Foreign Technology in China's Automobile Industry: Implications for Energy, Economic Development, and Environment

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Although there are still relatively few cars in China today, with the accession to the World Trade Organization demand for passenger cars is expected to grow substantially during the coming decades. To tap into this exploding market and acquire more advanced technology, all the major Chinese auto manufacturers have established joint ventures with foreign companies. This paper explores the role of foreign automakers—particularly the Big Three (Ford, General Motors, and DaimlerChrysler)—in transferring technology. Although these foreign firms have helped to modernize the automobiles on the road today, emissions control and fuel efficiency technology installed in Chinese cars is considerably behind European, Japanese, and U.S. levels. Foreign firms and the Chinese government share the responsibility to correct this laggardness.

Ask urban Chinese residents if they would like to own a car and most will surely give you an affirmative answer. The prospect of millions of Chinese car buyers has propelled foreign and domestic auto manufacturers to pour billions of dollars, mostly during the last decade, into developing a vibrant automobile industry in China.[1] Yet, as automobile production surged upward during the 1990s, questions started to arise about the implications of such explosive growth in the Chinese automobile industry. In particular, policymakers, researchers, and environmental organizations in China and abroad have begun to discuss the connections and trade-offs among economic development, energy use, and environmental quality.

Although few Chinese can actually afford to purchase cars now, a substantial potential demand for vehicles is likely to emerge in the future. Indeed, an unprecedented spike in demand for cars occurred during the first six months of 2002 when sales increased a whopping 40 percent over the same period in 2001. Despite the increased sales over the past two years, with 20 percent of the world's population, Chinese citizens still own only 1.5 percent of the total number of cars in the world. This stands in stark contrast with the United States where Americans own 25 percent of the world's cars with only 5 percent of the population. Put another way, China currently has about the same number of cars per person as the United States did in 1913 (David & Diegel, 2002).

The role and influence of foreign technology in the Chinese automobile industry has varied considerably during the past century, partly because Chinese government leaders have been inconsistent about whether or not to foster a vibrant automobile sector in China and what role foreigners should play in this development. Despite uncertainty among policymakers, during the past 20 years every major Chinese automobile company has formed at least one joint venture with a foreign firm to acquire more advanced technology. The effectiveness of the subsequent technology transfer, however, is not well understood. This paper will explore four core questions to understand the breadth and impact of foreign auto firm investments in China:

- Are Chinese auto firms learning from their foreign partners?
- Are foreigners contributing to the modernization and development of the industry?
- What are the energy and environmental implications of having many more cars on the road?
- How are foreign firms contributing to or helping to solve these environmental and energy problems?

To shed light on these questions, this paper will first explore the energy, economic development, and environment dimensions of increased automobile usage in China. Then, the role of foreign technology during the historical development of the industry will be examined before turning to summaries of three case studies on the Big Three's (Ford, General Motors, and DaimlerChrysler) joint ventures and other activities in China. Possible lessons will be considered at the end of the paper.

IMPLICATIONS OF AUTOMOBILE USE IN CHINA

Economic Development Dimensions

Undoubtedly, the Chinese government's decision to make the automobile sector a mainstay of the economy has greatly contributed to economic development in China. A huge amount of foreign direct investment (FDI) has poured into the sector, and there were 1.5 million Chinese employed by this industry as of 2001. The Chinese auto industry contributed $12 billion to the economy in 2001, representing 5 percent of the total value-added of manufacturing in China, a near doubling of this percentage from its level in 1990 (CATARC, 2002).

During the 1990s, China received more foreign investment than any other developing country ($38.4 billion in 2000 alone) as investors sought to reap some of the gains of China's fast-growing economy. Much of this foreign investment in China was in the automobile industry. By 2001, more than 800 Chinese companies in vehicle-related industries had received FDI and the total agreed investment was valued at $233 billion with actual registered capital of $12 billion (Zhang, 2002).[2]

Foreign direct investment in the automobile sector has contributed to the economic success of this industry in China in a number of ways. It has created desirable and stable jobs for Chinese workers in the joint venture firms and strongly benefited the wider economy especially through spillovers into the parts and components sector. By having to meet the requirements of the foreign-invested joint ventures, Chinese parts suppliers were forced to improve the quality of their products, reduce costs, and become more competitive exporters.

On the other hand, FDI is not always positive for the recipient country. For example, one study concluded that foreign investment rarely stimulates new economic development in developing countries because FDI tends to follow, not breed success (Amsden, 2001). Perversely, there appears to be an inverse correlation of domestic skill formation with foreign investment in developing countries: *high* levels of FDI are associated with *low* levels of domestic skill formation. This is because multinationals often supplant domestic technology providers and reduce the need for more domestic innovation.

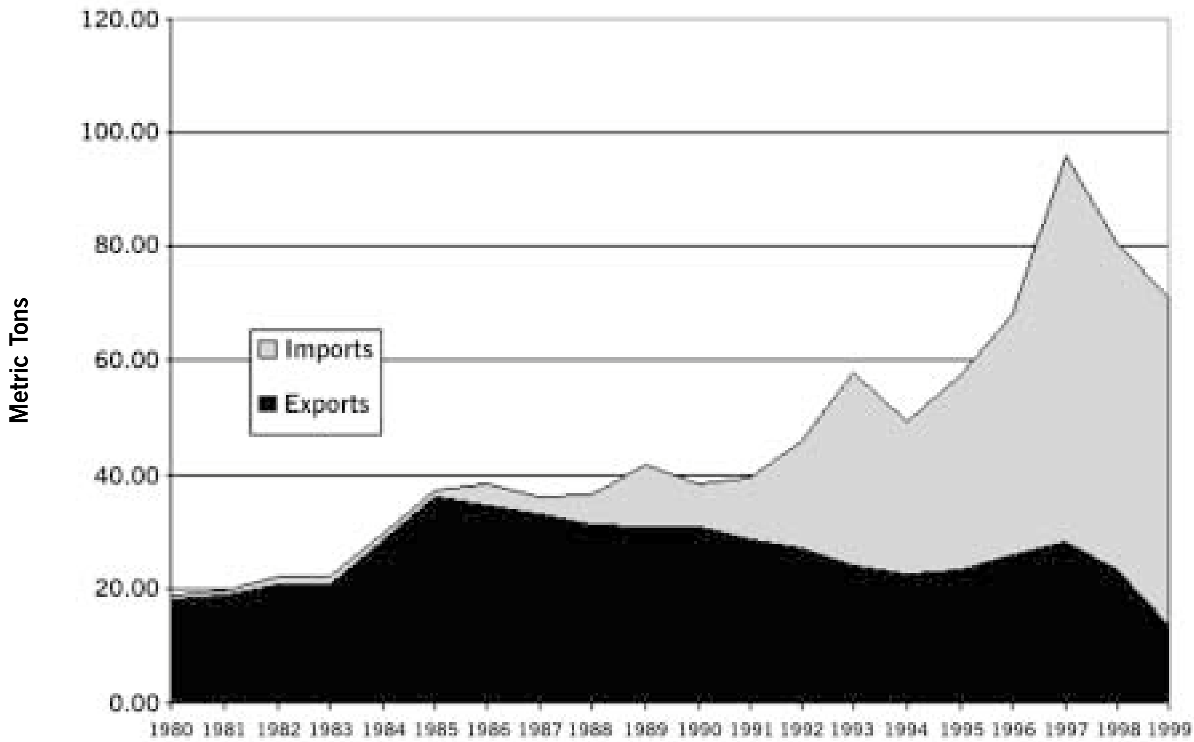
There is some evidence that FDI in the Chinese automobile industry has indeed reduced the incentive for indigenous Chinese technological innovation in the automobile industry, and this may hurt the economic prospects of the industry in the longer term. But FDI cannot bear the entire brunt of the blame. The Chinese government's policies towards the sector have been inconsistent and sometimes contradictory. Moreover, local governments who own most of the Chinese auto companies have been resistant to central government intervention to strengthen the sector.

China's entry into WTO will force its auto manufacturers to "sink or swim" in the international market. Most of the joint ventures are frantically trying to improve the quality and price of their cars while some tariff protection remains. For many Chinese manufacturers, the outlook is not good because most even cannot compete in the domestic market against the joint venture firms. If many of the domestic car firms disappear, significant unemployment and labor market dislocations could occur. Some of the Chinese partners in auto joint ventures have acquired respectable product manufacturing capabilities, but they still lack design capabilities and thus have not achieved technological independence. Unshielded exposure to the international market will probably condemn China's domestic auto manufacturers to foreign reliance unless the government can devise alternative methods to build up local technological and business skills and thereby give Chinese manufacturers more bargaining and market power. Already the government is experimenting with new tariffs that essentially create the same incentive to localize parts and components, as did the government's requirement for joint ventures to use 40 percent local content.

It is certainly in China's economic interest to insure its automobile industries survive the country's entry into WTO. The sector's potential is exemplified in the United States where the auto industry claims that it and related industries provide one out of every seven American jobs (but only about 600,000 direct auto manufacturing jobs) (Alliance of Automobile Manufacturers, 2001). If China cannot develop its own capabilities, it will lose many such economic benefits. Cars assembled in China with foreign technology will help retain employment and tax revenue from sales. However, if Chinese auto manufacturers could become leaders in their own right without using technology transfer from the joint ventures, a greater share of the profits (that would otherwise be lost to the foreign companies) could be retained and reinvested to strengthen the auto sector. While the emergence of a strong, self-sufficient Chinese auto industry is not plausible in the short term, a middle ground solution for China would be to find incentives to make the foreign companies commit to the joint ventures more heartily, reinvest their profits, train Chinese workers more thoroughly, and view China as a potential source of innovative ideas.

As important as the automobile industry is to China's economic development, the environmental costs of automobile use may offset some of the economic benefits.

Figure 1. Chinese Imports and Exports of Crude Oil and Petroleum Products



Source: Lawrence Berkeley National Laboratory, Energy Research Institute 2001

State Environmental Protection Administration (SEPA) Minister Xie Zhenhua has stated that the costs of all forms of pollution to China's economy could equal 4 to 8 percent of annual GDP (U.S. Embassy, 2000). Air pollution from motor vehicles is a growing source of these costs.

In addition, the costs of substantial oil imports cannot be ignored. Oil imports are already expensive for China and are also one of the biggest drains on China's foreign exchange reserves. If China becomes a major importer of oil, world oil prices would probably rise in response to this vast increase in demand. Increasingly, China probably also will be forced to use valuable resources defending oil shipping lanes and contributing to political stability in the Middle East.

Energy Dimensions

Any visitor to one of China's big cities cannot help but notice that these cities are already jammed with vehicles. Most of China's eight million passenger cars are used in cities. In fact, 17 percent of China's cars are located in Beijing, Shanghai, Chongqing, and Tianjin (CATARC, 2002). These urbanites are not just puttering around the city—they also seem to enjoy hitting the open road. Beijing alone reportedly has thirty automobile clubs including one called the "Off Roader 4WD Club" (Liu, 2002) where people gather to drive their rugged vehicles long distances over the countryside.

Despite the traffic-jammed streets in major cities, there are still relatively few cars on the road in China. Automobiles do not currently consume very much energy in China—as of 2000, the entire transportation sector only consumed seven percent of commercial energy supply (EIA, 2002a). Thus, energy-related concerns about cars in China arise primarily regarding *future* automobile oil consumption.

Mostly because of the rising popularity of automobiles, both oil consumption and oil imports grew rapidly during the 1990s, which was central to China's shift to become a net oil importer in 1993. China is not well endowed with oil reserves. Traditionally, oil was mainly used in industrial boilers and a few power plants, which explains the previous low import rates. (See Figure 1). By 2000, total Chinese automobile oil consumption equaled total oil imports at about 1.2 million barrels a day (bbls/day) (B. Xu, 2002). As of 2001, imports had risen to a net 1.6 million bbls/day (compared with 10.6 million bbls/day for the United States). Already, China imports a greater percentage of its oil from the Middle East than the United States—almost half (48 percent) of

China's current imports come from the Persian Gulf region compared with just one quarter of U.S. imports. Given its increasing dependence on oil, China has predictably signed major oil exploration and production contracts (worth at least $5.6 billion) with Peru, Sudan, Iraq, Venezuela, and Kazakhstan during the past ten years to assure themselves sufficient oil supplies in the future (McGregor, 2000; X. Xu, 2000).

Because automobile ownership in China is relatively low, China's future oil consumption could vary depending on three simple variables: how many people will buy cars, what is the fuel economy of those cars, and how many miles the cars are driven each year. Three general scenarios (see Table 1) include:

Best-case scenarios. China's vehicle oil consumption in 2020 could be less than 1 million barrels per day if:

1) China's steady growth in automobile sales is considerably slower than it was on average during the 1990s (perhaps because good public transportation alternatives are provided);
2) Fuel economy is doubled from the current average U.S. fuel economy (to 50 mpg, which is about the same as currently-available hybrid-electric cars); and,
3) Chinese car owners drive only 5,000 miles each year,

Table 1. Scenarios for Chinese Passenger Vehicle Oil Consumption in 2020

Scenarios	Assumptions	Number of Cars (Millions)	Average Fuel Economy (mpg)	Miles Driven Per Year	Oil Consumption (Million bbls/day)
Best Case	Low Growth, High Efficiency, Low Miles	45	50	5,000	0.3
	Low Growth, Medium Efficiency, Medium Miles	45	35	7,500	0.6
	Low Growth, Low Efficiency, Medium Miles	45	24	7,500	0.9
Midrange	Medium Growth, High Efficency, Low Miles	110	50	5,000	0.7
	Medium Growth, Medium Efficiency, Medium Miles	110	35	7,500	1.5
	Medium Growth, Low Efficiency, Low Miles	110	24	5,000	1.5
	Medium Growth, Low Efficiency, Medium Miles	110	24	7,500	2.2
	Medium Growth, Low Efficiency, High Miles	110	24	11,000	3.3
	High Growth, High Efficiency, Low Miles	245	50	5,000	1.6
	High Growth, Medium Efficiency, Medium Miles	245	35	7,500	3.4
	High Growth, Low Efficiency, Medium Miles	245	24	7,500	5.0
High Growth	Very High Growth, High Efficiency, Low Miles	830	50	5,000	5.4
	Very High Growth, Medium Efficiency, Medium Miles	830	35	7,500	11.6
	Very High Growth, Low Efficiency, High Miles	830	24	11,000	24.8

Source: Author's calcuations based on the following assumptions:

Low Growth (10% annually) is much slower growth than actual average in China (actual was 18%).
Medium Growth (15% annually) is about the actual average 1990s growth in China (actual was 18%).
High Growth (20% annually) is half as fast as the annual growth rate from 2001-2002 in China (which was 40%).
Very High Growth assumes there are as many vehicles per person in China as there were in the U.S. in 2001.
Low Efficiency assumes that the fuel economy in China in 2020 is equal to 2002 U.S. average fuel economy.
Medium Efficiency assumes a 2% improvement in fuel efficiency each year for 17 years.
Medium Miles is the approximate number of miles currently driven in Japan each year.
High Miles is the approximate number of miles currently driven in the U.S. each year.

significantly less than their Japanese counterparts, who drive 7,500 miles a year.

Midrange scenarios. China's vehicle oil consumption could be between 1 to 5 million barrels per day in 2020 if: (1) The growth in automobile sales stays fairly constant from what it was on average during the 1990s (15-20 percent per year) until 2020; and (2) either fuel economy improves or the number of miles driven is held to at least 5,000 miles per year. Table 1 shows that within the midrange, total vehicular oil consumption could vary considerably depending on the various combinations of levels of fuel economy and number of miles driven.

High growth scenarios. The most extreme scenario assumes that: (1) there are as many cars per person in China in 2020 as there were in the United States in 2001; (2) the average fuel economy of Chinese cars in 2020 is equal to the average fuel economy of U.S. cars in 2001; and (3) Chinese drivers drive as far as U.S. drivers do each year. The resulting oil consumption from Chinese automobiles in this high-growth scenario could reach 24.8 million barrels per day.

These scenarios illustrate that China's future vehicle oil consumption is highly dependent on how fast the automobile sector grows, how fuel-efficient vehicles are in 2020, and how far the cars are driven annually in the future. Aside from these three variables, there are many other factors that will affect China's future oil consumption, such as the price of fuel and the degree to which alternative methods of transportation are used. For the sake of comparison, it is helpful to look at other estimates of future Chinese oil consumption to see how they compare. The U.S. Energy Information Administration's International Energy Outlook 2002 projects China's total oil consumption (including vehicle oil consumption) in 2020 to be between 7 and 12.8 million barrels per day, depending on the rate of China's economic growth (EIA 2002b). Narrowing in on motor vehicles more specifically, a 2001 Argonne National Laboratory study estimated that Chinese vehicles would consume between 4.5 and 6.6 million barrels per day of oil by 2020 (He & Wang, 2001).

There are also security dimensions to China's rising oil imports that not only affect China but also many other countries in the world. If, for example, China becomes extremely dependent on oil from the Middle East, it also will have to take a major security interest in a region that has long been of significant interest to the European Union, Russia, and the United States. China's oil dependence thus would require close cooperation between these four giants. The Chinese government also is likely to be even more territorial about oil and gas reserves off China's coast and in the South China Sea. The rights to some of these possible reserves have long been in dispute with some of Chinese neighbors.

Environmental Dimensions

The most immediate environment and health problem related to automobiles in China is urban air pollution. There is increasing evidence that motor vehicles are now the primary source of urban air pollution in China, which was not the case even ten years ago. Heating, cooking, power generation, and industrial coal consumption used to be the main contributors to urban air pollution, but in the biggest cities coal was mostly replaced by natural gas for residential uses during the 1990s.[3] Power plants are still a significant source of urban air pollution as well, but many of these are being relocated outside of the cities. Seven of the ten most polluted cities in the world are located in China; caused in great part by growing auto emissions. For example:

- In Beijing, the site of the 2008 Olympics: 92 percent of the carbon monoxide (CO) emissions, 94 percent of the hydrocarbon (HC) emissions, and 68 percent of the nitrogen oxides (NO_x) emissions are attributed to automobiles during the warm seasons. Even during the cold winter months the majority of the emissions come from automobiles (76 percent of CO, 94 percent of HC, 68 percent of NO_x) (GEF, 2001).
- In Shanghai, vehicles are responsible for 90 percent of CO, 70 percent of HC, and 50 percent of NO_x emissions as of 1999 (Ma, 2002).

In general, vehicles are estimated to account for 85 percent of CO emissions and 45 to 60 percent of NO_x emissions in typical Chinese cities (Walsh, 2000). A recent study estimated that CO and HC emission factors for Chinese cars in use are 5 to 10 times higher than those factors in developed country cars; while NO_x emissions from Chinese cars are 2 to 5 times higher (Fu, Hao, He, He & Li, 2001).

The high emissions from autos in China are due to the lack of environmental control measures. For example, prior to 2000, emission standards for automobiles did not exist, leaded fuel was still widely used, and catalytic converters were not installed on cars. In 2000, the Chinese government banned the use of leaded fuels, required catalytic converters, and adopted the European system for controlling automobile emissions, requiring all new

Table 2. Comparison of Air Pollution Emission Standards for Gasoline Passenger Vehicles (grams/km)

Country, Year	CO	HC	NO_x	CO_2
Euro I, 1992	4.05	0.66	0.49	none
China, 2000	4.05	0.66	0.49	none
Euro II, 1994	3.28	0.34	0.25	none
China, 2004	3.28	0.34	0.25	none
Europe, 1995*				187
U.S. Tier 1, current	2.6	0.16	0.37	none
Euro III, 2000	2.3	0.2	0.15	
Euro IV, 2005	1	0.1	0.08	
U.S. Tier 2, 2007	1.3	0.01	0.04	none
Europe, 2008*				140

*Separate and voluntary standard; [A] There are different "emission bins" for the NO_x standard but the fleet has to average at the number provided. There is an interim NO_x standard of 0.3 g/mile that eases the transition until 2007 and it is gradually phased out between 2004 and 2007.

Sources: European Commission, "Emission Standards for Road Vehicles," EU Energy & Transport Figures, http://europa.eu.int/energy_transport/etif/environment/emissions_cars.html; Bearden, David, "EPA's Tier 2 Proposal for Stricter Vehicle Emission Standards: A Fact Sheet," CRS Report for Congress, #RS20247: (www.ncseonline.org); Interview with Li Pei, China State Environmental Protection Administration, May 16, 2002.

cars to meet EURO I standards, which were required of European automobile manufacturers in 1992. In 2004, China will require cars to meet EURO II standards, which match 1994 standards in Europe. Thus, Chinese auto emission standards lag European levels by ten years. In this area, China is lagging behind U.S. levels even more because vehicular air pollution emission standards are more stringent in the United States than in Europe, especially with respect to diesel emissions. (See Table 2).

One of China's most ambitious initiatives to address automobile pollution is the national Clean Vehicle Action program. SEPA and the Ministry of Science and Technology (MOST) established this program in 1999 with the target of having 10 percent of all taxis and 20 percent of all buses in 12 cities run on alternative fuels such as clean natural gas (CNG) or liquefied petroleum gas (LPG) by 2001. Although an estimated 129,000 alternative-fuel capable vehicles (AFVs) were on the road by May 2002 (most of them retrofits), it is not clear how many of them actually use the alternative fuels because there has been no systematic monitoring or enforcement (Zhao, 2002). In Shanghai, adoption of LPG fuel has been widespread among the taxis because the government subsidized the price of LPG fuel. Ninety percent of the 42,600 taxis in Shanghai are retrofitted Volkswagen (VW) Santanas but, astonishingly, one municipal official recently acknowledged that most of these so-called "clean" vehicles do not even meet the basic EURO I standard because of a 30 percent increase in NO_x emissions (Ma, 2002). Since the alternative fueled vehicles cannot even meet the minimum air pollution standards for regular vehicles, this program cannot be considered a success.

Another significant concern related to automobiles and the environment is carbon dioxide emissions, a potent greenhouse gas thought to cause global climate change. Industrial and auto emissions have already made China the second-largest emitter of greenhouse gases, after the United States. Today, this environmental problem raises less immediate concern for Chinese citizens than local air pollution issues, but over time climate change probably will pose one of the biggest challenges to automobile use in China (and the rest of the world). One key way to reduce greenhouse gas emissions from vehicles is through fuel efficiency, for carbon dioxide is a natural byproduct of burning gasoline in car engines and unlike other common air pollutants it cannot be lowered by a catalytic converter. China currently has no fuel efficiency standards, although they are reportedly under development.

As Chinese policymakers and research institutes form fuel efficiency standards, they can learn from the mistakes in the U.S. experience. In the United States (like much of the world), transportation is the fastest growing sector for energy consumption and greenhouse gas emissions because fuel prices have remained relatively low and government regulations to reduce automotive fuel consumption have been stagnant for decades. As a result, U.S. vehicles are not becoming more fuel-efficient. Compounding the problem is the fact that Americans are driving their cars farther and farther each year (in part because of the persistently low gas prices).

Because Chinese consumers have limited disposable income, they rate fuel economy among their top concerns when purchasing a vehicle, which provides some incentives for auto manufacturers to produce more fuel-efficient cars. General Motors (GM) actually decided to improve the fuel economy of its Buick *Xin Shi Ji* (New Century) luxury sedan in order to make its product more competitive in China because this model had acquired a reputation of being a gas-guzzler. None of the other foreign manufacturers, however, have improved the fuel economy of their models. Two U.S. manufacturers introduced the following notoriously inefficient sport-utility vehicles (SUVs) to China: the Jeep Cherokee, Chevrolet Blazer, and Chevrolet S-10 pick-up. On the bright side, U.S. manufacturers also are introducing fuel-efficient compact cars as well.

Foreign Technology in the Development of China's Auto Sector

Foreign technology has influenced the development of China's automobile sector for a long time, but its impact has been most pronounced during the last decade. The speed of change in auto production in China is a surprising story—only forty years ago in 1963 China produced a grand total of eleven cars. Twenty years later, production was still less than 10,000 passenger cars each year (Harwit, 1995), but by the year 2002 more than a million Chinese-made cars were sold in China.

In order to make this profound transformation, China had to quickly acquire the necessary knowledge and technological capabilities for automobile production. Twice—in the early 1900s and in the 1970s—starting with little infrastructure and no industry policy, Chinese leaders were faced with a classic "make or buy" technology dilemma. Would it be better to try to develop automobile production capabilities indigenously or was China too far behind the world leaders for this to ever be feasible? What could it hope to obtain from foreign providers of technology? A historical perspective reveals that the government has been highly inconsistent regarding these questions.

Early Fits and Starts

The Pre-War Era

An important precondition for successful economic development in "late-industrializing" countries like China is the acquisition of pre-World War II manufacturing experience. Such long-term manufacturing experience provides many obvious benefits for industrializing countries and builds confidence among foreign investors that their speculation will pay off (Amsden, 2001). Just before World War II, a number of pockets of manufacturing industries cropped up along China's eastern coast. These manufacturers were most concentrated in northeast China (known then as Manchuria) and in the handful of free-market "treaty ports" that had been set up by foreigners (Fairbank, 1951). This manufacturing experience was closely linked with the knowledge brought by the Japanese in Manchuria (when they controlled northeast China starting in 1931) and the Europeans and Americans in the treaty ports.

With respect to the automobile sector, China had meager pre-war manufacturing experience. In the early 1900s, vehicles were all imported, mainly inundating the Shanghai market. The Chinese business and political elite drove these cars. For example, revolutionaries and rivals Sun Yatsen and Zhou Enlai are both reported to have driven Buicks during their time. It was expensive for the foreigners to ship these burdensome products to China so a few parts and components companies sprang up in Beijing, Tianjin, and Shanghai to provide some of the heavy components for vehicles. In these three cities, several crude assembly plants also were established to put foreign and domestic parts together (Harwit, 1995). Not surprisingly, these three cities became centers of automotive expertise in the late twentieth century.

Despite the growing number of assembly and part plants, foreign companies did not invest in China at that time as they were doing in other developing countries. For example, GM built an assembly plant in India in 1928 and another in Brazil in 1929 but merely opened company offices in Shanghai that same year.

Meanwhile, some Chinese companies were acquiring manufacturing experience in other sectors that would trigger future technology transfers into the automobile sector. The current Chang'An Automobile Group was actually founded as the Shanghai Western-Style Artillery Bureau in 1862—established as part of the Qing Dynasty's "westernization" experiment. Using its experience with artillery production, Chang'An gradually began manufacturing other types of machinery and produced its first vehicle in 1958 using technology imported from the Soviet Union.

Closed Doors and Campaigns

After the triumph of Chairman Mao Zedong's communist revolution, China relied heavily on its northern neighbor and ally, the Soviet Union, for a broad-range of technical assistance. In the motor vehicle industry Mao wanted the capacity to transport rural products and military supplies, so the Soviets helped start China's First Auto Works (FAW) in 1953 in the northeast city of Changchun where there were remnants of manufacturing infrastructure left behind by the Japanese. The first product produced by FAW was the *Jiefang* (liberation) truck, a version of the Soviet ZIS 150 model (Harwit, 1995). The Soviets also transferred the SUV design to Chang'An. Amazingly, this basic design dating back to the 1950s is still in production at DaimlerChrysler's Beijing Jeep joint venture. First Auto Works produced its first passenger car in 1958—the *Hongqi* (Red Flag) black sedan was based on Daimler Benz's 200 model and served as limousines for the government elite.

These foreign collaborations came to a sudden stop after the Sino-Soviet split in 1960, when Mao halted all foreign technology transfer and assistance into China. The Chinese automobile sector was thus cut off from technology and foreign investment for a crucial *two decades*—years in which the Japanese and Korean auto manufacturers built up their own indigenous capacity to challenge the North Atlantic automobile firms. Indeed, Japanese firms were not all that far ahead of the Chinese in the 1950s. For example, Nissan produced only 865 passenger cars in 1950 (Halberstam, 1986), while the Chinese annual production in the late 1950s was less than 100 (Harwit, 1995).

Development of the automobile industry also was hindered by central government policies, especially the Great Leap Forward campaign (1958-1960). Instead of consolidating companies and taking advantage of mass production techniques as European and American auto companies were doing, the Chinese government's aim was to stimulate small-scale industrialization throughout rural areas. After the Great Leap Forward, the "Third Front" campaign was promulgated in 1964 to promote self-reliance and develop an inland industrial and military base. During these years, heavy industry was decentralized and dispersed around the country to make factories more immune from attack and to prepare for a potential war. By 1969, there were 33 automobile factories producing a grand total of 150 cars (Harwit, 1995). Many of the Third Front auto factories are still in place, including the famous Shiyan Number Two Automobile Factory in Hubei province (Shapiro, 2001) now known as Dongfeng Automobile Company (Zhang, 2002).

Essentially no passenger cars were produced during the Cultural Revolution (1966-1971) and according to government statistics there was also no investment in the automobile industry (CATARC, 2002).

Second Infancy

China's automobile industry experienced a second infancy after the country reopened its doors to the world in the 1970s. In the motor vehicle sector much expertise had been forgotten or lost and since the early 1960s there had been little or no development of new technologies, cultivation of skilled and creative workers, or acquisition of technological capacity. Realizing they needed new vehicles, but hesitant of becoming totally reliant on imports, China's government decided to reach out to foreign companies through technology licensing and the formation of joint ventures. Initially, China asked the Japanese for help, who responded by exporting a large number of trucks and providing some technical assistance to the Chinese during the early 1970s (Harwit, 1995). However, the Japanese were wary of generating a potential competitor so the extent and duration of their technology transfer was limited.

After opening up the economy in the late 1970s, the *first* major manufacturing joint venture to be established was the Beijing Jeep joint venture signed between the state-owned Beijing Automobile Industry Corporation (BAIC) and American Motors Corporation (AMC) in January 1984. Shortly after its establishment, a second joint venture was cemented between the Shanghai Automotive Industry Corporation (SAIC) and VW in October 1984. Chinese companies also licensed technology from foreign firms, of which two prime examples are the ubiquitous compact cars used as taxis in many major cities. Tianjin Automotive Industry Corporation licensed technology from Daihatsu in 1986 to produce the *Xiali* (Charade) mini-sedan often seen in use as the red taxis in Beijing and Tianjin. Similarly, Chang'An licensed technology from Suzuki in 1983 to produce its own mini car, which is also used as the yellow taxi in Chongqing (Chang'An Automobile (Group), 2002).

Trying to Learn from Foreigners

After this flurry of activity in the 1980s, the government began to reconsider its strategy. China had not gained much knowledge from the foreign firms that essentially selected what would be transferred and how, without necessarily teaching their Chinese partners anything significant. The only real requirement for the foreign companies was to get the technology into production—there were no specific stipulations on technology transfer. For example, while the government wished to increase passenger cars, as late as 1990 very few were actually being produced—only accounting for less than ten percent of total vehicle output (Zhang, 2002). There existed many differing views within the government about whether China should try to foster its own domestic industry or whether it was too late to catch up with the foreign firms.

As the government mulled over these questions in the early 1990s, two new joint ventures were formed: one between VW and First Auto Works to produce Jettas in 1990 and the other between French Citroen and Second Auto Works (now Dongfeng Auto Company) to produce the *Fukang* compact in 1992. With or without a clear policy, auto manufacturers were coming into China. The time had come for the Chinese government to shape this investment to meet its domestic goals.

1994 Auto Policy

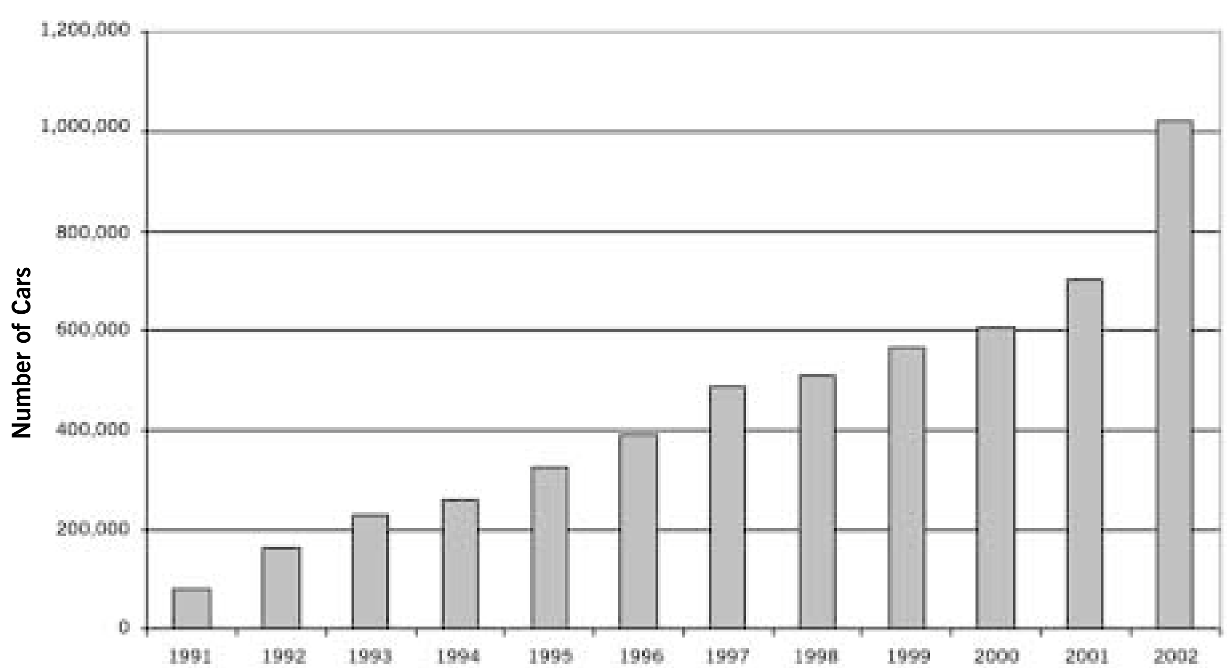
China's government officials finally reached agreement and issued the first real industrial policy for the automobile industry in 1994. This policy took a radically different approach from the defacto policy of the 1980s in two main ways:

1) Consolidation. The new policy sought to consolidate the dozens of automobile companies into a few powerhouse firms akin to the "Big Three" model in the United States. More precisely, the Chinese government was striving for a 'Big Three, Mini Three' arrangement, intending focus most of its own energies and investment on those six companies.

2) Protectionism and technology transfer. The Chinese government also decided to protect all manufacturers located in China (including joint ventures) from international competition by establishing import quotas and stiff tariffs (80 to 100 percent) on both vehicles and parts. Foreign ownership in joint ventures was limited to fifty percent to give the Chinese partners more control and bargaining power. Another major change was the placement of specific requirements on foreign investors. For example, all joint ventures must localize their parts and components by at least forty percent (and powerful incentives were created to go beyond compliance). Foreign firms vying for new joint ventures were asked to transfer more knowledge to their partners and they were told to establish joint technical centers for training Chinese workers.

The above requirements did not seem to deter the next foreign investors in China in the least. After the 1994 policy was issued, almost every big multinational automobile firm bid on a project to establish a joint venture with Shanghai Auto Industry Corporation (SAIC), which is considered by many to be the best Chinese passenger car company. In the end, General Motors made the largest single foreign investment ever into China when it established its $1.2 billion joint venture. Although the $1.2 billion figure is often reported, GM's total registered capital in China was actually only

Figure 2. Passenger Car Production in China (1991-2002)



Source: CATARC, 2002 Auto Industry of China; China Auto (January 2003)

$350 million, which is still very large by comparison with other foreign investors (Murtaugh, 2002). Also in 1997, Honda took over Peugeot's troubled joint venture with Guangzhou Automotive Manufacturing Company and Ford entered into negotiations with Chang'An in 1999.

There was a veritable flood of investment into the automobile sector during the 1990s from the Chinese government and foreign sources. According to government statistics, total agreed investment into the automobile and related industries from all sources totaled nearly $60 billion during the 1990s. To put this in perspective, total investment from 1953 to 1989 equaled only $1 billion, and 88 percent of that amount was invested during the mid to late 1980s (CATARC, 2002).

Rapid Growth But Continuing Small Scale

Although both domestic and foreign investment in China's automobile industry began in earnest during the 1980s, substantial growth in production and sales did not occur until the mid-1990s. As late as 1991, only 81,055 cars were produced, but this number doubled in 1992, and continued to grow rapidly. During the 1990s, the average annual growth rate of passenger car production was 27 percent. This means passenger car production was doubling about every two and a half years. For a few companies, the growth has been positively dramatic. Between September 2001 and 2002, sales grew 61 percent for FAW-VW, 101 percent for SAIC-Chery, 113 percent for Shanghai GM, and 123 percent for Dongfeng Auto Company (China Automotive Research & Technology Center, 2002). (See Figure 2).

It is easy to be impressed by such numbers because new retail auto sales in the United States grew on average only 0.3 percent each year during the 1990s (David & Diegel, 2002). But, total production numbers tell a completely different story. In 2000, 17.2 million new cars were registered in the United States compared with just 612,000 cars produced in China. Most automobile companies in China still produce less than 100,000 vehicles a year, so the total vehicle stock is still very small. By 2002, there were only 8.5 million passenger cars in China compared with 179 million in the United States.

In retrospect, the 1994 reforms had mixed results. The consolidation of the automobile industry into a handful of big firms was not realized. Instead of the intended six major firms, there are 13 large automobile companies out of the total 118 manufacturers. The high degree of protection given to the industry by the government was not repaid by concerted and effective efforts within the industry to become more competitive in the world market. Today, only a handful of passenger cars are actually exported from the country. Most manufacturers ruefully admit that their cars are of inferior quality and much more expensive than the foreign competition. On the other hand, the policy did effectively force manufacturers to localize a high percentage of their parts and components, creating thriving spillover industries. For example, in 1994 the localization rate for the VW Jetta was only 24 percent but by 2000, it had reached 84 percent (Huang, 2002).

Thrust into the Unfettered Free Market

Entry into WTO is expected to shock the Chinese automobile industry more than any other sector of the Chinese economy with the exception of agriculture, which is expected to lose 9.6 million workers. Highly protected sectors like automobiles, cotton, and wheat will contract significantly while labor-intensive open sectors such as textiles and clothing will be the main beneficiaries of the open markets (Li & Wang, 1998). The terms of entry into WTO for China were very specific regarding the automobile sector:

- Reduce import tariffs for complete vehicles from the current 80-100 percent to 25 percent by 1 July 2006;
- Reduce import tariffs for parts and components from 35 percent to 10 percent by 1 July 2006;
- Decrease import quotas on vehicles 15 percent per year until they are cancelled in 2005;
- Phase out import licenses by 2005;
- Eliminate all government requirements for foreign automakers regarding technology transfer, maintaining a foreign exchange and trade balances, and meeting localization standards; and,
- Give provincial governments the authority to approve foreign direct investment projects up to $150 million by 2005.[4]

Given the resistance of Chinese automobile firms to reform and change, it was most likely a deliberate strategy on the part of the central government to concede their protections of this industry. Thus it appears the Chinese government may once again have reversed course with respect to its automobile industrial policy. Whether the industry can withstand the withering competition from abroad is an open question. It seems almost inevitable that Chinese automobile companies will become even more reliant on their foreign partners for advanced technologies and management expertise. An examination of how Chinese manufacturers are working with the Big Three U.S. automakers may help gauge the future strength and viability of China's domestic industry, as well as the potential for advances in pollution control technology.

Case Studies of The Big Three in China

Beijing Jeep

Beijing Jeep Corporation (BJC) was the trailblazer for automobile joint ventures in China. American Motors Corporation (AMC) originally initiated this joint venture in 1983. Chrysler later bought AMC and eventually merged with Daimler-Benz to become DaimlerChrysler AG in 1999. Each successive foreign owner assumed ownership of the minority foreign stake in Beijing Jeep. Beijing Automobile Industry Corporation (BAIC), owned by the Beijing municipality, has remained the sole Chinese partner throughout the 20-year history of the joint venture.

There was a strong motivation for the joint venture back in the late 1970s. BAIC was producing the BJ212 utility vehicle (now called the BJ2020), a Soviet technology given to China back in the 1950s. This World War II-era utility vehicle was dated and ill suited to the Chinese military's needs. The military wanted a modern soft-top four-wheel drive vehicle. In addition, the Chinese government hoped BAIC would learn enough from AMC to produce a 100 percent Chinese-made vehicle.

As it entered into negotiations with BAIC in the early 1980s, American Motors Corporation was in financial trouble at home. American Motors Corporation saw in BAIC the potential of a vast market, incredibly low labor costs, and a potential export base for East Asia (Halberstam, 1986; Mann, 1997). AMC was perhaps too optimistic because even though China had a billion people, almost none of them could afford to buy a car, much less a four-wheel drive Jeep.

On 5 May 1983, AMC accepted a minority stake in the joint venture for a term of twenty years. Of the total $51 million in equity, Beijing provided $35 million (mostly in equipment assets worth 69 percent) and AMC provided $16 million (half of which was the contribution of technology). The plan was to continue production of the BJ212s for the first five years, introduce AMC's Jeep Cherokee XJ model, and work on developing the canvas-top military vehicle to be introduced later. The Cherokees were initially to be assembled from complete knockdown kits (CKDs) imported from the United States.[5]

Production got off to a rocky start and almost crashed to a halt in 1986 when Beijing Jeep was unable to obtain enough foreign currency to purchase the Cherokee CKD kits from Detroit. After recovering from this crisis, Beijing Jeep's production and sales rose to a peak of 81,000 in 1995 before declining sharply to a dismal low of 10,000 in 2001 (a smaller number of cars than were produced by BAIC in 1983 *before* AMC entered the picture). In 2001, Chrysler introduced its second model, a luxury Grand Cherokee. The soft-top military vehicle desired by the Chinese was never designed or produced. However, 200 Chinese Beijing Jeep engineers—frustrated by the lack of development—continue to research the design of such a vehicle unassisted by foreign experts.

Beijing Jeep never secured permission from the government to produce regular sedan-sized passenger cars. This explicit goal of DaimlerChrysler was only indirectly realized in late 2002, when a new joint venture between Beijing Auto Holding Company (BAHC) and Korean Hyundai Motor Company (of which DaimlerChrysler owns 10.46 percent) was announced to produce passenger cars (initially the Hyundai Sonata). The total investment by 2003 will be $400 million dollars with 50/50 ownership.

Technology Transfer

Most of the technology transfer in Beijing Jeep occurred just after the formation of the joint venture in 1984. The mechanism was for Beijing Jeep to purchase Cherokee kits from AMC and then assemble them in China. AMC did not really make any money from selling the vehicles in China, profiting mostly from selling the kits to BJC. This structure reduced the incentive for AMC to transfer any knowledge about the technology. Beijing Jeep never stopped producing the old BJ212/BJ2020 because it proved to be quite profitable. Astoundingly, sales of the vintage BJ2020 have consistently *exceeded* sales of the U.S. Cherokee to this day even though very little has been done to improve it other than adding the Cherokee engine. The growing success of the BJ2020 is a huge irony because instead of transferring more advanced technology to China, AMC and then Chrysler profited hugely from keeping the old WWII-era Jeep in production in China (Mann, 1997).

Even more ironic, the staunchest support for the old BJ2020 comes from a group of Chinese technical engineers employed by the BJC Technical Center. The BJ2020 was the only model with which they have ever been allowed to tinker—its existence justifies *their* existence.

After the government issued localization policies in 1994, Beijing Jeep managed to use some Chinese-made parts, reaching 80 percent localization by 2000 (Huang, 2002). Thus, it could be argued that AMC's main technological contribution was not the vehicle technology itself, but the cultivation of good local parts and components suppliers. Surprisingly, the Cherokee technology was never updated or refreshed after being introduced in 1985. In the new 30-year contract, BAIC has full rights to the Cherokee technology, now that it is no longer in production anywhere else in the world so they may finally make some changes to it.

Although Beijing Jeep is the oldest automobile joint venture in China, Chinese engineers employed at the company believe they have not acquired any advanced capabilities. One Beijing Jeep Chinese engineer lamented, "I'm not even sure that we are even where Chrysler was in 1980," adding, "The only way to close the gap is for DaimlerChrysler to send engineers to China to work with us. The top executives in the big companies only see China as a market to sell vehicles. They don't see China as a place to *develop* vehicles."[6]

Air Pollution Control Technology

Beijing Jeep claims that all of its vehicles meet the EURO I air pollution standard and some vehicles are EURO II "capable." Thus, DaimlerChrysler has not transferred very advanced pollution control equipment to China. Regarding fuel economy, Beijing Jeep's vehicles are the worst of the Big Three in China. Company officials report that the average fuel economy of the old BJ2020 at a constant speed of 60 kilometers (km) per hour is 10 liters (L)/100 km (24 miles per gallon, mpg). Actual on-road fuel economy is probably forty percent worse at 14 L/100 km (17 mpg). The newest Grand Cherokee is reported at 12 L/100 km at a constant speed of 60 km/hour (20 mpg), which translates to about 16 L/100 km (15 mpg) under normal driving conditions.

Shanghai GM

General Motors' (GM) influence in China dates back to 1922 when GM cars began to be exported to China. By the 1930s, one out of every six vehicles on China's roads was of the Buick nameplate. After the Communist revolution, GM ceased its exports to China and refrained from investing there until 1994. Of the Big Three, only GM has secured a solid foothold in China and this can mainly be explained by GM'S high-risk, aggressive commitment to manufacturing automobiles in China. GM has brought the most modern technology of any U.S. investor; has the best relationship with its Chinese partner, the Shanghai Automotive Industry Corporation (SAIC); and seems to have set standards that other foreign companies are scrambling to match.

In 1994, the GM China office was opened in Beijing and in 1995 negotiations began with SAIC on a major joint venture. In 1997, then-Vice President Al Gore witnessed the signing of the deal to create Shanghai GM (SGM). It is commonly reported that GM's investment represents the largest single U.S. foreign direct investment in China (Faison, 1998).

General Motors was anxious to win this joint venture because it believed SAIC was the best automobile company in China. Indeed, SAIC was highly profitable due to many advantages. Notably, the Chinese government had long ago chosen SAIC to be the primary passenger car producer enabling it to acquire the most relevant technological experiences than any other domestic company. There was one fairly large disadvantage: SAIC was already enmeshed in a gigantic joint venture with Volkswagen called Shanghai VW, which was producing the most passenger cars in China and had been doing so since the mid-1980s.

Technology Transfer

During the joint venture negotiations, it was clear to GM that the Chinese government wanted GM to establish a joint technical center with SAIC. This desire had been expressed to other foreign companies in the past but in the wake of the 1994 auto policy, GM was the first company to actually agree to establish such a center with additional investment. Therefore, a separate $50 million joint venture was established between GM and SAIC called the Pan Asia Technical Center (PATAC). PATAC's main purpose is to provide engineering support to SGM and other Chinese auto companies but it also has established an in-house emissions testing center and employs about 400 Chinese engineers. While PATAC does not have the explicit function of training Chinese engineers, it is also filling that need.

Shanghai GM's first vehicle, a Buick *Xin Shi Ji* (New Century) luxury sedan, rolled off the production line in December 1998. The sedan was priced at about 330,000 RMB ($40,000). At the time, there was little competition in the domestic market—merely the imported Audi 200, the dated Audi 100, and the same old FAW *Hongqi* (Red Flag) sedan that, while cheaper, was really not a competitor due to poor quality. After the Buick was launched other producers were sparked into introducing new models; Audi responded with the Audi A6 and Honda began producing its Accord in Guangzhou. Finally, VW introduced its Passat.

Production of the Buick *Xin Shi Ji* started with 47 percent localization of parts and components. Though some of the technology in the vehicle was a little dated, it represented a substantial improvement on luxury cars previously available to the Chinese consumers who all believed the Buick to be "current" technology. By 2000, SGM had reached a 60 percent localization rate for its Buick sedan, importing only $140 million of parts annually from the United States (Graham, 2000). As of 2002, SGM was on track to sell nearly 100,000 vehicles and had achieved 8 percent of the total market share for passenger vehicles (Smith, 2002).

Only two years after introducing its inaugural luxury sedan, Shanghai GM launched a compact sedan called the Buick *Sai Ou* (Sail)[7] for private consumers in the burgeoning Chinese middle class. Priced initially at about 100,000 RMB ($12,000), this vehicle was put into the market against the VW Jetta and *Tianjin Xiali*, as well as the VW Santana, which is a bigger car but has similar buyers. The *Sai Ou* is a 1.6-liter engine version of the Opel Corsa, which is sold in 80 countries around the world. It has dual air bags and antilock brakes as standard features, a first for a compact car in China (Leicester, 2000).

Again, GM was the source of the vehicle technology that was adapted for Shanghai GM. But this time the product and process adaptation included Chinese PATAC engineers, who started production of the *Sai Ou* with 70 percent local content, the highest fraction ever for a joint venture in China.

Unlike many other foreign joint venture auto companies in China, SGM has made technological improvements during the course of production. Notably, because fuel economy turned out to be important to Chinese consumers, SGM reduced the engine size of the Buick luxury sedan to 2.5 liters after the vehicle had been in production. Consequently, the Chinese model actually has better fuel economy than the U.S. version. In both cases, Shanghai GM introduced a more modern product than that being produced by Shanghai VW and other competitors, provoking them to either upgrade their product or introduce an entirely new model. Still, SGM's Chinese workers believe they have not learned very much from GM. One Chinese national working for GM commented that the fault lies with both partners: "The foreign companies are not good teachers, but the Chinese companies are not so clever."[8]

Pollution Control Technology

Of the three U.S. manufacturers, GM has certainly made the most substantial efforts with respect to fuel economy and environmental technology transfer. All of Shanghai GM's models meet EURO II standards (Europe's 1994 standards). According to SGM, the fuel economy of the Buick *Xin Shi Ji* is roughly equivalent to the U.S. Buick Century. SGM reports that the Buick *Sai Ou* gets 9-10L/100 km (23-26 mpg) in normal driving. In other environmental activities, SGM's technical joint venture, PATAC, hosts one of the few national emissions testing centers; GM paid for a SEPA study on how to accelerate the phase-out of leaded fuel and sponsored a recent workshop on on-board diagnostic technology. GM also donated an electric vehicle to a national electric vehicle demonstration project in Shantou (Guangdong province).

… revolutionaries and rivals Sun Yatsen and Zhou Enlai are both reported to have driven Buicks during their time.

Chang'An Ford

Of the Big Three, Ford Motor Company (the second-largest auto company in the world) is the last to manufacture a passenger car in China and has the weakest reputation. Similar to GM, Ford also had an early involvement in China dating back to 1913, when a small number of Model T Fords were exported to China. It was not until 1992 that Ford opened a representative office in Beijing, long after AMC and Volkswagen had been in operation. Even then, Ford failed to land a joint venture auto assembly agreement with a Chinese partner for another nine years.

Instead, Ford invested in six joint ventures related to manufacturing parts and components, spinning these off in 2000 (Luo, 2002). In 1995, the company finally established Ford Motor China Ltd. and bought a twenty percent stake in Jiangling Motors Corporation where it licensed the Transit bus technology to China for production in Jiangling's facilities.[9]

The first vehicle produced by Ford's Chinese partner, Chongqing Chang'An Automobile Group Company Ltd. (Chang'An), was the World War II-era Jeep-style vehicle given to the Chinese by the Soviets. Chang'An produced 1,390 of these vehicles between 1959 and 1963. After the Cultural Revolution, this technology was transferred to BAIC, future partner of AMC (now DaimlerChrysler). Located in Sichuan Province, Chang'An is now the fifth-largest automobile company in China and well known for producing what the Chinese call the *mianbao che* (literally "bread car"), a minibus that unmistakably looks like a loaf of bread on wheels (Xinhua Economic News Service, 2002).

In 1983, Chang'An recommenced its vehicle production, licensing the minibus technology from Suzuki. In 1993, Chang'An actually formed a joint venture with Suzuki called Chongqing Chang'An Suzuki to produce subcompact cars. The Suzuki joint venture is to coexist with Ford's new joint venture at Chang'An.[10]

In April 2001, Ford finally concluded negotiations for a $98 million joint venture agreement with Chang'An (Lippert, et al., 2002). Chang'An will invest $23.5 million in the joint venture using cash and other assets, and its parent Chang'An Automotive Group Liability Company Ltd. will contribute the remainder of the investment. Ford will contribute $49 million worth of cash and assets (Avery, 2002).

Chang'An Ford aims to break into the small to mid-sized car market in China with a Ford Fiesta, targeting the burgeoning upper-middle class consumer with a low-priced car that is "tailored for the family owner and small business entrepreneur. . ." (AFX Asia, 2002). The goal, according to one proud Chang'An representative, is to "directly compete with the Buick *Sai Ou*."[11] The car is anticipated to cost about 100,000 RMB ($12,195).

Technology Transfer

Ford is transferring all the vehicle technology and the design of the manufacturing plant to Chang'An. Together, they are building a new set of manufacturing facilities in the new industrial area of Chongqing. Workers have been trained in Ford's India plant, and production commenced in February 2003 at the plant, which has a 50,000 annual production capacity.

Sixty-two percent of the parts for the Ford Fiesta will be made domestically (Lippert, et al., 2002). The remaining parts initially will be imported and shipped three days up the Yangtze River to the plant. In August 2002, Ford India began exporting parts to the Chongqing plant and it plans to export regulators, steering columns, horns, some chassis components, hinges, brackets, hoses, gearshift knobs, and smaller metal parts to China.[12]

Chang'An would like to collaborate in a separate joint technical center for Chongqing with Ford. Ford China said they were "open" to such a center because it would give them a technical base in a region they expect to be a big market and because it would please the government, but had no plans to establish one any time soon (Wong, 2002). Ford may not be quick to create a center in Chongqing, because Ford Taiwan (Ford Lio Ho Motor Co.) recently established its first research center in Asia and fifth one in the world, a $289 million design and research center in Taiwan (*China Post*, 2002). This center will include a small internal technical center where engineers will work on product adaptation.

The Ford Fiesta car in production at the new Chang'An Ford plant is of second or third generation. It will probably be more modern than the cars produced in coordination with Suzuki but far from cutting-edge. It is too soon to tell whether or not Ford will update and refresh the technology it transfers to China. It seems Ford will fall in between Shanghai GM and Beijing Jeep in terms of the modernity of its technology transfer.

Pollution Control Technology

Environmentally, because it will be a sub-compact car, the fuel economy of the Ford Fiesta can be expected to be quite good. Chang'An Ford reports that the fuel economy of the Chinese Fiesta is 34 miles per gallon but no independent verification of this report is possible because the Chinese government does not test the fuel economy of Chinese vehicles. Ford also has said that the Fiesta will meet Euro II air pollution control standards, which is required in China's big cities. Ford's other notable environmental activities in China include their annual Environment Protection Prize, which is granted to an organization (or individual) in China that has promoted environmental protection. In addition, Ford has sponsored some workshops on automotive emissions control and has made grants in coordination with the National Science Foundation of China for environment-related research.

INITIAL CONCLUSIONS

For nearly a century, foreign firms have been introducing automobile technology into China. At times, foreign firms introduced contemporary technology and at other times they sent over models with little remaining commercial value elsewhere. Very few of the foreign technologies have been refreshed once they are in production in China—some like the Jeep Cherokee have not been upgraded at all. The U.S. companies' Chinese counterparts have gained some knowledge about manufacturing and business practices, but little understanding of how to design automobiles. In other words, the foreign companies have had a *modernizing*, but not a truly *developmental* effect on the Chinese automobile industry because the U.S. firms did not transfer much knowledge along with the products.

The extent of technological modernization has varied substantially among foreign automobile firms and across time. The best explanation for this variation is that Chinese government policies governing foreign investment in this sector have been wildly contradictory over the years, sending different signals to foreign and Chinese manufacturers alike. Yet, foreign firms themselves have had differing attitudes and approaches to China, which has strongly affected their technology transfer. GM took a high-risk approach to China, which appears to be paying off. In contrast, Chrysler and Ford have been much more cautious and conservative, transferring more dated technology, with less success. In Chrysler's case, Beijing Jeep was the first automotive joint venture in China so their caution is understandable. Ford's risk-aversion seems to have more to do with their concerns about intellectual property rights and the vibrancy of the Chinese auto market.

None of the foreign firms have transferred to China environmental technology that is equivalent to what is currently installed in vehicles in Japan, the United States, or Europe. This is unfortunate because there is a unique opportunity in China to "leapfrog" to advanced, clean, efficient vehicle technologies before the projected wave of demand crests there. But, a number of challenges currently impede the efforts of foreign firms to deploy cleaner vehicle technologies in China:

- The simple absence of Chinese laws mandating that automotive emissions be more sharply reduced, which would require more advanced technologies to be transferred from the foreign firms;
- Poor fuel quality, which renders advanced catalytic converters ineffectual;
- The incremental costs of certain highly advanced environmental technologies; and,
- Chinese domestic firms not affiliated with foreign firms through joint ventures have a harder time complying with environmental regulations because they lack pollution control technology.

If the Chinese government were to pass more aggressive emission performance standards, it is likely the foreign manufacturers and their Chinese partners would find a way to comply as they easily have done in the past. There is no evidence that foreign auto companies are deliberately seeking a "pollution haven" in China, but without the proper legal or economic incentives they are not likely (on their own) to do better than China's law requires. Few legal or market incentives exist for foreign auto firms to transfer cleaner and more efficient technologies in China. Therefore, the Chinese government should prioritize the creation of incentives for the transfer of pollution control and fuel efficiency technologies to China. In addition, China should redouble its efforts to bolster Chinese domestic capabilities in these areas through R&D programs and educational initiatives.

There is also a role for the U.S. government and international NGOs to help in deploying cleaner vehicle technologies in China. NGOs can provide assistance to the Chinese government on how to formulate policies to reduce vehicular emissions of air pollutants and also can help to educate the public about the benefits of cleaner air and greater fuel efficiency. It is arguably in U.S. national interest to help China avoid a major reliance on foreign oil and significant growth in greenhouse gas emissions (Sims, 2001). Thus, the U.S. government could pursue a strategy of enhanced international energy cooperation by lifting its ban on foreign aid, supporting educational and researcher exchanges, and providing technical assistance. In the international arena, the United States could incorporate environmental concerns into its free trade agenda at the World Trade Organization and support an agreement on international investment containing minimum environmental or fuel efficiency performance standards.

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Endnotes

[1] The focus of this paper is on passenger cars, which are being defined as all light-duty vehicles including cars, pick-up trucks, minivans, and sport utility vehicles (SUVs).

[2] "Registered capital" is the amount of capital actually received in China.

[3] In rural areas, indoor air pollution caused by burning biomass and coal for heating and cooking is the biggest concern. Overall, motor vehicles are not the largest source of national air pollution but they are the biggest source of concern in the cities.

[4] Until 2002 when it was raised to $60 million, the limit was $30 million, giving the central government great influence over the terms of FDI agreements in the automobile sector (Huang, 2002).

[5] Complete knockdown kits are packages of every single part and component for the vehicle, which are then shipped elsewhere for assembly.

[6] Interview in Beijing at Beijing Jeep 11 June 2002.

[7] *Sai Ou* literally means "compete with Europe."

[8] Interview at GM China in Beijing, 27 June 2002.

[9] Ford also has indirectly invested in China through Mazda, which is 33.3 percent owned by Ford. Mazda has been outsourcing production of its Mazda Premacy at First Auto Works Hainan Motor Company since June 2001 and the Mazda 323 in July 2002 (Japan Economic Newswire, 2002).

[10] Interestingly, General Motors owns a 20 percent stake in Suzuki. Therefore, Chang'An will be a partner, albeit indirectly, of the two firms most directly competitive in the U.S. market.

[11] Interview at Chang'An Auto in Chongqing, 17 June 2002.

[12] Ford India also exports complete knockdown kits (CKDs) of the Ikon to South Africa, Mexico, and Brazil
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Demand-side Management in China: Barriers and Policy Recommendations

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A major challenge for China's policymakers is to determine how best to provide the necessary energy to fuel China's extraordinary economic growth. The traditional approach has been to rely on increasing the supply of conventional energy resources, particularly coal, which accounted for over two-thirds of China's energy in 2000. China has achieved tremendous success over the last twenty years in reducing its energy intensity – the energy consumed per unit of GDP. Over the last two decades, China's energy consumption per 10,000 RMB ($1,208) has fallen from the equivalent of 7.89 tons of standard coal to 2.77 tons. Yet despite these achievements and a low per capita consumption, China's energy intensity is still three times higher than the world average. The energy efficiency in China's rapidly growing power sector, which is the second largest in the world, is three-quarters that of advanced international standards.

One tool that has proven effective for delivering energy efficiency in many countries, but has not yet been widely adopted in China, is demand-side management (DSM). DSM is a mechanism in which a utility or other state-designated entity uses funds derived from the electrical system to promote energy efficiency through targeted educational or incentive programs. Demand-side management is an important mechanism that can complement and extend government, private sector and international assistance efforts to help electricity end-users capture the full range of efficiency opportunities available today in China and induce the development of next generation energy efficiency measures. Although DSM programs in a number of countries have faltered in the wake of electric utility restructuring, new approaches to financing and administering DSM and incorporating demand-side resources into competitive markets are meeting with considerable success.

A number of barriers stand in the way of implementing effective DSM programs in China. Utilities do not have the proper incentives to carry out DSM programs. To the contrary, China's current rate design creates a disincentive, or conflict of interest, since utilities make money by selling electricity rather than saving electricity. Equally important, no financing mechanism exists to provide the necessary funding for DSM programs in China. As China restructures its electric utility industry, it has an opportunity to develop power market rules and regulatory structures that would make DSM profitable for utilities or independent DSM program administrators, provide adequate funding, and permit demand-side resources to compete with new generation in the marketplace.

This report analyzes some of the major barriers to DSM in China, and recommends several policy measures for overcoming those barriers, both before and after electric industry restructuring. Recommendations include:

- Decoupling utility profits and electricity sales via a revenue cap;
- Introducing a system benefit charge, (a small, "non-bypassable" surcharge on the electric rates of all electricity consumers) to fund DSM programs;
- Developing performance-based regulation to encourage utility investment in DSM by rewarding compliance with energy efficiency indicators;
- Considering independent DSM program administration by a private provincial or regional institution;
- Requiring distribution utilities to use least-cost planning or portfolio management; and,
- Incorporating demand response into wholesale markets.

The full report is available on the Energy Foundation's Web site at http://www.energyfoundation.org