese companies invest **only a small percentage of their sales in R&D**. The Chinese automakers spend less than 2 percent of revenue on research and product development, or about half the global average, according to the China Association of Automobile Manufacturers (CAAM). In the past, Chinese manufacturers were often accused of just copying design and technology from other companies, but they increased their R&D efforts significantly in the 2000s. To distance themselves from these accusations they are expected to continue this trend in the future. Especially **independent manufacturers** have intensified their efforts in research. For instance, Chery increased significantly its investment in research and innovation since 2004. Chery expend more than seven percent of the total revenue in R&D in recent years. In addition to numerous R&D facilities, Geely operates three colleges and one university which is one of the few officially recognized private universities in China. The companies Brilliance and Build Your Dream (BYD) have established several research facilities as well. State-owned manufacturers such as SAIC and Dongfeng cooperate, especially with foreign automotive companies in the field of R&D. Together with its partner General Motors, SAIC maintains, for

example, the Pan Asia Technical Automotive Center in Shanghai to research on alternative drive systems and collaborates closely with the Jiao Tong University in Shanghai. [MunichInnovationGroup (2013)]

In general, **Chinese companies** such as SAIC, Dongfeng, Geely, and Brilliance will have to further **increase their spending** on research and development to close the gap to their foreign competitors, because technical innovations are still lagging behind the rest of the world in maturity. Despite the efforts in recent years, it will take some time until China belongs to the best around the globe in terms of research and development. But the Chinese have the money to proceed and to lift their automotive industry on the level of current global leaders. Thereby, **knowledge transfer by acquisitions** could play an increasingly potential part in the future. Most likely, the Chinese automotive industry will spend money until they make it work and end up with one or more globally perfected Chinese automotive manufacturers.

As an example, a description of selected universities and their R&D efforts in collaborations with foreign and Chinese automotive companies in China will follow.

The College of Automotive Engineering (CAE) of China’s renowned **Tongji University in Shanghai** was founded by the merger of the **Automotive Engineering Department, New Energy Center of Automotive Engineering** and the **College of Automobile Marketing and Management** in accordance with the requirements of the Shanghai International Auto City. The college has sophisticated research facilities including various testing tables for cars and spare parts, large scale

software for design and analysis as well as testing and trial production bases. Currently, a wind tunnel is under construction which is supposed to be unique in size and type in China. The College has been active in **research for the car industry** and has completed a number of state and local key research projects. [Tongji (2014)]

One of the main fields of research is **new clean technologies** receiving a massive funding from the government; this field of research is including the development of **plug-in hybrid and electric vehicles** (battery and fuel cells). The CAE maintains close **cooperation with several automotive manufacturers** besides VW such as Daimler and BMW. For example, Audi initiates a partnership with Tongji University with the foundation of the ‘**Audi Tongji Joint Lab**’ which aims to research in the field of electric mobility. The College also has conducted **extensive collaborative programs with several famous universities in the US and Germany**. In an intensive collaboration, named ‘**TU9 Electromobility**’ project, between German and Chinese universities, a group of German technical universities (TU9) and a group of Chinese technical universities, headed up by Tongji University, share the goal of making electric mobility a key component of future mobility concepts. Since 2010, the universities have started a range of joint research projects on electric mobility. Chinese Ministry of Science and Technology and the German Federal Ministry of Education and Research strongly support research in this area via strategically targeted measures and programs. The other Chinese partners are the **Huanzhong University of Science and Technology**, the **Tsinghua University** and the **Beijing Institute of Technology** which are collaborating with the

German **Karlsruhe Institute of Technology**, the **Technical University of Munich**, and the **Technical University of Berlin**. In addition to its research, the CAE offers a wide range of trainings for manufacturers of cars and spare parts. The **training center** enjoys an excellent reputation in the automotive industry, too. [Tongji (2014)] [TU9 Electromobility (2014)]

The **Beijing Institute of Technology** and its National Engineering Laboratory for Electric Vehicles is designed as the authorized **national test base for EV drive motors** in China. The laboratory was approved and established in 2009. Until now, it has successfully developed over 20 types of complete electric vehicles such as pure and hybrid electric sightseeing buses, fuel cell vehicles, and pure electric cars out of which ten types of complete car products has been listed in the national automotive product database. In addition, several key components and parts for electric vehicles come from the development of the laboratory. A special achievement of the university was that **50 pure electric buses** were used on four major routes in the Olympic village during the Beijing Olympic Games and Paralympic Games in 2008. [BIT (2014)]

Another example of a first class university is the **Tsinghua University in Beijing**. This research university may be compared to top universities in the United States. It is regarded by most domestic and international university rankings as **one of the top higher learning institutions in China**. The university laid the focus on engineering and it makes a significant contribution to the training of leading engineers and scientists in China today. The **Department of Automotive Engineering (DAE)** of Tsinghua University focuses on

automotive safety, energy efficiency, and environmental protection. The DAE maintains several R&D institutes, set up jointly with local governments and businesses including the State Key Laboratory of Automotive Safety and Energy Conservation. The DAE has extensive scientific **cooperation with many well-known domestic and foreign vehicle companies**, such as Volkswagen, General Motors, Toyota, and Ford. The **Tsinghua University Science Park (TusPark)** is an important factor in the cooperation between the university and the economy. The TusPark is a megalopolis for international companies. Of particular interest is the joint research and development with Toyota

Cooperation which has recently been extended for five years. [Tsinghua (2014)].

Furthermore, almost all technical universities in China have established several collaborations in different forms with Chinese and international automotive manufacturers. In particular, the universities in **automotive clusters** (see chapter 5) intensify their research and collaborations with automaker. In Shanghai, for instance, there is, in addition to the Tongji University, the **Shanghai Jiao Tong University of Technology** with its 'National Engineering Laboratory for Automotive Electronic Control Technology' or the **Fudan University** with its intensive cooperation with the

automotive supplier Bosch. Figure 16 illustrates an overview of top Chinese universities in mechanical engineering and further automotive-related universities in the year of 2012. [CUCAS (2012)]

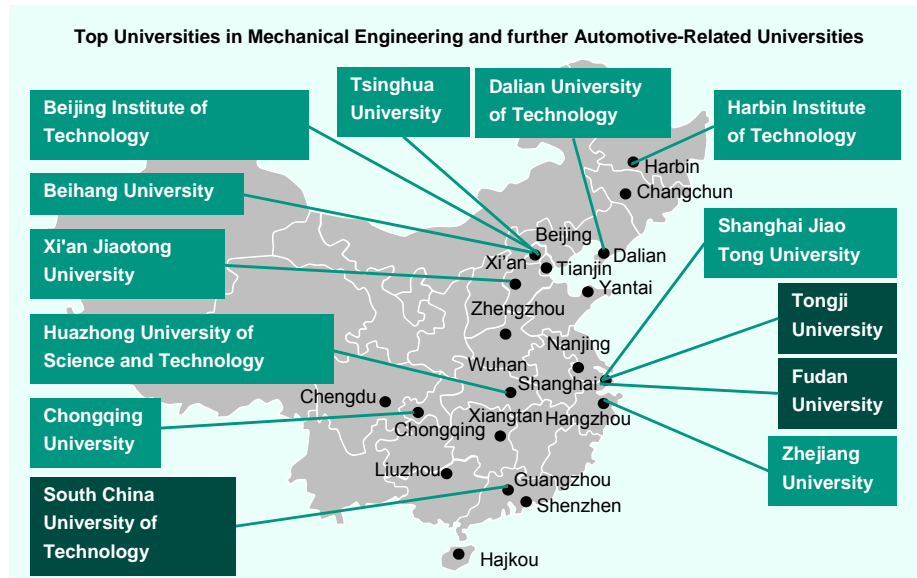


Figure 16: Top universities in mechanical engineering in 2012 and further automotive-related universities in China¹⁶

¹⁶ Own figure.

Development Focus Areas of the Automotive Sector

4.1 Comfort and Safety

Road traffic in China involves substantial risk potential. According to official figures of the Ministry of Public Security (MPS) in China, the number of deaths on the road amounted 75,572 in 2011. But unofficial sources expect more than 100,000 road deaths annually. There are probably several reasons for this. The rather insufficient driver training and the often times poor conditions of streets cause a substantial number of accidents. The serious consequences are usually due to a **lack of adequate vehicle safety parts and systems**. Rising vehicle population and the rapidly enlarged automobile market scale in China will enhance danger of traffic accidents and will bring more challenges to vehicle safety. In China, almost all technical vehicle standards were focused on the engine performance, while standards of vehicle safety had not been established before the turn of the millennium. On the first August in 2006, the initial **China-New Car Assessment Program (C-NCAP)** was established by China Automotive Technology & Research Center.

The United States has led the way in safety standards for vehicles and other well motorized countries followed the example in order to make vehicle safety more internationally comparable and to avoid trade issues. Since the C-NCAP was internationally feeble, stricter and more detailed guidelines were applied for the Chinese crash test in July 2012. The regulations of the new test were adapted to the Euro NCAP. The adjustments cover, among other things, a neck protection test under low-speed, an acceleration of the frontal crash from 56 km/h to 64 km/h which is **in line with international standard** and an inclusion of active safety programs, such as electronic stability control

(ESC). [China Car Times (2011)]

Safety issues have a long tradition in China and safety always happens to be the weakest point of Chinese automotive manufacturers. While vehicles developed by international manufacturers are usually able to get the highest rating from C-NCAP, the Chinese companies often fail domestic crash tests. In 2011, the midsize car Emgrand EC7 of Geely was only the fifth domestic car that received the highest crash test score after the introduction of the test in 2006. Therefore, it is essential for domestic automotive manufacturers to improve the safety technical performance of their vehicles. Especially Geely has ambitious safety aims for its vehicles. The company has also started to equip its home market models with safety technologies. For instance, it has installed a 360-degree panoramic imaging system in its Geagle GX7 SUV. Nowadays, **safety systems** are largely the domain of vehicles of the premium segment, but they are expected to trickle down to mainstream cars in emerging countries and almost every vehicle in developed countries as well. [Automotive News China (2011a)] [Zhou et al. (2013)]

Citizens of China put more emphasis on safety of vehicles and also on the vehicle collision test to assess risks. Especially consumers of the rising premium market are more aware of **active and passive safety systems**. According to [McKinsey (2013)] these consumers even rate safety as their gravest concern. Moreover, additional features on cars such as active and passive safety devices are becoming certainly more common due to rising incomes in China. The **growing awareness of safety** of Chinese citizens is also evident, among other things, from the fact that the Ministry of Public Security (MPS) seeks to make the use of child-

"The Chinese market for active safety systems will continue to grow in the coming years due to rising safety expectations as well as the growing taste for luxury vehicles in the still burgeoning vehicle market."

Dr. Zhao Fuquan, executive director of Geely Automobile Holdings Limited, 2012. [Zhou et al. (2013)]

safety seats in vehicles mandatory to reduce injuries and fatalities. International automakers are also helping to promote the use of child seats. VW donates 5,000 booster seats for children as the first step of a campaign and the company also will start to produce these seats in China. [Bloomberg (2013b)]

The increasing concern of safety and comfort to China's vehicles consumers will also be reflected by an increasing demand of electronic components. **China's automotive semiconductor market** is expected to grow by 11 percent to 4.6 billion USD in 2014. Especially microcontrollers and sensors that help improving the car safety and comfort are expected to grow significantly. According to a report from IHS Technology, the prognosticated revenue growth will reach 6.2 billion USD after three more years of a strong double-digit rise of the China automotive microchip market by 2017 (see Figure 17). Semiconductors are the **basis for vehicle safety and control applications** including advanced driver assistance systems (ADAS) (see chapter 4.1.1) and infotainment systems such as navigation equipment as well. [IHS Technology (2014)]



Crashtest

Foreign companies have a fundamental knowledge in solving problems of vehicle transportation. Despite the fact that China keeps getting better at making cars, the technical foundation of **Chinese companies** is still at a **lower technical level** and they still cut corners to success. Chinese manufacturers often simplify the design, use cheaper materials or back down on crash tests. Usually, Chinese manufacturers conduct about 70 crash tests and rely more on computer simulations to test active and passive safety systems during the development of their vehicles. In contrast, international manufacturers typically conduct about 125 to 150 crash tests for each new model and even more if the cars are sold in many different markets around the world. In China, there is no required minimum of crash tests. With this strategy, Geely could save at least 200 million RMB of development costs and also about two years of development time. The major aim is to sell cheap cars, which cost less than half of the comparable cars produced by the foreign competitors. These vehicles are a **compromise between acceptable quality and attractive price** and are becoming popular, especially in emerging markets. But due to the reduced development time and to the cheaper components and materials, the vehicles only fulfill **minimum standards of safety regulations**. This reflects a consideration strategy to just eliminate the major safety risks. [Automotive News (2012)]

Although the intensive development of electronic devices for the safety of vehicles such as EBD

(Electronic Brakeforce Distribution) or CAPS (Collaboration with Active and Passive Safety) has been specified in the 11th five-year plan, **limited importance** has been devoted to safety performance of vehicles by the government compared with efforts of energy conservation and the control of pollutant emission. Tightening C-NCAP regulations was of essential importance to stimulate automotive manufacturers to improve their safety technologies. **Development of vehicle safety technologies** entails large amounts of research and development as well as human capital. Independent R&D of these highly integrated technologies is extremely difficult for any individual company, especially for Chinese automotive companies or part manufacturers with relatively little technical knowledge. Therefore, several manufacturers have formed a number of **partnerships with key suppliers** in recent years to collaborate closely together in research and development centers. Similarly, collaborations with universities were established for the technology development and also technology transfer via acquisitions of automotive parts suppliers by

Chinese companies will play a more important role (see chapter 3). [Sun/Wang (2012)]

Therefore, the **automotive parts suppliers** are looking for a business growth story. Particularly vehicle safety parts and systems are strongly demanded in China. Similarly to vehicle manufacturers, automotive parts suppliers are **continuing their expansion in China**. However, not only production facilities are being built. R&D facilities in China are becoming more and more important. Therefore, suppliers also invest significantly in China. The Swedish-American company Autoliv Inc. has just built a textile factory and R&D center in Shanghai to support the growth of its Asian airbag business. In 2013, the German supplier Bosch opened a new testing ground in Donhai in east China. The facility allows testing of the company's antilock brakes, electronic stability control systems, as well as its driver assistance systems. In order to be successful in the long term, **innovations on site are essential**. The main aim is to win more and more Chinese manufacturers as customers and to stay ahead of the competition

through technical know-how and further technical innovations from upcoming Chinese competitors. [Bratzel et al. (2011)]

On example of a **newcomer of Chinese suppliers** can be observed at the tire market. Yet, the position of the established brands is unchallenged in holding the lead position in international comparison. The market share of the five largest tire brands Bridgestone (Japan), Michelin (France), Goodyear (USA), Continental (Germany) and Pirelli (Italy) is approximately more than 50 percent worldwide. Particularly, they are well represented in the premium segment, but in terms of medium sized and compact cars, competitors based in growing economies gain market shares rapidly due to their **aggressive pricing**. Therefore, pressure put on the market leaders is constantly increasing. Until now, cheaper tires manufacturers cannot keep pace with major tire producers in terms of quality. For example, they have a significantly inferior handling in curves, a longer braking distance and a lower riding comfort. However, with **fast-growing home markets** so far largely unknown Chinese manufacturers such as Hangzhou, for example, features a very good basis for growth in the future. Current leading tire manufacturers cannot afford to rely on their lead they have gained in the past. Because the safety performance of a vehicle is knowledge and technology intensive, the same applies to all other vehicle safety parts. [Wirtschaftswoche (2014b)]

the vehicle. In technical terms, ADAS systems consist of **sensors that detect the surrounding environment** of the vehicle, **computer systems that process and analyze the data** collected by sensors and **systems that implement or share** the analysis of the computers. Cameras, radar systems, and ultrasonic are examples for sensors. The implementation may occur in the form of displays that inform the driver or even actuators that directly intervene in the steering systems and brakes. Modern cars have a variety of such electronic systems, especially premium and medium-sized cars produced by international manufacturers. But in recent years, ADAS systems are **becoming increasingly common with Chinese manufacturers**. Such systems are very cost-intensive because of the large number of sensors and high-tech computer systems as well as numerous connections between the systems whose developments are very complex. [Planing (2013)]

In recent years, ADAS had a great success in **Western markets**. Already in the year of 2007, about 88 percent of all new vehicles produced in Europe at least featured an anti-lock braking system (ABS) on board and 50 percent of the new vehicles produced in Europe were equipped with electronic stability control (ESC). In comparison, only 64 and 6 percent of new vehicles were equipped with ABS and ESC respectively in China. But due to the prosperity of the Chinese automotive industry and the demand for more vehicle safety, a **tremendous expansion is foreseeable**. However, when implementing ADAS to the vehicles in China, the manufacturers adapt these systems to regional conditions and customers preferences. Not only the technical adoption, but also the adoption of the driver's behavior and traffic situation in China must

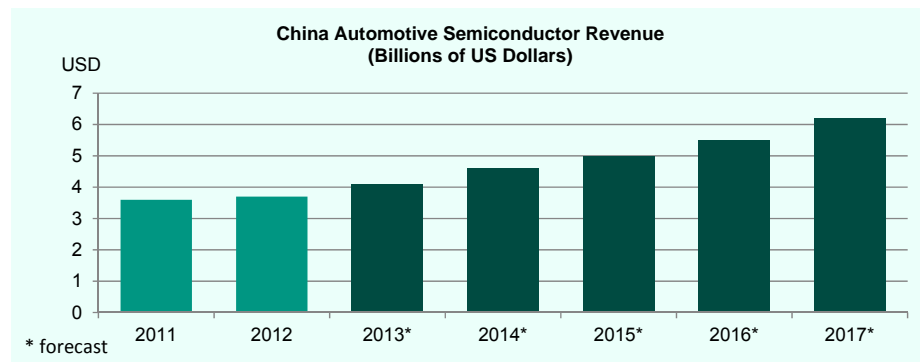


Figure 17: Development of China's automotive semiconductor revenue¹⁷

¹⁷ Own figure based on [IHS Technology (2014)].

4.1.1 Advanced Driver Assistance Systems

Rising desire amongst Chinese vehicle customers for safety features also relates to advanced driver assistance systems (ADAS). The aim of these systems is to **directly support the driver or even**

be taken into consideration. The already existing ADAS are generally based on the needs of drivers in Western countries, but in China more **chaotic traffic situations and a more unconventional driving culture prevails**. The driving environment is more complicated with more kinds of road participants and infrastructural issues. An unexpected traffic situation may happen more often. Besides, the Chinese drivers feature worse driving habits compared to western drivers and less understanding of and respect for road and safety regulations. In China, drivers often change the lanes or drive even in between two lanes which can trigger the warning of Lane departure warning (LDW) too much. In addition, in most of the roads, especially in non-urban regions, the streets do not have lanes on the streets at all. Therefore, the use of LDW would maybe not be feasible in China. Moreover, the warning design concept of Western countries needs to be adapted. Due to the different traffic situation in China, the warning systems could tend to overreact. If the same system would be applied, drivers would most likely be frequently warned which might be annoying rather than informative. [Duan/Chen (2011)] [Duan/Chen (2011)]

In general, **advanced driver assistance systems are driven technologically** that means that new features are implemented when they are technical feasible rather than because they are absolutely required. Up to now, this pertains especially to more mature markets. China has a lot of catching-up activities ahead which they will most likely master in the upcoming years. According to a report by IHS Automotive, the **market for ADAS** in China is forecasted to grow to a value of 3.1 billion USD by 2019, up from 971 million USD in 2013. The total market revenue will triple in six years and

growth rates will mostly be around 20 percent during the initial years and will moderate to around 13 percent in the last years of the forecast (see Figure 18). IHS refers to the growing awareness of driving safety among both vehicle manufacturers and consumers. In particular, regulations and C-NCAP assessments drive the development of ADAS at the manufacturers in China. Even so the overall market is expected to expand tremendously, not all systems will experience strong growth in the near future. In addition to the unique driving behavior, IHS Automotive states that the key reasons for the poor implementation rate are **low consumer acceptance and high product costs**. Systems such as night vision, intelligent speed adaption, and driver monitoring will encounter a slower market. In contrast, blind spot detection (BSD) self-parking systems are expected to be the most successful ones. Self-parking systems support the drivers in the form of measuring parking spaces and taking of steering. In 2012, only one percent of all new vehicles in China were equipped with this system, but the self-driving system is expected to increase to 8 percent in 2019. BSD aids the driver by warning when there are other vehicles in the blind spot of the side-view mirrors which might not be seen by the driver. Resulting from overwhelmed cities and roads, Chinese drivers change lanes frequently to gain an advantage over others. Therefore, BSD is quite advantageous and practical for a Chinese driving environment, especially for young, inexperienced drivers. The IHS report forecasts that the rate of equipment will increase quickly to 9 percent by 2019, up from just 1 percent in 2013 which means that a total quantity of around 2.2 million passenger vehicles sold were equipped with BSD over these years. In China, the demand of **cheaper and more basic safety systems** such as tire-pressure

monitoring system (TPMS) or electronic stability control (ESC) that are not usually considered as part of ADAS will strongly increase and quickly reach the equipment rate of 100 percent, up from current low single-digit rates. [IHS Technology (2013)]

Nowadays, almost all advanced driver assistance system products **are imported into China**. Either imported cars are already equipped with ADAS or imported systems are installed in vehicles produced in China. Because of the very low installation rate of ADAS in China and because of very low transportation costs overall compared with the cost of ADAS products production activities on site were not profitable in an economic context. In the coming years, the major part of all ADAS products will still be imported into China. However, **some system manufacturers are expected to transfer production facilities to China** due to the huge expected increase in sales in the Chinese market. The most extreme version of ADAS is autonomous driving. A self-driving car evolves from several driver assistance technologies.

Autonomous Driving

Within the meaning of advanced driver assistance systems, the term ‘autonomy’ is understood to mean the ability of a vehicle to act correctly in road traffic **without any intervention by the driver**. Fully automated vehicles are able to navigate through traffic without any human interaction. In a **reduced form** of partially automated vehicles, the driver’s only tasks are to monitor systems and to intervene in particular situations, which are not in control by the systems. A large number of vehicle manufacturer have already announced to **market autonomous vehicles by the year 2020**. Looking at the increasing pace of development in recent years, this scenario seems plausible. In 2010, it became also known that Google has recorded more than 200,000 kilometers on busy roads and has reached more than 1,500 kilometers without human intervention in its ‘Self-Driving Car’- project. And in 2013, many companies have demonstrated **prototypes** of autonomous vehicles and have announced intentions to bring more and more features into the market. A hardly practical idea became strategic vision of tomorrow’s mobility. At

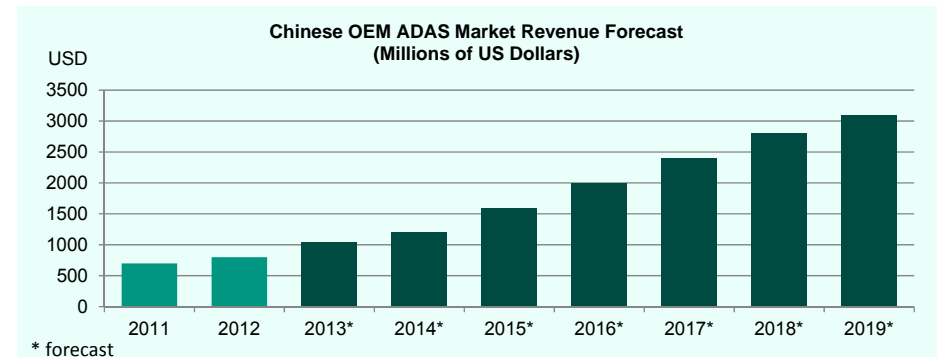


Figure 18: Chinese OEM ADAS market revenue forecast¹⁸

¹⁸ Own figure based on [IHS Technology (2013)].

the end of the year 2013, Volvo has announced a project to deploy 100 highly autonomous cars on selected roads in the Swedish city of Gothenburg by 2017. The cars will be able to handle most of the traffic situation without any driver interaction, but in certain traffic situation the car may have to return control to the driver. **Volvo aims to be one of the leaders** in the autonomous area. However, cars which can be used only in a small selected area do not suffice to realize significant growth. But in **cooperation with the Chinese manufacturer Geely**, Volvo is in an ideal position to introduce the new technology. Smaller and probably even electric vehicles for urban and pollution free mobility would perfectly fit to China's mobility requirement. Around the year 2020, the company seeks to realize the market introduction of its completely automated vehicles. Highly autonomous vehicles may need little human input, while completely autonomous cars need absolutely no human interactions. [n-tv (2013)] [Winner/Weitzel (2012)]

China also seems to be moving ahead with the technology of self-driving cars. The National Nature Science Foundation organizes an annual Chinese driverless vehicle competition, called '**Future Challenge of Intelligent Vehicles**', since 2008. The vehicles in the competition are designed primarily by Chinese universities and are equipped with foreign know-how. In 2013, a self-driving car, called '**Fierce Lion 3**' and developed by Military Transportation University (MTU) of the People's Liberation Army (PLA), is supposed to complete a 114-kilometer journey and without any human instructions within 85 minutes, with a top speed of 105 kilometers per hour. During the journey, the car is said to complete several maneuvers on the freeway, including cruising in one lane, following

traffic, changing lanes, passing slower traffic for 33 times and refraining from making a pass because of safety concerns several times. However, the final evidence is still lacking. The 'Fierce Lion 3' seems to be China's first unmanned vehicle to pass a freeway test but in comparison, **Chinese vehicles manufacturers are in the initial stage** of self-driving cars. Similarly to the overall ADAS area, **international companies are the technological leaders**. The two major state-owned Chinese automakers, SAIC and BAIC have started the development of self-driving cars just in the second half of the year 2013. SAIC signed collaboration with research institute of CHINA Aerospace Science and Industry Corporation to jointly research on and develop self-driving cars. BAIC signed collaboration with two state-owned research institutes, named China Academy of Sciences and China Academy of Engineering. Build Your Dream (BYD) also started to collaborate with Singapore's largest infocomm research institute, the Institute for Infocomm Research (I2R), in a joint laboratory to develop electric vehicles with autonomous vehicle sensors. [Welt (2013b)]

In total, the idea of self-driving cars appears ever closer on the technological horizon. However, it must not be forgotten that the approval for use on public roads is the critical path along the road to launch a new vehicle. Besides the technical part, there are **a lot of legal issues** which need to be clarified before the market entry will take place. The crucial question is who is responsible in the case of an accident. The manufacturers have built the car, the software developers have created the smart tech inside and actually the driver was not driving. In this respect, the autonomous technology requires not just the collaboration of vehicles manufacturers and technology providers but also

the **willingness of cities and governments**. Once again, the government could play a decisive role in this area. Self-driving cars, which are able to increase road safety, ease traffic congestions and minimize CO2 emissions, could be especially beneficial for China's mega cities such as Shanghai, Beijing, and Chongqing.

4.1.2 Connectivity and Intermodality

Due to urbanization and growth, especially in the big metropolises of China, congestion, smog and crowded public transport become a serious issue. The need for **new mobility concepts** in both individual and public transport sector increases. Two of such concepts in the automotive industry are **connected cars and intermodality**. In the future, cars are able to communicate via the internet to every object featuring an IP address. New mobility concepts such as car sharing aim to complement existing public transport system by providing short-term access to public vehicles.

Connectivity

In the first quarter of 2013, 71 million smart phones were sold in China. Compared to global sales of 210 million smart phones, this is a share of about 34 percent. Hence, the country represents the **largest sales markets**, both for automotive vehicles and for smart phones. What could be more practical than combining the two future growth drivers and to implement the smart use of mobile services into a vehicle? Mainly **telematics systems** play a decisive role in the future, which combine telecommunication and information to provide internet based services before, during and after driving. [na presseportal (2013)]

The **global connected car market** will be worth 39

billion Euros in 2018 up from 13 billion Euros in the year 2012, according to the research company SBD and the GSM Association (GSMA) which represents the interests of mobile operators worldwide. Currently, the world's largest automotive market still ranks fourth with about three million cars in 2013, after the USA, Japan and Europe, among the markets with the highest rate of connected cars. According to a study by Oliver Wyman, the number of connected new cars on China's streets will rise to 68 million. Therefore, China will feature the second largest market after the USA with about 82 million by 2018. This means that 58 percent of new vehicles in China would be connected cars. In comparison to Japan with 89 percent, North America with 87 percent and Western Europe with 78 percent, **China still has a great potential for growth**. Telematics is still a young market in China. In China, navigation is a key application in the automotive industry. OEMs compete intensively with the automotive aftermarket. The aftermarket segment for navigation systems has already a remarkable size in China providing buyers the option to update or replace the navigation equipment in their vehicles after purchase. However, **infotainment, fleet management, remote maintenance and safety embedded telematics** are a system in which the connectivity and the computer system are embedded into the car. An example is GM's OnStar system. Tethering systems, such as Mercedes Command, rely on a computer system embedded into the car, but use the smart phone of the driver for connectivity. [GSMA (2013a)] [na presseportal (2013)]

Because of the great potential, all car manufacturers and suppliers worldwide are working feverishly on vehicle connectivity. China's desire

for electric mobility is also one of the drivers for connectivity. Telematics systems are needed in EVs to locate the nearest charging station, to find out if charging stations are available or to receive real-time traffic information that may affect cruising range. Companies such as BYD, Dongfeng or Chang'an have **already introduced telematics systems** in 2011 and push the issue since that time. Local telecommunications companies play a very important role in the development of new systems. SAIC, FAW, and Geely, for example, collaborate with China Unicom; Chang'an collaborates with China Mobile. Chery has built a laboratory with South Korea's SK Telecom Corporation which entered China in 2000, to develop a telematics system for Chery's vehicles. Accordingly, the government has also plans and provides financial support for the development of connected cars as well as it drives forward the expansion of existing infrastructure within the framework of the project 'Internet of Things'. Telecommunication standards LTE and 3G that are absolutely essential have to be available throughout the country. Yet, the **big cities show a nearly Western standard**, but the network coverage in the west of the country is more like in developing countries. The government will spend more than tens of billions of USD at the first stage and will roll out policies that would unite efforts from companies on the whole value chain such as automotive suppliers, chipset makers, wireless carriers, and software providers. [IHS iSuppli Corporation (2011)]

For established manufacturers, **collaborations with local companies are the key to success**. This is the way to offer their systems to Chinese customers. In all relevant segments, strong local companies exist. Especially in the mobile and

online business, there is **no alternative to collaboration with a Chinese partner**. There is no chance for existing well-running collaborations with international enterprises in China [na presseportal (2013)]. For example, BMW, Audi, Ford, GM, and Toyota maintain collaborations worldwide with Google relating the subject connected cars. But in China, the local Baidu search engine is market leader and, therefore, several international collaborations are irrelevant. GM and Toyota are two of the pioneers in the Chinese market. Since the year 2009, both manufacturers have already implemented their telematics systems OnStar and G-Book. GM collaborates with SAIC and Toyota collaborates with Baidu, respectively. GM's OnStar provides turn-by-turn navigation, roadside assistance, hands-free calling, emergency response, and several other services. Worldwide, the system has 6.7 million subscribers. In January 2014, GM announced that the network in China increased by 40% within one year to 700,000 users. Moreover, OnStar is in discussions with China Telecom to offer LTE service in China [Automotive News China (2014g)]. In 2012, BMW followed with its ConnectedDrive system. The system is installed in BMW's 5 and 7 Series cars and the company collaborates with China Unicom and Baidu. Audi's AudiConnect and Ford's SYNC make the first steps in China. [na presseportal (2013)]

In addition, vehicle manufacturers maintain laboratories to develop applications that are especially tailored to the **particular needs in the Chinese market**. There is a specific market environment with different cultures and even different languages within the country. It is essential for Western OEMs to establish a local partner network. Figure 19 illustrates examples of

telematics brands of different manufacturers.

Intermodality

Basic requirements for intermodal transport systems are **high-performance public transport networks, high availability of alternative mobility solutions and vehicles** as well as an **efficient and innovative information and communication technology**. Particularly in Western countries in which those structures are available changes in mobility patterns can be observed. Local governments see them as convenient ways to reduce parking needs in the city centers and improve overall transportation efficiency. Among the providers of new concepts, there is also a variety of vehicle manufacturers which seek to gain experiences with new business

Manufacturer	Telematics Brand
SAIC Motor	inKanet, iVoka
Shanghai GM	OnStar, VoiceLink, E-Motion
BMW	ConnectedDrive
Audi	AudiConnect
Honda	HondaLink
Nissan	Carwings Zhixing+
Toyota	G-Book
FAW	D-Partner
Chang'an	In Call
BYD	i-System
Geely	G-Netlink
Ford	SYNC, MyFord Touch™
BAIC	Tima Star
Qoros	Qoros Qloud

Figure 19: Examples of telematics brands and their connection to car manufacturers ¹⁹

models providing their own fleets of vehicles. **New mobility concepts are still very new in China**, but they feature good opportunities to succeed. The desire for mobility is very high and many Chinese customers have unsuccessfully participated in big cities' license lottery, are tired of waiting for the bus or the metro and peaks they are not able to hail a taxi in the morning. **Car sharing concepts** aim to complement the existing public transport system by providing on demand and short-term access to public vehicles. It intends to reduce the car population in a city to prevent congestion and reduce pollution. There are two different car sharing models: The station-based model, which requires returning the cars to a designated station and the free-floating model which allows users to pick the car up and leave it wherever they want to within a specific car sharing zone. [Progenium (2013)]

During the World Expo in 2010, Shanghai seeks to adopt the car sharing model used in Bremen, Germany. In practice, the car leasing company Shanghai Dazhong has attempted to copy the concept of Bremen, although without much success. The biggest problem is that **local governments** do not promote it, so far. They are not willing to provide central parking spaces for vehicles and to come up with detailed regulations clarifying liabilities in case of an accident. Local governments tend to further develop **public transportation and the expansion of subways** to reduce emissions, congestions, and other downsides of transportation. Furthermore, the bans which prohibit the use of vehicles on certain days in big cities such as Beijing would also apply to car sharing vehicles, if a license exists at all. Thus, an adequate profitability of car sharing could not be achieved. Furthermore, there is still the Chinese

¹⁹ Own figure based on [GSMA (2013b)].

mentality in which an own car is an important status symbol and, therefore, most Chinese aspire to have their own car. For example, the Hangzhou Chery Intelligence Company in the provincial capital of Zhejiang is one of very few companies providing car sharing. [China Daily (2014a)]

In China, **car sharing** was made popular by the 2008 Olympic Games in Beijing. In order to reduce the air pollution in the city, the government limited number of cars on the road. Since then, people started to organize themselves to travel to a similar destination and more and more online forums have been established. Especially during the Spring Festival holiday, it becomes increasingly popular. However, this upcoming type of shared cars is called **carpooling**. Carpooling was once illegal in Beijing and still it is in many Chinese cities. Passenger safety and the rampant use of illegal taxis, called black taxis, are still areas of concerns. [China Daily (2014a)]

In total, vehicle manufacturers could benefit from high demand and could use car sharing to introduce consumers to new technologies such as pure electric vehicles. Moreover, station-based models could help implementing a large number of charging stations in cities. Mostly, car sharing trips are short city trips which would **perfectly suit to EVs**. Currently, there are some nascent car sharing programs, however, car sharing is still at an initial stage in China and no vehicle manufacturer heavily invests in larger car sharing projects. They just aim to have some small demo fleets of electric vehicles within a few years. There are **still too many open questions**. That is probably the reason why Daimler starts a totally new business model in China and invests in luxury travels including limousine rentals now. [Daimler (2014)]

4.2 Sustainability

The rapidly growing Chinese automotive industry and a higher level of motorization of the Chinese population will have enormous effects on China itself but also on the world as a whole. In particular the subjects **environmental and climate protection** as well as the issue of **energy security** are playing a key role in China. While global impacts of the Chinese mass motorization will become relevant, the local consequences are already clearly visible. Especially big megacities such as Beijing or Shanghai which have a dense and constantly growing population are struggling with the consequences of mass motorization. Although the motor vehicles are generally not the largest source of **air pollution in China**, pollutant emissions of the traffic are playing a disproportionately large role, especially in the larger cities. Other sources of pollution feature larger shares such as industry, particularly the energy generation industry, and households. According to a study conducted by the government in Beijing in 2014, in which the air quality of 74 cities has been analyzed almost all cities have exceeded the maximum values determined by the government. 71 of the analyzed cities are facing pollution problems. Therefore, Wu Xiaoqing, Vice Director of the National Environmental Protection Agency of China, announced that the Chinese parliament is currently working on further laws and regulations aiming to **improve the environmental protection** in China. [Spiegel (2014)]

So far, the government in Beijing has installed an extensive body of **regulations and policies** regarding energy efficiency. Together with continuous advances in technology and activities by the industry sector, these regulations and

policies are expected to yield substantial improvements to China's energy efficiency and cause significant reduction in greenhouse gases. In particular, policy **initiatives to promote** electric mobility play a significant role in the government's plans and are part of the 12th five-year plan. The current five-year plan has ambitious aims regarding energy efficiency and sustainability as well.

According to the 'Brundtland Report' report of the United Nations in 1987, the definition of environmental sustainability states that it is supposed to ensure that the current economic and social activities do not exploit the existing natural resources to the effect that it will have a disproportionate impact on the development of future generations. **Pressures on the ecosystem** are, among other things, the pollution of air, water and land, the contribution to global warming, and the loss of biodiversity. In addition to the development of alternative drives, the automotive industry intends increasingly to use sustainable raw materials and to develop new lightweight materials to reduce the vehicles weight and, therefore, to reduce fuel consumption as well as emissions. [Peters et al. (2012)][United Nations (1987)]

4.2.1 Development of Alternative Drives

All manufacturers worldwide have the same goal to reduce carbon dioxide emissions. However, the implementation differs from manufacturer to manufacturer. No matter if Chinese or foreign, **all manufacturers are investing a large amount in new, ecofriendly, alternative drive technologies**. However, the important question is which is the most promising technology of the future - fuel cell or battery? On the one hand, there is the world's largest manufacturer Toyota which is one of the



Air Pollution over Shanghai

promoters of fuel cells. On the other hand, the German auto giant Volkswagen sees the future in battery electric vehicles. The two concepts are polarizing the whole industry and the world's largest auto market, China, is able to be the key battleground according to experts of the industry. [Automotive News China (2013e)] [Handelsblatt (2014c)]

China seems to be favorably positioned to become the world's largest electric vehicle market, as the country is endowed with large deposits of lithium and rare earth metals needed for the production of batteries and electric engines. Furthermore, Chinese companies have strong experience in consumer battery and the government provides strong support in this field. The emphasis on alternative-fuel vehicle comes as **Beijing ramps up a program** to put 5 million new energy vehicles which are defined as all-electric battery vehicles and plug-in hybrids on the road by 2020. A **new round of subsidies** announced recently by the central government expanded the definition of new-energy cars to include fuel-cell cars as well. However, **the main focus in China remains on battery electric vehicles**. Nissan, for example, plans to sell a fuel-cell car in Japan and North America starting in the year 2017, but such as Volkswagen and other vehicle manufacturers, sees battery electric technology as the future in China and plans to start selling a locally developed battery electric car in China under its Venucia brand. [Automotive News China (2013e)]

In 2010, China's central government introduced generous **sales subsidies** for locally produced EVs and plug-in hybrids. The central government also has instructed state-owned electric utilities and oil companies to build charging stations which are urgently needed. However, the breakthrough of electric mobility in China has not been achieved so far. Symbolic for this is that sales volumes are still very low, although several carmakers have begun to market and sell such vehicles, under the existing subsidies. In total, **only 14,604 EVs and 3,038 plug-in hybrids were sold in China in 2013**, according to the China Association of Automobile Manufacturers (CAAM). Additionally, one of China's largest power grid operators, State Grid Corp. of China, is supposed to build 4,000 battery charging stations by 2015. But by the end of 2013, it has only constructed 400 stations. [Automotive News China (2014k)]

Until now, the Chinese market for alternative-fuel vehicles has been highly fragmented because of strong local protectionism. Municipal governments have steered the subsidies to **hometown automakers**, effectively freezing out competitors from other regions. For instance, Beijing's municipal government, yet, has excluded plug-in hybrids from its list of eligible vehicles because the city wanted to ensure that BAIC which only produces electric cars, receives as much of the subsidies as possible according to Yang Jian, managing editor of 'Automotive News China' [Automotive News China (2014k)]. In recent months, electric vehicle sales began to increase after municipal governments allowed automakers from other cities to apply for subsidies for electric vehicles and plug-in hybrids. Cities such as Beijing, Shanghai and Tianjin have liberalized their subsidy policies after the central government had urged

them to stop **local protectionism**. [Automotive News China (2014k)]

On a global scale, international manufacturers are placing their highest amounts of investments in improving the traditional combustion engine instead of alternative drives by 2019. According to a study by KPMG, three out of four European, American, and Japanese manufacturers plan to invest the largest proportion of powertrain resources into **internal combustion engine (ICE) optimization**. EV and plug-in hybrid vehicles are only playing a minor role. KPMG has surveyed 200 automotive executives including vehicle manufacturers, suppliers, dealers, and service providers. Nevertheless, the situation is different in China. Only every third Chinese manufacturer concentrates on diesel and gasoline engines. Main reason for this are requirements issued by the Chinese government which continues to push the introduction of clean energy-efficient vehicles and requires, amongst others, foreign automakers to develop **new EV brands for their local Chinese joint ventures**. [Handelsblatt (2014b)] [KPMG (2014)]

Therefore, several international manufacturers have established new EV brands, especially developed for the Chinese market. In particular, **Daimler** has developed and introduced a **promising all-electric vehicle** with **BYD** at the Beijing Auto Show in April 2014. The **Denza** EV will be launched on the China car market early in the second half of 2014 and will have an operating range of around 300 km. The price of the compact sedan is supposed to be 43,300 Euros (370,000 RMB). It is eligible for government subsidies that vary from 111,000 RMB to 117,000 RMB in six cities: Shenzhen, Shanghai, Beijing, Guangzhou,

Hangzhou and Tianjin. Consequently, the price for customers will be around 30,000 Euros. Experts have expected a much higher price; however, it is a lot of money in a country in which an average car such as the VW Jetta only costs about 8,000 Euros. [Automotive News China (2014i)] [Handelsblatt (2014b)]

Additionally, **BMW's Chinese joint venture** has unveiled a new brand, called **Zinoro**. The full-electric vehicle is based on the BMW X1 and the car is going into limited production and will only be available to private and institutional customers through a **leasing arrangement** from two initial stores in Shanghai and Beijing. The idea is to use this first vehicle as a way to introduce the EV concept to the market, build the brand and drive future demand. Other examples are **Kaili and Tantus** which **Volkswagen** has jointly developed with its **joint venture partners FAW and SAIC**. The market launch was planned for 2014, but it is currently stopped due to a lack of demand and charging stations. [FAZ (2013c)]

The **US automaker Tesla**, pioneer in electric mobility, has also introduced its electric vehicle Tesla model S at the Beijing Auto Show. In comparison to the other EVs, Tesla targets more wealthy buyers and sells its model at a price of 86.000 Euros. The company expects that China will become the largest market for Tesla. Therefore, it plans to invest about hundreds of millions of dollars in **charging infrastructure**. Tesla hopes to collaborate with China's two major network operators, State Grid Corp. of China and China Southern Power Grid, to build a sufficient infrastructure for its customers. However, Tesla is still unlikely to produce vehicles in China, although local production would enable the company to

"Highest priority is given to plug-in hybrids."

Prof. Jochem Heizmann, Chief Executive Officer and President of Volkswagen Group China, 2014. [Börsen-Zeitung (2014)]

avoid import duties and become eligible to the Chinese government's vehicle subsidies. [Automotive News China (2014j)]

Chinese carmakers are also making progress in developing their own new-energy vehicles. But the hopes of the Chinese government that they would jump western carmakers are fading. According to Fang Jianhua, general manager of Hefei Guoxuan High-tech Power Energy Co., Ltd. several top manager of Chinese state-owned vehicle manufacturers are pressurized to pursue growth and are, therefore, attracted to the higher sales and profits generated by **conventional vehicles**. [China Daily (2014c)]

As seen at the Beijing Auto Show in April, **plug-in hybrid vehicles gain in importance** in China. Chinese and foreign manufacturers announced to launch several plug-in hybrid vehicles to the Chinese market. Based on the number of new energy vehicles that will be launched in the near future in China, plug-in hybrids soar in popularity. **Various manufacturers announced to launch additional plug-in hybrid models** over the next years. For instance, BYD plans to introduce two additional plug-in hybrid models by 2016 after unveiling the Tang plug-in hybrid. Although BYD is the largest EV producer in China, at the Beijing auto show, the company displayed only one new EV, the Denza. Chinese market leader Volkswagen

plans to introduce ten electric and plug-in hybrid models in China by 2018 to strengthen its market position. The majority is plug-in hybrids and will be imported from Germany so far. Only two of those planned models will be battery electric vehicles. The company will begin local production of plug-in hybrids in the year 2016. Volvo and its Chinese partner Geely each launched a plug-in hybrid concept car. Production of both vehicles is scheduled to start in China in 2015. [Börsen-Zeitung (2014)]

Generally, **it remains doubtful** whether the electric vehicles will find a receptive market. There are still problems which have to be solved. One major problem is still the **lack of charging infrastructure**. In China's bustling cities, public charging stations for EVs and hydrogen fuel stations are still rare sights. A large share of China's urban population lives in giant tower buildings, whereby the connection between car and charger socket is hard to realize. The Chinese customers are still waiting for the planned remedy of large covered car parks with charging stations. Furthermore, the **price tag of EVs** remained significantly higher compared to conventional vehicles. At the same time, **key performance parameters** such as range do not match similar models powered by internal combustion engines. In total, probably not only economic indicators were relevant in the development and introduction of the electric vehicles but also political indicators. The development of all-electrical vehicles is very welcomed by the Chinese government.

In contrast to cars, **EVs have already been successful in the sphere of public transit buses**. In 2012, the government has urged all large and mid-sized cities to adapt vehicles with

alternative drives into their fleets. Especially **BYD** operates successfully with its 'Green City Solution' program in which the company has organized test drives and has even won tentative procurement agreements with several European and South American cities (see chapter 2.2). [BYD (2014)]

4.2.2 Development of New Lightweight Materials

In addition to improving the powertrain system, **lightweight** technology may also be able to improve energy efficiency. Due to new materials such as advanced steels, Al, Mg, Ti, and plastics, e.g. carbon fiber (CFRP), vehicles become lighter, which improves fuel-efficiency and agility. Worldwide, the market for lightweight vehicle body manufacturing is supposed to grow by an average of around 15 percent annually according to a study by the consultancy Berylls Strategy Advisors. The market is forecasted to increase fivefold by the year 2025 to about 100 billion Euros (see Figure 20). High-strength and ultrahigh-strength steels are supposed to be the **major material of the future** with a market share of around 45 percent according to the study. Conventional steel will be replaced accordingly. [Brüninglinghaus (2013)]

Even though the arguments of sustainability and environmental friendliness plead for lightweight vehicles, lightweight automotive construction has also to be profitable and must not compromise safety. Therefore, there will be standard **lightweight concepts** which are expected to match the certain vehicle segments in the medium term. **The lightweight construction technologies diffuse downwards** usually starting from the upper segments. Actually, the term lightweight concepts for vehicles includes all vehicle systems with

significant weight. But generally, the vehicle body is at the forefront because it is the dominant part with 35 to 40 percent of the vehicle weight in total. Besides the conventional vehicle body of steel, the first concept might be a vehicle body of around 60 percent of **high-strength and some ultrahigh-strength steels**. This concept is mainly used for small and cheaper vehicles. The next stage of concepts might be a steel intense multimaterial lightweight construction which is characterized by gradual addition of **aluminum or magnesium**. The increasingly usage of more expensive materials than conventional steel is used for mid-range cars. Then, the subsequent concept would be an aluminum intense multimaterial mix which is, for example, used in the current premium model S-Class of Daimler. In addition to aluminum, high-

strength and ultrahigh- strength steels are used. Further elements of a next concept could be plastics, magnesium, and **fiber- reinforced plastics such as glas- or carbon-fiber reinforced plastics**. This ultra-light construction will become a field for experimentation for the luxury segment. Nowadays, especially CFRP are mainly (except BMW i3) used in low volume productions. [Friedrich (2013)] [Brüninglinghaus (2013)]

Likewise, the study concludes that **China is becoming a major market** besides Europe for lightweight construction by 2025. However, the growth of both markets differs from each other. While in Europe the implementation of lightweight concepts in existing models, are the drivers of lightweight construction, the Chinese market will experience a substantial growth alone with its increasing sales. Additionally, Chinese manufacturers use more lightweight concepts for compact cars, rather than upper segment vehicles such as western companies. In total, the implementation of lightweight concepts in vehicles in China **will be driven at first by foreign manufacturers and their joint ventures**. However, Chinese manufacturers started to build R&D centers and to collaborate with research facilities regarding lightweight construction. In 2013, Great Wall, for example, opened a technical center with Shanghai Baosteel Group Corporation, China's largest steelmaker, in Baoding to develop, among other things, new plates of ultrahigh-strength steel to reduce vehicle weight [Automotive News China (2013g)]. [Brüninglinghaus (2013)]

To promote the development of Chinese automotive lightweight construction, an alliance was established in the end of 2007 in China. The

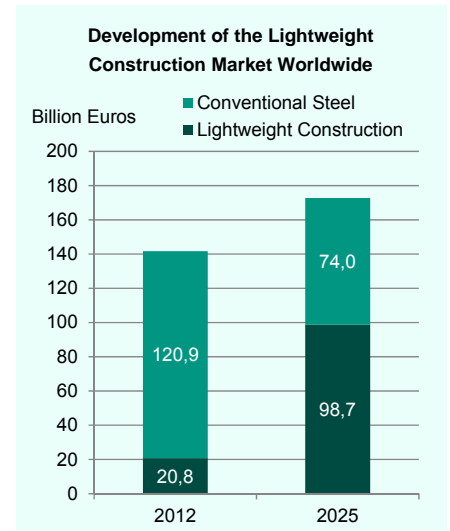


Figure 20: Development of the automotive lightweight construction market worldwide²⁰

²⁰ Own figure based on [Brüninglinghaus (2013)].

"We don't see so much of the conversion of steel to plastics at the Chinese OEMs, we are seeing that with the joint ventures; they are the booming factories in China."

Gerd Behnstedt, Executive Vice President of Corporate Sales at Inergy, 2013 [Automotive News China (2013f)]

manufacturers and their joint ventures, rather than from the local Chinese ones. [Ma/Lu (2013)] [Automotive News China (2012)] [Automotive News China (2013f)]

automotive lightweight alliance participants include main vehicle manufacturers, suppliers, research institutes as well as universities. The main aim to establish this alliance is to improve fuel efficiency and as a consequence to decrease CO2 emissions. But in addition to the gap in further developments of lightweight construction, **Chinese manufacturer still have to catch up in the terms of vehicle weight** with their current models. In 2012, for example, in order to reduce weight, manufacturers in Western Europe, the United States, and Japan used normally an average of 130 to 180 kilograms of plastic parts per vehicle in their economy cars. In comparison, Chinese competitors used only about 50 kilograms of plastic parts and used instead **a higher amount of heavier metal parts in their cars** which increase fuel consumption. One example is the market for plastic fuel tanks which is expected to grow from 50 percent of cars sold in China in 2013 to 70 percent by 2020. In the United States and Western Europe, more than 90 percent of cars are already equipped with plastic fuel tanks to reduce weight. According to Gerd Behnstedt, executive vice president of corporate sales at the European plastic fuel tank manufacturer Inergy Automotive Systems, the increased demand for lightweight vehicle parts is coming mostly from international vehicle



Vehicle Body

Geographical Structure

5.1 Industrial Cluster

Due to the **decentralized development** of the Chinese industry, local structures have emerged. Significant importance has been attached to the cities Changchun, Shanghai, Beijing and Guangzhou. The first production facilities of the big state-owned automotive manufacturers have been in these cities. Moreover, a mechanism for economic development in China is to attract foreign direct investments into industrial areas. International companies have settled in the **major cities on the east coast**. Not until later, plants were built in western regions of China to access new markets, to generate fewer costs or due to government pressure. These days the locations of automotive manufacturers and suppliers in China can be classified into **six major industry clusters** including the Yangtze River Delta Region, Pearl River Delta Region, the Bohai Region, Northeast China Region, Central China Region and the Southwest China Region. The automotive clusters are illustrated in Figure 21. Figure 22 illustrates the production bases of international OEMs in China. In comparison, Figure 23 shows a map of Chinese major passenger vehicle production bases. All manufacturers have been taken into account in the figures which have been considered in this study. Due to the large number of automotive manufacturers, especially Chinese companies, an extraction of the most important ones was necessary. Additionally, one has to keep in mind that this is a snapshot. [Kasper et al. (2006)]

Northeast Region

This region is one of the first industrial regions of China with various vehicles manufacturers as well as components suppliers. In 1953, FAW started the first and oldest automobile production in

Changchun. The cluster has a **solid industrial structure** and a **high-level educational base** related to the automotive industry. The region has greatly benefited from incentives of the government. In the late 1980s and 1990s, when the international manufacturers started to enter the Chinese market, FAW became a key partner. Afterwards, the government promoted the diffusion of the industry from Changchun to other cities in the region and new automotive manufacturers, such as Brilliance Group and Hafei Automobile have established production facilities. Nowadays, the Northeast region is **one of China's most important automobile production bases** and boasts several automobile manufacturers such as the FAW Group, FAW-Volkswagen, Sichuan FAW Toyota Changchun, FAW-Mazda, Hafei Automobile, Brilliance China Automotive, BMW Brilliance, and Jinbei-GM. In addition, Mitsubishi engine and a large number of automotive components and parts suppliers are located in this cluster. [Kuchiki/Tsuji (2011)] [Holweg et al. (2009)]

Yangtze River Delta Region

This region is also a **historical cluster** in China. In the 1950s, SAIC, as one of the big three state-owned manufacturers in China, was founded in this cluster. It covers parts of Jiangsu, Zhejiang, and Anhui provinces and the core of this cluster, Shanghai. In the 1980s, the establishment of joint ventures began with Shanghai VW and Shanghai GM. Following this, Chery and Geely manufactured their vehicles in this region with the rise of the young tigers. On this basis more and more automobile components and parts suppliers have clustered around the automobile manufacturers and have formed a **leading automotive cluster**. In Shanghai, there are more than 50 world-class automotive components joint ventures. The

main players in this cluster are, amongst others, SAIC, Shanghai VW and Shanghai GM in Shanghai, the relatively independent automobile manufacturer Geely in Zhejiang Province, Chang'an with its joint venture partner Ford and Nanjing-Fiat in Nanjing as well as Chery in Anhui Province. The city of Zhejiang has become one of the major auto parts production bases in China. [Kuchiki/Tsuji (2011)] [Chery (2014)]

Pearl Delta Region

The automotive industry evolved in the 1980s in this cluster. The growth was especially driven by the **proximity to Hong Kong** and by the international trade there. The cluster covers Guangzhou, Shenzhen, and Haikou as well as the surrounding cities. Although Guangzhou Peugeot went bankrupt in 1997, an important region for international manufacturers was originated. In

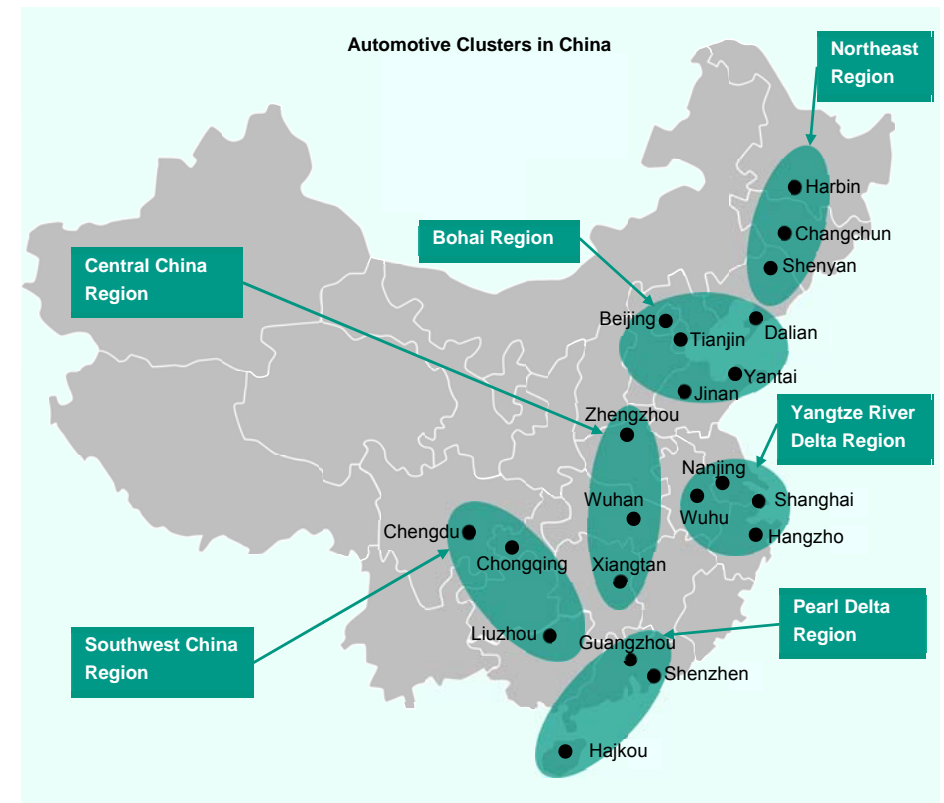


Figure 21: Automotive clusters in China²¹

²¹ Own figure based on [Kuchiki/Tsuji (2011)].

1998, Honda acquired Peugeot's production line and brought new opportunities. Nowadays, Guangzhou Automobile Industry Group (GAIG) has additionally established a joint venture with Toyota. The **government in Guangzhou** has set up several automotive industry parks providing low land prices and other incentives. With the entering of the **three Japanese manufacturers** Toyota, Honda, and Nissan followed by a large number of Japanese parts and components suppliers as well as the entering of Hyundai and other companies an important automotive cluster has emerged. Additionally, BYD and Hafei have production facilities in Shenzhen and Mazda and FAW manufacture in Kaikou. [Kuchiki/Tsuji (2011)] [Holweg et al. (2009)]

Bohai Region

The most important city in this region is **Beijing** followed by **Tianjin**. The advantages of the cluster are the location at the **political and economic center** of China as well as the developed economy with an increasing demand and high developed infrastructure. With great support of the government the two metropolises and the surrounding cities stepped into a period of rapid growth since the 1980s. Nowadays, there are, for example, Beijing Benz, Beijing Hyundai, and Beijing Jeep in Beijing. FAW Toyota, FAW Xiali, and Tianjin FAW manufacture cars in Tianjin. The commercial vehicle manufacturer Sinotruck produces its vehicles in the city of Jinan. General Motors and its joint venture partner SAIC operate production facilities in Yantai and Chery has a production base, among others, in Dalian. Additionally, there are a large number of automotive parts and components suppliers in the region. [Kuchiki/Tsuji (2011)] [Holweg et al. (2009)]

Central China Region

This region mainly refers to Hubei Province, which is an **important transport hub** in China with its proximity to the Yangtze River. Because of its remote location the region has developed more slowly in comparison to Yangtze and Pearl Delta Region. Dongfeng which is one of China's big state-owned manufacturers was founded in Shiyan which is a typical automotive city where 90 percent of companies are allocated to the automotive sector. Due to its **well-developed waterway and land transportation**, the cluster attracted Peugeot-Citroën, Honda and other auto makers. The representatives of vehicle companies are Dongfeng Motor, Dongfeng Peugeot-Citroën, and Dongfeng Honda in Wuhan. Geely operates a production plant in Xiangtan and Nissan operates one in Zhengzhou. [Kuchiki/Tsuji (2011)]

Southwest China Region

This region mainly covers the cities **Chengdu, Chongqing, and Liuzhou**. Chongqing is well-known for its industry and an important city in China where a large number of automotive companies compete. The majority of vehicles manufacturers in this cluster operate in a joint venture. One representative vehicle manufacturer is Chang'an which operates with its joint ventures Chang'an Ford Mazda and Chang'an Suzuki. Toyota has a production plant with its joint venture Sichuan FAW Toyota Motor Cooperation in Chengdu, where FAW and Geely also have a production base. SAIC GM Wuling manufactures the vehicle Chevrolet Spark in Liuzhou. Lifan which is one of the largest Chinese motorcycle producers also manufactures passenger vehicles in Chongqing. [Kuchiki/Tsuji (2011)] [Chang'an (2014)]

5.2 Geographical Development

Due to the large investments made by each manufacturer, several plants will open in the near future and will change the geographical structure in China's automotive industry. Especially, **Western China has enormous potential** for automakers as incomes rises and more people can afford cars. Car sales in western China are expanding faster than in the country's wealthy coastal cities. The growth has led foreign automakers to increase production in an area where they can quickly increase sales. Additionally, several **Chinese cities are competing** to become important auto hubs. Cities such as Wuhan, Chongqing, Chengdu, and Shenyang consider themselves as **China's biggest vehicle manufacturing site** in the future. Yet, the industrial hubs in China are Shanghai, Beijing, and Guangzhou. Since China adopted economic reforms in the late 1970s, the coastal cities became especially well developed. For example, Shanghai and its Jiading district is already a key automotive city in China and aims to stay like that, according to the head of the district Ma Chunlei. Nowadays, cities in central China gain in importance and represent a connecting link between the coastal regions in the east and the emerging west. This development is boosted by regional governments which are aiming to transfer their administrative areas into major automotive manufacturing and logistics hubs and to become the largest vehicle producer in China. Therefore, they offer financial support to domestic as well as international manufacturers to set up production facilities in their city. There is a real **competition in attracting automotive manufacturers** as well as automotive parts and components suppliers. [China Daily (2012)]

"We aim to cover everything from the manufacturing of cars and components, to research and development, design, sales, and the training of the next generation of executives, engineers and designers."

Ma Chunlei, head of Jiading district in Shanghai, 2012. [China Daily (2012)]

In the west of China, the cities **Chongqing and Chengdu** have evolved into a key region for auto makers and parts suppliers within the past few years. Both cities produced about 3 million vehicles in the year 2013 together. While Chongqing is still an important production site in China with nearly 2 million produced vehicles, Chengdu has ambitious goals. In 2011, the government in Beijing has approved the '**Chengdu-Chongqing Economic Zone**' which is supposed to play a central role in economic development of western China and is supposed to be on a similar level of development such as the coastal cities by 2020. In 2013, both metropolises have attracted around 15 percent of China's total vehicle production. Among other things, **motorways and high-speed railways** between the two cities have been considerably improved in the recent years. Chongqing which is often called the largest city in the world is located directly on the Yangtze River and was once capital of motorcycles in China. In Chongqing, main manufacturers are Chang'an Automobile Group and its joint venture partners Ford and Suzuki. By 2015, the metropolis will be Ford's largest production complex in the world, with three plants capable of assembling a total of more than 1 million vehicles a year. Japan's Suzuki just opened a 770 USD million factory, its second in the city, which

will double its capacity to 500,000 vehicles annually. General Motors and its Chinese joint venture partners start the production of a 1 billion USD factory that will build 400,000 cars and just as many engines annually. [Automotive News (2013)] [GTAI (2014)]

Chengdu, the capital city of Sichuan Province, is gaining increasing importance in the eyes of foreign investors. Foreign direct investment grew to 9.9 billion USD in the first eleven months in 2013. Although the vehicle production was around 400,000 in 2012 and around 750,000 in 2013, 1.35 million vehicles are supposed to be produced annually by 2015 in Chengdu. Main manufacturer is FAW with its joint venture partners Volkswagen and Toyota as well as Geely with its new Volvo plant. After expanding its vehicle and engine plant for 2.34 billion Euros, FAW-Volkswagen produced 486,000 vehicles in its plant in 2013 and aims to produce 600,000 vehicles. By the end of 2013, Volvo started the production of 120,000 vehicles annually. Toyota plans to raise the annual production capacity of its plant in Chengdu to 50,000 vehicles by 2015, up from 30,000 vehicles today. In addition to automobile manufacturers, more domestic and international suppliers set up production facilities in western China. Especially in Chengdu, parts manufacturers saw a significant jump in finished products. The **exponential increase** in Chengdu accounts for about 90 percent of Sichuan province's total auto parts production. For example, Bosch has opened its second Chassis System Control plant in China in 2013 and the company seeks to invest a total of 102.69 million Euros in Chengdu. [China Daily (2014b)] [GTAI (2014)]

Another upcoming city is the city of **Wuhan** in

central China's Hubei province. It has not acquired the sophistication of the coastal cities, but it is already an important vehicle production site in China. Wuhan is home to the state-owned manufacturer Dongfeng and due to Dongfeng's growth in the past, the city has benefited from this. With Nissan, PSA Peugeot Citroën, Renault, and Honda, four international vehicle manufacturers do already business in Wuhan. Nissan, Honda and PSA have set up production lines in the city. Renault received government permission to produce vehicles in Wuhan recently. A fifth international company, General Motors, is on the way to produce vehicles with its joint venture partner SAIC in the city of Wuhan. The manufacturer started building an assembly plant with a production capacity of about 300,000 cars per year when the production will start in 2015. The plant includes an option of adding another assembly line to double the capacity to 600,000 cars per year. Yet, also Hyundai and Volkswagen are considering a production facility in Wuhan. Volkswagen initially will invest 8 billion RMB in the plant which is supposed to be build up to 600,000 vehicles per year and will be the FAW-VW's fifth assembly plant in China [Automotive News China (2014h)]. As the OEM's expand, domestic and foreign suppliers will follow. One advantage of Wuhan is that the **labor costs** are still at a lower level compared to the more developed cities in the east of China. But the biggest advantage of the city in central China is its **unique geographic location**. With two rivers, the Yangtze and Hanshui, and one of China's trunk railway lines running through it, Wuhan affords easy access to central, southwest, northern and eastern regions in China. In China, there is no comparable city which is located so conveniently. By the year 2016, after the GM and Renault plants will have started

production, Wuhan could overtake Shanghai as the county's largest vehicle production city with a total production of around 3 million vehicles each year. [Automotive News China (2013d)]

In total, Western cities are supposed to play an important role in the future of China's automotive industry and the geographical structure will change.



City of Chongqing

Summary

In this study "State of Automotive Technology in PR China – 2014", the current state as well as the future development of the Chinese automotive industry was analyzed. For this purpose, an extensive secondary research (technology studies, market scenarios, press releases, interviews, etc.) was conducted.

As part of the summary, it becomes distinct:

- So far, foreign manufacturers have benefited from joint ventures and dominate the market in China. The government and Chinese companies seek to turn around this fact and are planning to spread their know-how by takeovers.
- China seeks to keep up with the international competition in all respects. This development requires high quality products produced by cutting-edge methods and machines.
- The increasing concern of safety and comfort to China's consumers will be reflected by an increasing demand of safety components. Moreover, connected cars and intermodality have great potential in China.
- The government supports significantly the development of new energy development, especially all-electric vehicles. However, there has been no breakthrough due to problems which have to be solved at first. The current trend is moving toward plug-in hybrids.
- The geographical structure of the automotive sector in China will change in the future. While, the coastal regions are in the focus so far, new

"The risk of missing out on China is greater than the risk of being part of it."

Heinrich von Pierer, former CEO Siemens AG, 2006.

automotive hubs will emerge in the western part of the country.

China is and will remain an extremely important market for the automotive industry worldwide. It still features enormous potential and due to the government and growing demands, sales will continue to grow.



Weiqi – China's oldest Game

List of References

[Automobil Produktion (2013)]

Automobil Produktion (2013): "Chinas Autobranche drängt mit Macht auf den Weltmarkt", <http://www.automobil-produktion.de/2014/01/experte-chinesischer-autohersteller-fallen-2013-deutlich/> (last access 15.03.2014).

[Automobil Produktion (2014)]

Automobil Produktion (2014): "Exporte chinesischer Autohersteller fallen 2013 deutlich", <http://www.automobil-produktion.de/2013/10/chinas-autobranche-draengt-mit-macht-auf-den-weltmarkt/> (last access 27.11.2013).

[Automotive News (2012)]

Automotive News (2012): "China's automakers find new success at making better cars", <http://www.autonews.com/article/20120922/GLOBAL03/120929970/chinas-automakers-find-new-success-at-making-better-cars> (last access 19.03.2014).

[Automotive News (2013)]

Automotive News (2013): "Western China generates growing auto sales in a high-growth market", <http://www.autonews.com/article/20130422/GLOBAL02/130429983/western-china-generates-growing-auto-sales-in-a-high-growth-market> (last access 10.04.2014).

[Automotive News China (2011a)]

Automotive News China (2011): "Chinese aren't ready for mature markets", <http://www.autonewschina.com/en/article.asp?id=6397> (last access 06.12.2013).

[Automotive News China (2011b)]

Automotive News China (2011): "Chery to build plant in Venezuela, report says", <http://www.autonewschina.com/en/article.asp?id=7089> (last access 29.12.2013)

[Automotive News China (2012)]

Automotive News China (2012): "Automakers, plastics suppliers form alliance to advance lightweight vehicles", <http://www.autonewschina.com/en/article.asp?id=9565> (last access 06.04.2014).

[Automotive News China (2013a)]

Automotive News China (2013): "China's low speed EV market is poised to grow", <http://www.autonewschina.com/en/article.asp?id=11075> (last access 06.12.2013).

[Automotive News China (2013b)]

Automotive News China (2013): "VW opens plant in Xinjiang region as part of western expansion", <http://www.autonewschina.com/en/article.asp?id=10714> (last access 11.12.2013).

[Automotive News China (2013c)]

Automotive News China (2013): "Ford sales jump 46% on Changan JV volume", <http://www.autonewschina.com/en/article.asp?id=10751> (last access 11.01.2014).

[Automotive News China (2013d)]

Automotive News China (2013): "Wuhan is poised to be China's Motor City", <http://www.autonewschina.com/en/article.asp?id=10924> (last access 11.04.2014).

[Automotive News China (2013e)]

Automotive News China (2013): "EVs vs. fuel cells: China is key battleground", <http://www.autonewschina.com/en/article.asp?id=11152> (last access 21.04.2014).

[Automotive News China (2013f)]

Automotive News China (2013): "Plastics suppliers target big China investments", <http://www.autonewschina.com/en/article.asp?id=10394> (last access 26.04.2014).

[Automotive News China (2013g)]

Automotive News China (2013): "Great Wall opens technical center with Baosteel", <http://www.autonewschina.com/en/article.asp?id=10793> (last access 26.04.2014).

[Automotive News China (2014a)]

Automotive News China (2014): "VW, Hyundai, Toyota top brands in China in 2013", <http://www.autonewschina.com/en/article.asp?id=11292> (last access 31.01.2014).

[Automotive News China (2014b)]

Automotive News China (2014): "Toyota, Honda set records as backlash fades", <http://www.autonewschina.com/en/article.asp?id=11188> (last access 31.01.2014).

[Automotive News China (2014c)]

Automotive News China (2014): "Ford rides sales surge to top Toyota, become 5th-biggest foreign automaker", <http://www.autonewschina.com/en/article.asp?id=11183> (last access 04.02.2014).

[Automotive News China (2014d)]

Automotive News China (2014): "Shanghai denies BYD claims that it favors local EV producers", <http://www.autonewschina.com/en/article.asp?id=11263> (last access 04.02.2014).

[Automotive News China (2014e)]

Automotive News China (2014): "Hyundai plans 4th China assembly plant", <http://www.autonewschina.com/en/article.asp?id=11352> (last access 23.02.2014).

[Automotive News China (2014f)]

Automotive News China (2014): "VW, Hyundai, Toyota top brands in China in 2013", <http://www.autonewschina.com/en/article.asp?id=11292> (last access 23.03.2014).

[Automotive News China (2014g)]

Automotive News China (2014): "OnStar's China subscriber network increases 40% in a year to 700,000", <http://www.autonewschina.com/en/article.asp?id=11216> (last access 23.03.2014).

[Automotive News China (2014h)]

Automotive News China (2014): "VW plans factory in central China, report says", <http://www.autonewschina.com/en/article.asp?id=11340> (last access 23.04.2014).

[Automotive News China (2014i)]

Automotive News China (2014): "BYD-Daimler joint venture's first electric car goes on sale", <http://www.autonewschina.com/en/article.asp?id=11639> (last access 23.04.2014).

[Automotive News China (2014j)]

Automotive News China (2014): "Tesla to spend 'hundreds of millions of dollars' on charging stations in China", <http://www.autonewschina.com/en/article.asp?id=11654> (last access 26.04.2014).

[Automotive News China (2014k)]

Automotive News China (2014): "China's EV market is poised to rise but not ready for takeoff", <http://www.autonewschina.com/en/article.asp?id=11483> (last access 27.04.2014).

[Automobilwoche (2013a)]

Automobilwoche (2013): "In China drohen ungemütliche Zeiten", <http://www.automobilwoche.de/article/20131121/NACHRICHTEN/131129964/1276/automobilwoche-kongress-in-china-drohen-ungemuetliche-zeiten> (last access 18.12.2013).

[Automobilwoche (2013b)]

Automobilwoche (2013): "Peking genehmigt Joint Venture: Renault darf Autos in China bauen", <http://www.automobilwoche.de/article/20131205/NACHRICHTEN/131209935/renault-darf-autos-in-china-bauen#.UtZVp7Qu2ZQ> (last access 08.01.2014).

[Automobilwoche (2013c)]

Automobilwoche (2013): "China streitet über Joint Venture-Regeln", <http://www.automobilwoche.de/article/20131216/NACHRICHTEN/131219979/1276/auslandische-autobauer-china-streitet-um-joint-venture-regeln#.UtZMT7QZHIU> (last access 18.01.2014).

[Automobilwoche (2013d)]

Automobilwoche (2013): "Daimler und BYD starten Verkauf Mitte 2014", <http://www.automobilwoche.de/article/20131120/NACHRICHTEN/131129992/daimler-und-byd-starten-verkauf-mitte-2014> (last access 28.01.2014).

[Automobilwoche (2013e)]

Automobilwoche (2013): "Audi eröffnet Entwicklungszentrum in China", <http://www.automobilwoche.de/apps/pbcs.dll/article?AID=/20130201/NACHRICHTEN/130209994/audi-eroffnet-entwicklungszentrum-in-china#.UxclnIVGWZQ> (last access 18.01.2014).

[Automobilwoche (2014a)]

Automobilwoche (2013): "Einstiegsmodell für China: VW will neuen "Volks-Wagen"", <http://www.automobilwoche.de/article/20140420/NACHRICHTEN/140429999/vw-will-neuen-volks-wagen> (last access 24.04.2014).

[Azza (2012)]

A. S. Azza (2012): "Strategische Handelspolitik als Schlüssel einer Infant Industry", GRIN Verlag GmbH, München, 2012.

[BAIC (2014)]

Beijing Automotive Industry Holding Co., Ltd. (2014): <http://www.baihc.com> (last access 16.01.2014).

[BBC (2013)]

BBC News Asia (2013): "Q&A: China-Japan islands row", <http://www.bbc.co.uk/news/world-asia-pacific-11341139> (last access 16.01.2014).

[BBVA Research (2012)]

BBVA Research (2012): "Automobile Market Outlook", http://www.bbva-research.com/KETD/fbin/mult/1301_ColombiaAutomobileOutlook_Jan13_tcm348-370632.pdf?ts=1642014, last access (13.03.2014).

[Berliner Zeitung (2014)]

Berliner Zeitung Online (2014): "Gefräßiger Drache in Afrika", <http://www.berliner-zeitung.de/politik/china-gefraessiger-drache-in-afrika,10808018,25838650.html> (last access 16.01.2014).

[Bielinski (2010)]

J. Bielinski (2010): "Forschungs- und Entwicklungstätigkeiten von multinationalen Unternehmen in China", Peter Lang Verlag, Frankfurt, 2010.

- [BIT (2014)]**
Beijing Institute of Technology - National Engineering Laboratory for Electric Vehicles (2014): <http://english.bit.edu.cn/Research/scientificResearch/95179.htm> (last access 12.03.2014).
- [Bloomberg (2012)]**
Bloomberg Businessweek (2012): "The March of Robots Into Chinese Factories", <http://www.businessweek.com/articles/2012-11-29/the-march-of-robots-into-chinese-factories> (last access 16.02.2014).
- [Bloomberg (2013a)]**
Bloomberg Businessweek (2013): "China Decade From Having Global Carmaker, Bernstein Says", <http://www.bloomberg.com/news/2013-02-22/china-is-10-years-from-having-global-automaker-bernstein-says.html> (last access 16.02.2014).
- [Bloomberg (2013b)]**
Bloomberg Businessweek (2013): "China Pushing Child Safety Seats to Reduce Accident Toll: Cars", <http://www.bloomberg.com/news/2013-11-24/china-pushing-child-safety-seats-to-reduce-accident-toll-cars.html> (last access 16.03.2014).
- [Bode (2009)]**
A. Bode (2009): "Wettbewerbsvorteile durch internationale Wertschöpfung", Springer Gabler Verlag, Berlin/Heidelberg, 2009.
- [Börsen-Zeitung (2014)]**
Börsen-Zeitung (2014): "Noch ein paar Hausaufgaben beim Billigauto", Vol. 80, pp. 09, 26.04.2014.
- [Bratzel et al. (2011)]**
S. Bratzel, R. Viereckl, D. Stein (2011): "China treibt uns nach vorn!", survey of the consultancy Management Engineers and the Center of Automotive Management, http://www.management-engineers.de/fileadmin/assets/pdf/studien/studien_2011/KF_PM_Zulieferstudie_2011_Final.pdf (last access 20.03.2014).
- [Brilliance (2014)]**
Brilliance China Automotive Holding Ltd. (2014): <http://www.brillianceauto.com> (last access 16.01.2014).
- [Brüninghaus (2013)]**
C. Brüninghaus (2013): "Markt für Karosserie-Leichtbau verfünffacht sich bis 2025", <http://www.springerprofessional.de/markt-fuer-karosserie-leichtbau-verfuenffacht-sich-bis-2025/4748536.html> (last access 30.04.2014).
- [BYD (2014)]**
Build your dreams Company (2014): <http://www.byd.com> (last access 16.01.2014).
- [Chang'an (2014)]**
Chang'an Automobile Corporation, Ltd. (2014): <http://www.globalchangan.com> (last access 16.01.2014).
- [Chery (2014)]**
Chery Automobile Co., Ltd. (2014): <http://www.cheryinternational.com> (last access 18.01.2014).
- [ChinaAutoWeb (2014a)]**
ChinaAutoWeb (2014): "China Auto Sales Hit Record High of 21.98 Million in 2013", <http://chinaautoweb.com/2014/01/china-auto-sales-hit-record-high-of-21-98-million-in-2013/> (last access 15.01.2014).
- [ChinaAutoWeb (2014b)]**
ChinaAutoWeb (2014): <http://chinaautoweb.com/chinese-brands/> (last access 15.04.2014).
- [China Car Times (2011)]**
China Car Times (2011): "New C-NCAP rules to be implemented next July", <http://www.chinacartimes.com/2011/09/new-c-ncap-rules-to-be-implemented-next-july/> (last access 19.03.2014).
- [China Daily (2012)]**
China Daily Online (2012): "'Detroit of the East' powers along", http://usa.chinadaily.com.cn/business/2012-03/13/content_14819920.htm (last access 19.04.2014).
- [China Daily (2014a)]**
China Daily Online (2014): "Car sharing catching on since ban was lifted", http://europe.chinadaily.com.cn/china/2014-02/06/content_17269536.htm (last access 19.03.2014).
- [China Daily (2014b)]**
China Daily Online (2014): "Chengdu drives auto parts manufacturing", http://www.chinadaily.com.cn/business/motoring/2014-02/20/content_17295349.htm (last access 29.03.2014).
- [China Daily (2014c)]**
China Daily Online (2014): "New-energy vehicles 'turning the corner'", http://www.chinadaily.com.cn/bizchina/motoring/2014-01/11/content_17229981.htm (last access 29.04.2014).
- [CUCAS (2012)]**

China's University And College Admission System (2012): "Top Chinese Universities in Mechanical Engineering, 2012", <http://www.cucas.edu.cn/HomePage/majorrankings/2011-11-10/1320919141d2437.shtml> (last access 15.04.2014).

[DAAD (2014)]

Deutsche Akademische Austausch Dienst (DAAD) Peking (2014): <http://www.daad.org.cn/> (last access 02.03.2014).

[Daimler (2014)]

Daimler AG (2014): "Mercedes-Benz steigt ins Premiumreisegeschäft ein", <http://www.daimler.com/dccom/0-5-7153-49-1665227-1-0-0-0-0-9293-0-0-0-0-0-0-0.html> (last access 27.01.2014).

[Dongfeng (2014)]

Dongfeng Motor Corporation Ltd. (2014): <http://www.dfmc.com.cn> (last access 07.01.2014).

[Duan/Chen (2011)]

L. Duan, F. Chen (2011): "The future of Advanced Driving Assistance System development in China", Vehicular Electronics and Safety (ICVES), 2011 IEEE International Conference, pp. 238-243.

[EFI (2014)]

Expertenkommission Forschung und Innovation (2014): "Gutachten zu Forschung, Innovation und Technologischer Leistungsfähigkeit Deutschlands", http://www.efi.de/fileadmin/Gutachten_2014/EFI_Gutachten_2014.pdf last access (23.03.2014).

[Faust/Gang (2012)]

P. Faust, Y. Gang (2012): "China Sourcing", Springer Gabler Verlag, Berlin/Heidelberg, 2012.

[FAW (2014)]

FAW Group Corporation (2014): <http://www.faw.com/> (last access 17.01.2014).

[FAZ (2013a)]

Frankfurter Allgemeine Zeitung (2013): "China ist kein Billigstandort mehr", <http://www.faz.net/aktuell/wirtschaft/arbeitskosten-china-ist-kein-billigstandort-mehr-12116248.html> (last access 17.12.2013).

[FAZ (2013b)]

Frankfurter Allgemeine Zeitung (2013): "Der Volkswagen Santana ist in China ein Renner", <http://www.faz.net/frankfurter-allgemeine-zeitung/automobilindustrie-der-volkswagen-santana-ist-in-china-ein-renner-12583095.html> (last access 07.01.2014).

[FAZ (2013c)]

Frankfurter Allgemeine Zeitung (2013): "VW verzögert E-Autos in China", <http://www.faz.net/aktuell/technik-motor/auto-verkehr/elektromodell-carely-vw-verzoegert-e-autos-in-china-12674977.html> (last access 07.02.2014).

[FAZ (2014a)]

Frankfurter Allgemeine Zeitung (2014): "General Motors schlägt in China gegen VW zurück", <http://www.faz.net/aktuell/wirtschaft/fruehaufsteher/autobranche-general-motors-schlaegt-in-china-gegen-vw-zurueck-12752921.html> (last access 17.01.2014).

[Focus (2014)]

Focus Online (2014): "Warum der 4000 Euro-Porsche nie gebaut wurde", http://www.focus.de/auto/gebrauchtwagen/youngtimer/billigauto-fuer-4000-euro-warum-dieser-porsche-nie-gebaut-wurde_id_3608094.html (last access 15.02.2014).

[Fourin (2013)]

FOURIN, Inc. (2013): "China Automotive Industry Maps", <http://www.fourin.com/english/CHINAMAP/ChinaMap.html> (last access 15.04.2014).

[Friedrich (2013)]

H. E. Friedrich (2013): "Leichtbau in der Fahrzeugtechnik", Springer Fachmedien, Wiesbaden 2013.

[Geely (2014)]

Geely Holding Group Co., Ltd. (2014): <http://www.geely.com> (last access 15.01.2014).

[GTAI (2013)]

Germany Trade & Invest (2013): "Lohn- und Lohnnebenkosten - VR China", <http://www.gtai.de/GTAI/Navigation/DE/Trade/maerkte,did=739508.html> (last access 15.01.2014).

[GTAI (2014)]

Germany Trade & Invest (2014): "Automobilindustrie in Westchina expandiert", <http://www.gtai.de/GTAI/Navigation/DE/Trade/maerkte,did=948174.html> (last access 15.04.2014).

[Great Wall Motors (2014)]

Great Wall Motors Company Ltd. (2014): <http://www.gwm-global.com> (last access 16.01.2014).

[General Motors (2014)]

General Motors Company (2014): <http://www.gmchina.com/gm/front/about/china> (last access 21.01.2014).

[GSMA (2013a)]

GSMA Connected Living programme: mAutomotive: "Connected Car Forecast: Global Connected Car Market to Grow Threefold Within Five Years",
http://www.gsma.com/connectedliving/wpcontent/uploads/2013/06/cl_ma_forecast_06_13.pdf (last access 23.03.2014).

[GSMA (2013b)]

GSMA Connected Living programme: mAutomotive: "China Telematics Brands Exposure Analysis Report",
<http://www.gsma.com/connectedliving/wp-content/uploads/2013/03/Presentation-6-Peter-Zhou-TCC.pdf> (last access 23.03.2014).

[Handelsblatt (2013a)]

Handelsblatt Online (2013): "Die falsche Bescheidenheit der Chinesen",
<http://www.handelsblatt.com/unternehmen/industrie/autostudie-die-falsche-bescheidenheit-der-chinesen/8906346.html> (last access 21.02.2014).

[Handelsblatt (2013b)]

Handelsblatt Online (2013): "Die chinesische Offensive",
<http://www.handelsblatt.com/unternehmen/industrie/changan-die-chinesische-offensive/8785266.html> (last access 21.02.2014).

[Handelsblatt (2013c)]

Handelsblatt Online (2013): "Mit den Flügeln des Drachen",
<http://www.handelsblatt.com/unternehmen/industrie/china-stuetzt-europas-autobauer-mit-den-fluegeln-des-drachen/8463850.html> (last access 21.02.2014).

[Handelsblatt (2014a)]

Handelsblatt Online (2014): "Absatz in Gefahr: Die Grenzen des chinesischen Auto-Boom",
<http://www.handelsblatt.com/unternehmen/industrie/absatz-in-gefahr-die-grenzen-des-chinesischen-auto-booms/9308584.html> (last access 21.03.2014).

[Handelsblatt (2014b)]

Handelsblatt Online (2014): "Daimler will China unter Strom setzen",
<http://www.handelsblatt.com/auto/nachrichten/denza-elektroauto-daimler-will-china-unter-strom-setzen/9806304.html> (last access 27.04.2014).

[Handelsblatt (2014c)]

Handelsblatt (2014): "Kampf der Systeme", Edition 25.02.2014, pp. 1-5.

[Handelsblatt (2014d)]

Handelsblatt (2014): "Wir brauchten einen Schock", Edition 23.01.2014, pp. 24.

[Holweg et al. (2009)]

M. Holweg, J. Luo, N. Oliver: "The past, present and future of China's automotive industry: a value chain perspective", International Journal of Technological Learning Innovation and Development, Vol. 2, pp. 76-118, 2009.

[IBTimes (2013)]

International Business Times (2013): "GM, Ford, VW Dominate China's Auto Industry: Why Can't Chinese Companies Like SAIC, Dongfeng, Geely, And GAC Make Cars That People Want To Buy?",
<http://www.ibtimes.com/gm-ford-vw-dominate-chinas-auto-industry-why-cant-chinese-companies-saic-dongfeng-geely-gac-make> (last access 07.01.2014).

[IFR (2013)]

International Federation of Robotics (2013): "World Robotics 2013 – Industrial Robots", study,
http://www.worldrobotics.org/index.php?id=home&news_id=267 (last access: 12.02.2014).

[IHS Technology (2013)]

IHS Technology (2013): "China's Advanced Driver Assist Systems Market to Triple in Six Years",
<http://press.ihs.com/press-release/design-supply-chain-media/chinas-advanced-driver-assist-systems-market-triple-six-year> (last access 21.02.2014).

[IHS Technology (2014)]

IHS Technology (2014): "China Automotive Semiconductor Market Drives Up 11 Percent in 2013, Thanks to Safety and Navigation Features",
<http://press.ihs.com/press-release/design-supply-chain/china-automotive-semiconductor-market-drives-11-percent-2013-thank> (last access 21.02.2014).

[IHS iSuppli Corporation (2011)]

IHS iSuppli Corporation (2011): "Embedded Telematics in the Automotive Industry",
http://gallery.mailchimp.com/e68b454409061ef6bb1540e01/files/Embedded_Telematics_in_the_Automotive_Industry_sw_iS.pdf (last access 21.03.2014).

[Industry Journal (2013)]

Industry Journal (2013): "Autos made in China", Siemens AG,
<http://www.industry.siemens.com/topics/global/de/magazine/industry-journal/2-2013/Documents/industry-journal-2-2013-de.pdf> (last access 07.12.2013).

[Jochem/lacovelli (2011)]

R. Jochem, D. Iacovelli (2011): "Erfolgsfaktoren für eine effiziente Lean Management-Transformation in China", ZWF Zeitschrift für wirtschaftlichen Fabrikbetrieb, Vol. 1-2, pp. 59-64.

[Luo (2005)]

J. Luo (2005): "The Growth of Independent Chinese Automotive Companies", http://global-production.com/scoreboard/resources/luo_2005_independent-chinese-automotive-companies.pdf (last access 26.03.2014).

[Kasper et al. (2006)]

G. Kasperk, M. Woywode, R. Kalmbach (2006): "Erfolgreich in China: Strategien für die Automobilzulieferindustrie", Springer Verlag, Berlin, 2006.

[Kuchiki/Tsuji (2011)]

A. Kuchiki, M. Tsuji (2011): "Industrial Clusters, Upgrading and Innovation in East Asia", Edward Elgar Publishing Ltd., Cheltenham, 2011.

[KPMG (2014)]

KPMG International Cooperative (2014): "Global Automotive Executive Survey 2014", <http://www.kpmg.com/global/en/issuesandinsights/articlespublications/global-automotive-executive-survey/Pages/default.aspx> (last access 23.03.2014).

[Ma/Lu (2013)]

M. Ma, H. Lu (2013): "Design, Evaluation Methods and Parameters of Automotive Lightweight", in "Proceedings of the FISITA 2012 World Automotive Congress", Vol. 8, pp. 965-975, Springer Gabler Verlag Berlin/Heidelberg, 2013.

[Manager magazin (2013)]

Manager magazin (2013): "Schlaraffen-Länder", Special Edition, 2013, pp. 54-58.

[McKinsey & Company (2012a)]

McKinsey (2012): "Bigger, better, broader: A perspective on China's auto market in 2020", <http://www.mckinseychina.com/wp-content/uploads/2013/01/McKinsey-Perspective-on-Chinas-auto-market-in-2020.pdf> (last access 03.12.2013).

[McKinsey & Company (2012b)]

McKinsey & Company (2012): "Innovating in China's automotive market: An interview with GM China's president", interview, http://www.mckinsey.com/insights/asia-pacific/innovating_in_chinas_automotive_market_an_interview_with_gm_chinas_president (last access 03.12.2013).

[McKinsey (2013)]

McKinsey & Company (2013): "Upward Mobility: The Future of China's Premium Car Market", http://www.mckinsey.de/sites/mck_files/files/Upward_mobility.pdf (last access 09.12.2013).

[MunichInnovationGroup (2013)]

Technische Universität München, Munich Innovation Group (2013): "Chinese Champions - Patente made in China", <http://www.chinese-champions.com/downloads/ChineseChampionsEN.pdf> (last access 13.01.2014).

[na presseportal (2013)]

na presseportal (2013): "Mit lokalen Partnern auf der Überholspur: Studie von Oliver Wyman zur Fahrzeugvernetzung in China (BILD)", <http://www.presseportal.de/pm/66435/2549766/mit-lokalen-partnern-auf-der-ueberholspur-studie-von-oliver-wyman-zur-fahrzeugvernetzung-in-china> (last access 21.03.2014).

[NCAP (2014)]

European New Car Assessment Programme (2014): <http://www.euroncap.com/home.aspx> (last access 09.02.2014).

[n-tv (2013)]

n-tv Online (2013): "Der Kampf ums autonome Fahren - Autobauer bremsen Google aus", <http://www.n-tv.de/auto/Autobauer-bremsen-Google-aus-article11970166.html> (last access 21.03.2014).

[Planing (2013)]

P. Planing (2013): "Innovation Acceptance - The Case of Advanced Driver-Assistance Systems", Springer-Verlag Berlin/Heidelberg, 2013.

[Peters et al. (2012)]

A. Peters, C. Doll, F. Kley, M. Möckel, P. Plötz, A. Sauer, W. Schade, A. Thielmann, M. Wietschel, C. Zanker (2012): "Konzepte der Elektromobilität und deren Bedeutung für Wirtschaft, Gesellschaft und Umwelt", <http://www.tab-beim-bundestag.de/de/pdf/publikationen/berichte/TAB-Arbeitsbericht-ab153.pdf> (18.03.2014).

[Produktion (2013a)]

Produktion – Technik und Wirtschaft für die deutsche Industrie (2013): "CIMT: Chinesen brauchen Automatisierung", <http://www.produktion.de/unternehmen-maerkte/maschinenbau/cimt-chinesen-brauchen-automatisierung/> (last access 13.02.2014).

[Produktion (2013b)]

Produktion – Technik und Wirtschaft für die deutsche Industrie (2013): "Chinesen entwickeln eigene Lean-Praxis", <http://www.produktion.de/top-story/chinesen-entwickeln-eigene-lean-praxis/> (last access 13.02.2014).

[Progenium (2013)]

PROGENIUM GmbH & Co. KG (2013): "New Mobility Concepts in BRIC Markets-Focus on China", http://www.progenium.com/Publikationen/DE/data/upload/publikation/130523_New%20Mobility%20Concepts%20in%20BRIC%201370266137.pdf (last access 25.03.2014).

[Qianzhan Industry Research (2013)]

Qianzhan Business Information Co., Ltd. Industry Research Center: "China Auto Industry Park Development Model and Investment Strategy Planning Report, 2013-2017", <http://en.qianzhan.com/report/detail/233e7e61210844e0.html> (last access 23.03.2014).

[Qoros (2014)]

Qoros Auto Co., Ltd. (2014): <http://www.qorosauto.com> (last access 18.01.2014).

[SAIC (2014)]

SAIC Motor Corporation Ltd. (2014): <http://www.saicmotor.com> (last access 07.01.2014).

[SCOPUS (2014)]

SCOPUS (2014): <http://www.elsevier.com/online-tools/scopus>, (last access 05.05.2014).

[Spiegel (2013)]

Spiegel Online (2013): "Crashtest: Erstmals Bestnote für chinesischen Autohersteller"
<http://www.spiegel.de/auto/aktuell/qoros-crashtest-bestnote-fuer-chinesischen-autohersteller-a-924455.html>
(last access 20.01.2014).

[Spiegel (2014)]

Spiegel Online (2014): "Studie zur Umweltverschmutzung: Chinas Städte ersticken"
<http://www.spiegel.de/wissenschaft/natur/china-luftverschmutzung-in-73-staedten-ueber-dem-limit-a-957592.html> (last access 20.04.2014).

[Steward Law (2012)]

Steward Law (2012): "China's support programs for automobiles and auto parts under the 12th five-year plan", <http://www.stewartlaw.com/stewartandstewart/LinkClick.aspx?link=Documents%2FS+%26+S+China+Auto+Par+ts+Subsidies+Report.pdf&tabid=119&mid=579&language=en-US> (last access 05.12.2013).

[Sun/Wang (2012)]

L. Sun, Y. Wang (2012): "Automobile Safety and Technical Policies in China", International Journal of Business and Social Science, Vol. 3, Issue 13, July 2012.

[Süddeutsche (2013)]

Süddeutsche (2013): "Das Dilemma des Milliardenmarkts", <http://www.sueddeutsche.de/wirtschaft/automobilbranche-in-china-wenn-das-risiko-mitfaehrt-1.1339959-2>, (last access 19.12.2013).

[Taj (2008)]

S. Taj (2008): "Lean manufacturing performance in China: assessment of 65 manufacturing plants", Journal of Manufacturing Technology Management, Vol. 19, Issue 2, pp. 217-234, 2008.

[Tongji (2014)]

Tongji University - College of Automotive Engineering (2014): <http://www.tongji.edu.cn/english/themes/10/template/Academics/College%20of%20Automotive%20Engineering.shtml> (last access 12.03.2014).

[Toyota (2014)]

Toyota Motor Corporation (2014): <http://www.toyota.com/> (last access 31.01.2014).

[Tsinghua (2014)]

Tsinghua University (2014): <http://www.tsinghua.edu.cn/publish/then/index.html> (last access 13.03.2014).

[TU9 Electromobility (2014)]

Sino German Network on Electromobility - TU9 Electromobility (2014): <http://www.sinogermanemobility.de/> (last access 12.02.2014).

[United Nations (1987)]

United Nations (1987): "Our Common Future", Report of the World Commission on Environment and Development, <http://www.un-documents.net/our-common-future.pdf> (last access 30.04.2014).

[Volkswagen AG (2011)]

Volkswagen AG (2011): "Volkswagen and Tongji University in Shanghai agree endowed professorship for human resource management", http://www.volkswagenag.com/content/vwcorp/info_center/en/news/2011/06/Volkswagen_and_Tongji_University_in_Shanghai_agree_endowed_professorship_for_human_resource_management.html (last access 21.03.2014).

[Volkswagen (2014)]

Volkswagen AG (2014): <http://www.volkswagen.de> (last access 21.01.2014).

[Winner/Weitzel (2012)]

H. Winner, A. Weitzel (2012): "Handbuch Fahrerassistenzsysteme", pp. 658-667, Vieweg+Teubner Verlag, Wiesbaden, 2012.

[Wirtschaftswoche (2013a)]

Wirtschaftswoche Online (2013): "Der riskanteste Standort im VW-Imperium", <http://www.wiwo.de/unternehmen/auto/werk-in-xinjiang-mutig-oder-einfach-nur-blauaeugig/9079890-3.html> (last access 11.12.2013).

[Wirtschaftswoche (2013b)]

Wirtschaftswoche Online (2013): "Roboter übernehmen Jobs im Reich der Mitte", <http://www.wiwo.de/unternehmen/industrie/china-roboter-uebernehmen-jobs-im-reich-der-mitte/7585908.html> (last access 11.02.2014).

[Wirtschaftswoche (2014a)]

Wirtschaftswoche (2014): "Brüder, zur Sonne!", Vol. 04/2014, pp. 20-14.

[Wirtschaftswoche (2014b)]

Wirtschaftswoche (2014): "Hand am Ventil!", Vol. 11/2014, pp. 56-58.

[Welt (2013a)]

Welt Online (2013): "Autobauern droht gewaltiger Machtverlust in China", <http://www.welt.de/wirtschaft/article122490018/Autobauern-droht-gewaltiger-Machtverlust-in-China.html> (last access 19.12.2013).

[Welt (2013b)]

Welt Online (2013): "China überrascht mit ausgereiftem Selbstfahr-Auto", <http://www.welt.de/motor/article113131954/China-ueberrascht-mit-ausgereiftem-Selbstfahr-Auto.html> (last access 19.03.2014).

[Zhou et al. (2013)]

L. Zhou, J. W. Watts, T. Nakamoto (2013): "The Rise of Safety Innovations in Intelligent Mobility", in Deloitte Review, Vol. 12, pp. 143-159, 2013.

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List of Abbreviations

ABS	Anti-lock braking system	ICE	Internal combustion engine
ADAS	Advanced driver assistance systems	IT	Information technology
AMC	American Motors Corporation	I2R	Infocomm Research
ASEAN	Association of Southeast Asian Nations	JMC	Jiangling Motors Corporation
BAIC	Beijing Automotive Industry Group Corporation	LDW	Lane departure warning (LDW)
BSD	Blind spot detection	MoE	Ministry of Education
BYD	Build Your Dream	MoST	Ministry of Science and Technology
CAAM	Chinese Automobile Manufacturers Association	MPS	Ministry of Public Security
CAE	College of Automotive Engineering	MTU	Military Transportation University
CAPS	Collaboration with Active and Passive Safety	NCAP	New Car Assessment Programme
CAS	Chinese Academy of Sciences	NDRC	National Development and Reform Commission
CFRP	Carbon fiber reinforced plastic	OEM	Original equipment manufacturer
CKD	Completely Knocked Down	PLA	People's Liberation Army
C-NCAP	China-New Car Assessment Program	PRC	People's Republic of China
CIMT	China International Machine Tool Show	RMB	Renminbi Yuan
DAE	Department of Automotive Engineering	R&D	Research and development
EBD	Electronic Brakeforce Distribution	SAIC	Shanghai Automotive Industry Cooperation
ESC	Electronic stability control	SGMW	SAIC-GM-Wuling Automobile
EU	Europe	SUV	Sport utility vehicle
EUCCC	European Chamber of Commerce in China	TPMS	Tire-pressure monitoring systems
EV	Electric Vehicle	TusPark	Tsinghua University Science Park
FAW	First Automobile Works	UN	United Nations
FAW-GM	FAW-GM Light Duty Commercial Vehicle	US	United States
FTRD	FAW Toyota Research & Development	USD	United States dollar
GDP	Gross domestic product	VW	Volkswagen
GERD	Gross domestic expenditure on R&D		
GM	General Motors		
GSMA	GSM Association		

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