

Washington D.C. July 16, 2008
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Testimony before the U.S.-China Economic and Security Review Commission
Regarding
Research and Development and Technological Advances in Key Industries in China

Overview of the Chinese Automobile Industry

For automakers seeking relief from a global price war caused by overcapacity and recession, China is almost the only game in town. With just ten vehicles per 1,000 residents in China as of 2006 (as opposed to 940 in the United States and 584 in Western Europe), there seems to be plenty of growth opportunities. Not surprisingly, nearly every major auto company has jumped into China, quickly turning the country into a new battleground for dominance in this global industry. In addition, China has become a major auto parts supplier. Of the world's top 100 auto parts suppliers, 70% have a presence in China.

China vaulted past Japan in 2006 to become the world's number-two vehicle market (after the United States). In 2006, car sales in China were up 37%, and sales of all vehicles including trucks and buses (7.2 million in total) were up 25%. Reports of record sales, new production, and new venture formations were plenty. After China's accession to the World Trade Organization (WTO) in 2001, the industry has been advancing by leaps and bounds. At the global level, China has moved to the third position in production behind the United States and Japan, and is slated to produce 8.5 to 9 million vehicles in 2007. Around 50% of the world's activity in terms of capacity expansion is seen in China.

Emerging Domestic Players and Advances in R&D

Strong Government support plays a crucial role for Chinese carmakers to gain global competitiveness. Over the past few years government officials from the State Development and Reform Commission (SDRC), industry experts and Chinese automotive entrepreneurs have jointly elaborated a new strategy plan which aims to catapult local players into the global OEM league.

The primary goal set forth in the nine policy guidelines of the SDRC's plan is to make China "the fourth pole of the global automotive industry" by such as

- Improving overall industry competitive position (e.g. by emancipating from their current JV-partner),
- Developing core technologies based on independent innovation (e.g. by encourage setup of independent or Chinese OEM affiliated R&D center),
- Establishment of venture capital system to offer multilevel finance channels to private automotive enterprises,

- Follow International practice on technical standards, laws and regulations (e.g. passenger safety standards, emission standards, preferential income tax rates for high-tech companies).

The original thinking behind the Open Door policy in China's auto market by forming JVs with multinationals was to access capital and technology and to develop Chinese domestic partners into self-sustaining independent players. However, this market-for-technology strategy failed to achieve its original goal. Cooperation with foreign car companies did bring in capital and relevant technology, but also led to over-dependence on foreign technology and inadequate capacity (or even incentive) for independent innovations. By forming JVs with all the major domestic manufacturers and controlling brands, designs and key technologies, multinational companies effectively eliminated the domestic competition for the most part of the last two decades. Only in the last few years did Chinese manufacturers start to design, produce, and market independent brands. In 2006, domestic companies controlled some 27% of the domestic market (mostly in entry- to mid-level segments). They have become masters at controlling costs and holding prices down, with a typical Chinese auto worker earning \$1.95 an hour against a German counterpart making \$49.50 an hour.

Ironically, the breakthrough for innovation and independent R&D came from newly established manufacturers without foreign partners. Local Government-owned Chery (Qirui) automobile, which started with \$25 million using second-hand Ford production equipment, produced only 2,000 vehicles eight year ago.¹ In 2006, it sold 305,236 cars, a surge of 118% over 2005, with plans to double that again by 2008.

Chery was founded in 1997 in Wuhu City, Anhui province and is controlled by the municipal local government. From the very beginning the company embarked on a different strategy than SAIC or FAW and paid attention to develop its own brand. But in fact, it relied in the first years much on foreign technology as its first car project used a licensed chassis from Seat's Toledo at the end of 1999.

Although Chery was sued by GM Daewoo for copying the Chevrolet Spark6 - also known as Daewoo Matiz - the company succeeded in establish a positive brand reputation at first time buyers of small compact city cars such as the Chery QQ. 60% of Chery's the 2005 turnover have been accounted for by the QQ and by end of 2006 more than 190,000 units were sold, thus helping Chery to reach economies of scales

¹ In May 2005, GM sued Chery in a Chinese court for counterfeiting the design of a vehicle developed by GM's South Korean subsidiary Daewoo. While this case created some media sensation, in November 2005, the parties, encouraged by the Chinese government, reached "an undisclosed settlement." The settlement terms were not revealed. It was not known whether Chery had to pay for its alleged infringement or whether it was barred from using the purportedly infringing design (http://iplaw.blogs.com/content/2005/11/gm_piracy_case_.html).

for the first time. Its successor, the compact sedan QQ6 (codename: S21) which was inspired by — but not copied from — the Volkswagen New Beetle, was planned to hit the markets in Europe in late 2006 with a very competitive target price.

Currently Chery is the only one Chinese OEM offering six models in China ranging from a subcompact city car, a mid-size Four-door sedan (Oriental Son/Eaststar), a SUV (Tiggo) and China's first MPV which was launched in July 2006, the V520 (B14) equipped with an Euro-IV engine co-developed with AVL-Austria.

The company's strategy already follows the plan of central government and the management has itself committed to developing world-class automobiles via technology cooperation with top engineering firms such as AVL-List Austria, Lotus Engineering, Mitsubishi Automotive Engineering, Prototipo and global Tier-1 suppliers such as Bosch, Siemens-VDO, Autoliv, Key Safety Systems as well as design cooperation with leading firms such as Bertone and Pininfarina.

Its research and development department - together with its international technology partners - are concurrently working on more than 10 new car models, some of them still design studies, or prototypes, pilots or near to production, for at least two new platforms, including but not limited to a four-door luxury sedan (B21 or A6), a new SUV (B22) a convertible (M14), a B-segment class car (S12 or A1), all supposedly dedicated to overseas markets such US and Europe.

With a clear vision and strong ambition to become a global player from the very beginning of the company foundation, Chery Automobile has already launched its products in 29 countries, mainly in the Middle and Far East. Furthermore, Chery is already assembling cars at the EU external border, such as in Kaliningrad for Russian OEM Avtotor. In 2003 Chery became the first Chinese manufacturer in Iran which established an assembly line on knock-down basis with Iranian SKT.

Later this year, the mid-size A5 and Oriental Son/Eaststar four-door sedan shall be assembled using CKD or SKD kits with Chery's Egyptian partner Daewoo Motors Egypt (DME), a former partner of GM Daewoo Auto and shall have an initial annual capacity of 25,000 units. In 2005, a strategic partnership has been entered into between Chery China and Visionary Vehicles of the USA for launching Chery products in North America.

Another approach of development is taken by one of the major State-owned auto groups, SAIC (Shanghai Automotive Industry Group). Until 1991, it has produced the Shanghai No. 1 sedan, the "Phoenix" SH760 - based on the 1956 Mercedes-Benz 220 series - for more than 33 years at the Shanghai sedan factory. This independent brand was given up after the SAIC-VW joint venture launched the hot selling VW Santana model. In the nineties the task of China's large state-owned automotive groups such as SAIC and First Automotive Works (FAW) has been to cooperate with multinational partner to assemble cars, mostly on SKD or CKD basis. This generated a huge profit for both, the Chinese as well as the Western partner.

But until now, all Chinese OEM JV-partners have not realized satisfactory their goal of sharing the market in exchange of technology, as long as they banked only on multinational brands. They had to accept that even a 50 percent equity share did not imply much legal sharing of intellectual property rights, brands, technology sources, parts supply, marketing network and aftersales services. As public and political opinion in mainland China put pressure on the Chinese side to emancipate from its Western partners, China automotive industry has entered the post-JV area yet by a number of “rules changes”.

This particularly applies for SAIC which got frustrated living in the shadows of its two foreign partners. Although the company made huge profits in recent years, it has not been regarded as independent OEM offering Chinese tailor-made cars to meet the needs of the emerging middle-class and first-time car buyers. SAIC has a joint R&D center with GM in Shanghai; the center was established in 1997 and named Pan Asia Technical Automotive Center (PATAC), serves Shanghai GM and SAIC-GM-Wuling, GM's two joint ventures in China. Its main purpose is to make localized adjustment to the existing design (design is done and controlled in Detroit); furthermore, any modification to the original design needs authorization from Detroit.

Unable to establish a self-dependent system of R&D within the JV framework, the company began its acquisition spree abroad in late 2002, when it paid almost \$60 million for a 10 percentage stake in GM Daewoo Automotive. The next deal was the buying of a controlling stake of 48.9 percent of South Korea's fourth largest OEM Ssangyong for about \$500 million. Then SAIC spent \$120 million to acquire the intellectual property rights and technology platform for the Rover 25 and Rover 75 model cars.

Although these separated deals did not reveal any independent brand or Going Out strategy until mid 2005, it became evident as SAIC announced later that it is going to invest \$445 million into a new car assembling venture using Ssangyong and Rover technology. The new company, Shanghai Luwei is headquartered in the city of Yizheng, Jiangsu province. This assembly shall have initially a capacity of 120,000 vehicles and mark a turning point for SAIC as the company now officially begins to compete against its foreign partner.

The next move to establish itself as a global player was the appointment of Phil Murtaugh, a former GM Greater China chairman and CEO as Vice President of Shanghai Automotive Industry Corp. (SAIC). This signal reflects that the Shanghai based car manufacturer also take note of the soft side of business and attract international experienced top management executives to speed up its overseas expansion.

With a mid-term investment of 1 billion Euros the company recently announced that it is going to develop its own brand and shall roll out more than 30 models between

2007 and 2010, achieving an output capacity of up to 300,000 units. SAIC launched its first own branded model ROEWE- based on the Rover 75 technology at Yizheng plant. However the company is still cooperating with both GM and Volkswagen on large scale production, and therefore has announced far less aspiring export targets as local and private-owned carmakers such as Chery Automobiles.

So far China's carmakers have reached a crossroads after some of them have already moved onto the global stage at matchless speed: they can either move up and increase their brand recognition and market position within home market and other emerging markets, or they focus on moving out into untapped but mature markets beyond Far and Middle East with high consumer expectations. The leading independent Chinese carmakers such as Chery, Geely and Great Wall Motors are trying both at the same time. They invest on a large scale in new technology, process and quality improvements to climb up the value chain enabling them to penetrate even mature markets. SAIC, on the other hand, can use the acquired Rover licenses restart vehicle exports to the same markets where the brand was well established and recognized.

The Bumpy Road to "Going Out"

The leading forces of Chinese auto firms in terms of outward expansion are independent producers such as Chery, Geely and Greatwall, because in order to survive in the tough competition in the auto industry, they have to and also have the independence to seek any possible markets in a global range. Compared with the joint ventures which are managed in accordance with the international partner's global strategies, they have more flexibility and autonomy to explore oversea markets. Chery and Geely started their exports soon after their first product launch into the domestic market. The market downturn in 2004 also pressured them to explore new markets. In 2004, almost all of China's sedan exports, about 10,000 units, were from Chery and Geely.

Beyond the domestic market, Chery now exports cars to 29 countries. In 2006, the company produced 305,000 cars and exported 50,000. Chery cars were expected to hit the European market later in 2007. It signed a deal with Chrysler that will see it produce Dodge-brand vehicles for the US and Western Europe markets in the near future. Geely Group plans to buy a stake in the UK taxi maker Manganese Bronze Holdings and start producing London's black taxis in Shanghai. It also aims to sell its affordable small vehicles in the US within several years.

In an effort to get closer to overseas markets, the Chinese players are starting to open overseas factories, too. Chery has assembly operations in Russia, Indonesia, Iran, and Egypt. The company now is planning to extend its reach in South America by opening an assembly plant to produce its Tigo-brand sport-utility vehicle in Uruguay. Brilliance produces vehicles in three overseas factories in North Korea, Egypt, and Vietnam, and Geely has a factory in Russia.

While the current picture of “Going Out” seems promising, Chinese auto export is still far from being a globally competitive force. Comparing with major multinational firms, Chinese firms are still at their infancy in terms of understanding and handling the complexities and challenges associated with operating in overseas markets. The majority of the exports go to emerging markets such as Russia, Iran, South Africa, etc. Furthermore, most of the vehicle exports are one-time market transactions, which in the long run will hurt the prospects of sustainable operations of Chinese firms in overseas markets. About 70% of vehicle export goes to mid-east, Southeast Asia, and Africa. In contrast, 70% of the component export goes to developed markets such as the U.S., Western Europe and Japan. Presently China will continue focus on exports of labor- and raw material-intensive auto parts, trucks, buses and medium and low grade passenger cars. Upon this, high-tech auto parts and complete vehicles under independent intellectual rights are expected to gradually contribute to take a larger proportion in the exports. Large automakers are encouraged to establish assembly factory, R&D center, sales and after service network in foreign countries. In the traditional ICE vehicle fields, technology in China is still 10 to 20 years behind the leading multinationals, especially in the core technologies fields such as engine, chassis, and automatic transmission etc, Chinese firms still have a long way to go.

Potential Entry to the U.S. Market

While getting into the U.S. market remains an ultimate target for many Chinese auto CEOs, it has proven to be the toughest place to enter with any hope of profit. Many firms tried various approaches in the last 3 years or so; we have yet to see a success story.

Chery entered an agreement with Malcolm Bricklin, CEO of Visionary Vehicles LLC in 2005 for exclusive dealership of Chery automobiles in North America market. They planned to set up a dealer network of up to 250 dealers to sell 250,000 cars in 2009. As of June 2006, 75 dealers have committed to invest \$4 million. However, the deal was suspended later in 2006 due to slow development of suitable model for the U.S. market. Chery’s later plan to produce a compact car with a Dodge brand for Chrysler is also delayed and possibly be terminated too due to the same safety and emission concerns. Chrysler instead will turn to Nissan for the small car. Geely Automobile Holdings, Chery’s chief rival, also retreated from a plan begin selling low-cost cars in the United States by 2008

Another high profile attempt is Chamco (China America Cooperative Automotive, Inc); this is a similar venture like Visionary that intends to sell SUV, Pickup trucks, etc built by another private-owned Chinese auto company ZX AUTO China. The company planned to sell a compact pickup truck (estimated price: \$13,250) and a midsize SUV (\$13,750), built in Mexico, in the U.S. by mid-2008. Chamco also plans to have 150 U.S. dealers, sell 75,000 vehicles a year in the first few years of the business and add a sedan and a crossover later on. Chamco promises to help

ZXAUTO reach safety and environmental standards in the U.S. This plan was certainly questioned by the experts in the industry and proved to be another failed adventure recently.

Many other deal and plans are still in the work for future potential market entries to the U.S., however, given the lack of foreign market operational experiences, lack of brand recognition, high regulatory barriers, higher cost of production (labor, materials, utilities, etc) back in China, coupled with much appreciated RMB and a declining U.S. demand. The chance of a successful entry from Chinese auto makers (producing Internal Combustion Engine based vehicles) in the near future is quite low.

The Great Race for New Energy Car

While the entry barriers for traditional ICE based vehicles are hard to overcome for Chinese auto makers, potential breakthrough may actually come from new energy car segment.

At present, energy conservation and environmental protection have represented a new wave of innovations; and the development of new energy technologies becomes an opportunity for China's auto industry to shorten the gap and enhance its international competitiveness. Total investment into this area in China has exceeded 6 billion RMB (about 850 million dollars) for the last 9 years and in the aspect of the new energy driving force technology, auto firms have made certain noticeable achievements.

China's Chaoyue (meaning to surpass) No. 3 fuel cell driven car from Shanghai received four gold medals during the Michelin Challenge Bibendum 2006 being held in Paris in June. The four categories of winning class A is in carbon dioxide emissions, emissions, noise and fuel efficiency. The car only consumes 1.03 kg of hydrogen for 100 kilometers.

This was the result of five years hard-work and the application of proper strategic policy in China's car industry. Starting in 2001, China has decided to put electric car research and development at the top of the agenda of the 10th five year plan key scientific and technological projects. Special attention has been given to manufacturing, researching and developing electric cars, hybrid fuel cars and fuel cell cars. Now China can claim itself ranking among the world advanced countries in car industry and has formed a strategy to transform its car energy system.

China has been short of well trained and experienced people who know all about car manufacturing, new energy and markets for the last two decades. However, in recent years, many returnees such as Wan Gang, who used to work in German Audi quit his job in Germany, returned to China. He was granted as the chief scientist and appointed as the team leader of the key electric car research and development project. They decided to research in the three types of car technologies as well as energy

driving system and batteries key technologies. Meanwhile, they also study policies, regulations and technologies and standards regarding new energy vehicles.

After five years of work, they finally succeeded in producing these three types of cars. Their fuel cell car technology has proved successful amongst the world advanced countries during the Paris competition. Their hybrid buses are used for passenger transportation and can be manufactured with a small scale while the pure electric cars are also manufactured in certain scale and are exported.

The FAW, Dongfeng, Changan and other car-manufacturers are all researching and manufacturing hybrid cars and bus samples which can save gas by 30% and reduce emission by 30% too. Their speed can be as high as 160 and 80 kilometers per hour respectively. Changan Automobile Company Limited's turbocharged hydrogen fueled engine, which is taking the lead in terms of technology in the world and has been ignited successfully, represents the latest achievement made in the application of new energy resources on motor vehicles in China as hydrogen can be directly used energy in such a type of engine.

Of the all the Chinese auto firms that are pursuing new energy cars, perhaps the most significant is BYD, which is promising breakthrough electric vehicle technology through its self-developed ferrous batteries. BYD auto is a subsidiary of BYD group, the leading provider of Nicd batteries (65% global market share) and lithium-ion cell phone batteries (30% global market share).

BYD has only been an automaker since 2003, when it acquired a small car company called Qinchuan Motor. The company's core business is producing batteries for mobile phones – it supplies companies including Nokia and Motorola. Since then it has developed its auto business, selling more than 100,000 cars in China in 2007, and the company sees major synergy between its batteries and its cars.

BYD showed four models at Detroit early in 2008, including the F6 large sedan with BYD's DM (dual mode) electric hybrid system, a technology that the company claims will revolutionize alternative powertrain systems. The F6DM has a range of around 60 miles in electric mode and a further 190 miles when using the petrol engine as a generator to charge the battery pack. And the ferrous batteries have a rapid charge facility - BYD said they can be recharged to 50% of capacity in just 10 minutes, though a full recharge takes 9 hours. It has a top speed of 100 miles per hour and Euro 4 compliant.

The F6DM will go on sale in China later this year, with about 6,000 dollar price premium over the standard ICE F6. The cars won't go on sale in the US until 2010 at the earliest. If succeed, it will be the world's first mass produced "plug-in hybrid", two years ahead of its major competitors in Japan and America at a lower price tag. At the moment, there is a world-wide race in producing the first commercially viable "plug-in hybrid" car. Among about a dozen competitors, GM is planning to offer

Chevy Volt (will be priced at above \$30,000) and Toyota is working on a plug-in model of Prius; both have a target launching time of 2010. The key to the race is the battery technology which BYD claims to have mastered through its own R&D efforts. The lithium iron phosphate batteries are much safer than the common lithium-ion batteries seen in early development efforts.

In summary, Chinese auto firms, especially the independent brand holders, have made significant progress toward producing competitive vehicles for domestic market as well as external markets through licensing, self-development, outsourcing, and acquisition to acquire technologies. However, the real breakthrough may not come from the traditional ICE based vehicles where Chinese firms are perceived to be still 10 to 20 years behind multinational firms. With a coordinated effort from government, independent research centers, universities as well as R&D center established by auto firms, China is not far behind in the area of new energy vehicle technologies. Some firms like BYD may even be among the leaders in offering a commercially viable “plug-in hybrid” and a pure electric car in the near future. Such kind of new technology based vehicles will overcome many entry barriers to the mature markets like the U.S.

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Dr. Tao is an assistant professor of management in college of business and economics in Lehigh University, Bethlehem, PA. He received his Ph.D. in Strategic Management and International Business from University of Pittsburgh in 2004. Started from 1998, his research has been focused on the automobile market in China. His early effort was on the market entry and post-entry development of multinational auto firms in China’s emerging market. More recently, his research interests rest on the outward auto FDI from China to external markets. He is also an active researcher of the IMVP (International Motor Vehicle Program) hosted by MIT and Wharton School.

As a dedicated researcher and independent observer of the Chinese automobile market, Dr. Tao has been travelling extensively in China and established contacts with auto executives, industry experts, auto-focused research centers as well as universities. He has been to most of the major auto shows in China and participated in key industry forums in recent years. Overtime, he has built a significant data archive regarding the history as well as the current development of China’s auto market.

Dr. Tao teaches Strategic Management at Lehigh University for MBA and undergraduate students. He is a member of Academy of Management, Academy of International Business and Strategic Management Society.