FOREIGN DIRECT INVESTMENT
AS A VEHICLE FOR DEPLOYING CLEANER TECHNOLOGIES:
TECHNOLOGY TRANSFER AND THE BIG THREE AUTOMAKERS IN CHINA

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ABSTRACT

The number of cars on the road in China is expected to double every six years at current growth rates. Currently, there are no Chinese fuel-efficiency standards for automobiles, and pollution-control standards are weak. China is already a net importer of oil, and will be an increasingly large source of demand for world oil supplies as the number of automobiles in China increases. Motor vehicles are also now the leading source of urban air pollution in China. The Chinese government has indicated that it wants to avoid a heavy dependence on foreign oil and prevent the worsening of air pollution, but China’s domestic technological capacity for clean automobile production is almost entirely dependent on foreign technology transfer. The U.S. Big Three automakers have all formed joint ventures in China and are in the process of transferring technology to their Chinese partners.

The central purpose of this research is to investigate the extent to which international technology transfer through foreign direct investment (FDI) is an effective mechanism for the deployment of cleaner technologies in developing countries. This dissertation provides three empirical case studies of Beijing Jeep, Shanghai GM, and Chang’An Ford based on dozens of interviews in the U.S. and China. The main findings are that: (1) U.S. firms transferred outdated automotive pollution-control technologies to China; (2) U.S. FDI helped to deploy somewhat cleaner automotive technologies, but their potential environmental benefit is being outweighed by having so many more vehicles on the road; (3) automotive technologies that were transferred were not necessarily updated in tandem with updates made to equivalent foreign models; and, (4) U.S. firms did not strongly contribute to improving Chinese automotive technological capabilities because little knowledge was transferred along with the product. Finally, one further implication from this study is that there appear to be limits to leapfrogging to substantially cleaner automotive technologies through technology transfer from foreign firms. These barriers can be overcome through international investment rules, U.S. and Chinese government policy, and the goodwill of foreign firms, but probably most effectively by Chinese regulations.

KEY WORDS: technology transfer, foreign direct investment, energy efficiency, passenger vehicles, automobiles, oil consumption, air pollution, China, Ford, GM, and DaimlerChrysler

AUTHOR: Gallagher, Kelly Sims
For my husband, Kevin
&
for my parents, William and Jo Ann Sims
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Chapter 1

INTRODUCTION

The central purpose of this research is to investigate the extent to which technology transfer through foreign direct investment is an effective mechanism for the deployment of cleaner technologies in developing countries. In particular, the international technology transfer from U.S. automotive firms to their Chinese joint-venture partners is evaluated through empirical case studies. There are three Sino-U.S. joint ventures in the Chinese automobile industry. In chronological order, these are Beijing Jeep, Shanghai GM, and Chang’an Ford. All three are examined here.

A number of questions will be addressed by this study. First, to what extent did U.S. firms transfer their cleanest automotive technologies to China? Second, how have the automotive technologies that were transferred affected human health and environmental quality in China? Third, to what extent has the transfer of automotive technology contributed to Chinese economic development, including the development of more advanced Chinese capabilities in automotive technology? Fourth, what are the factors on the U.S. side and on the Chinese side that have most influenced the patterns of transfer of automotive technology? Fifth, what can be gleaned from the answers to these questions about the incentives for and barriers to further automotive-technology transfer? Finally, based on the research, what can be inferred about China’s ability to leapfrog, with the help of technology transfer, to cleaner technologies such as gasoline-electric hybrid automobiles?
1.0 PROBLEMS AND OPPORTUNITIES

The Chinese automobile industry, perhaps surprisingly, is still very small. As late as 1990, only 42,000 cars were being produced each year in China, compared with nine million in the United States. After the Cultural Revolution ended in the 1970s, Chinese firms lacked the technological capabilities to design and manufacture new cars, and so they turned to foreigners to acquire these advanced technologies, usually by forming joint ventures. The prospect of a thriving automobile industry in China was attractive to the Chinese government because such an industry could strongly contribute to economic development in China – and it was equally attractive to foreign investors because China appeared to be a new, untapped market with enormous potential for growth, given China’s huge population.

As of 1980, there were some benefits to the scarcity of passenger cars in China. Cars were not major sources of urban air pollution in China. Also, Chinese cars did not consume huge quantities of imported oil, as they did in the United States. During the twenty years between 1980 and 2000, motor vehicles emerged as the leading source of urban air pollution in China. Partly because of the growth in automobiles, Chinese demand for oil soared, ultimately causing China to become a net importer of oil by 1993, and the world’s eighth-largest importer as of 2003, and the third-largest consumer of oil in the world. The Chinese automobile industry took off economically, and in 2002, one million passenger cars were produced in China for the first time, in response to a 40 percent increase in demand that year. China’s automobile industry currently employs 1.5 million workers and accounts for five percent of the total added value of manufacturing
there. The one constant in the midst of massive change is that Chinese firms continue to
be very dependent on their foreign partners for new technology.

There is an exceptional opportunity in China to alter the trajectory of automobile
growth by transferring cleaner technologies to China. There are still relatively few
automobiles on the road in China – only about 6 million compared with 179 million in
the United States. Motor vehicle oil consumption in China is currently one-tenth that of
the United States, greenhouse-gas emissions from automobiles are still relatively modest,
and the increasingly severe urban air pollution could be reversed through pollution
control.

During the 1990s, sales in new automobiles grew 18 percent annually, resulting in
a doubling in the number of passenger vehicles on the road every four years. The
opportunity lies in taking advantage of such growth by installing, in every new car that is
sold in China, the cleanest of the automotive technologies that are already sold
commercially in the United States, Japan, and Europe. If this were done, urban air
pollution could be minimized, a substantial part of the projected emissions of long-lived
climate-altering greenhouse gases from the Chinese automobile sector could be averted,
national oil imports could be contained, and the Chinese automobile industry could
continue to flourish, contributing to China’s steady economic development. Thus, this
research aims to determine how the chances of this outcome could be increased.
1.2 Contribution

This dissertation is the first empirical study of international technology transfer from the United States to China in the Chinese automobile industry. Aside from a study about the role of bureaucracy in the development of the Chinese automobile industry (Harwit 1995), and a book about the experience of foreigners working in China that focused on Beijing Jeep as a case study (Mann 1989), there have been few other studies about the interaction between Chinese and foreign automobile firms, particularly with respect to technology transfer.

In contrast, there have been numerous studies about international technology transfer in general (Rosenberg and Frischtak 1985; Reddy and Zhao 1990; Brooks 1995). In addition, articles and books have emerged in recent years about technology transfer for “sustainable” development (Martinot, Sinton, and Haddad 1997; Metz, Davidson, Martens, van Rooijen, and Van Wie McGrory 2000; Trindade, Siddiqi, and Martinot 2000). In 1998, Goldemberg suggested that developing countries should consider “leapfrogging” to cleaner energy technologies to avoid the same resource-intensive path of the industrialized countries (Goldemberg 1998). This dissertation will examine the most important barriers and incentives to acquiring cleaner automotive technologies as an industrializing country through technology transfer in the particular context of U.S. foreign direct investment in China’s automobile industry. In addition, the limits to leapfrogging in this situation are identified, and a strategy for overcoming those challenges is offered.
A number of terms will be used throughout this study that should be clearly defined at the beginning. First and foremost, the term “automobiles” is defined to include passenger cars such as sedans and hatchbacks, and light trucks such as sport-utility vehicles (SUVs), pick-up trucks, minibuses, and minivans. The term does not include large buses, heavy trucks, trains, or airplanes. Occasionally, the term “motor vehicles” is used, and this term does include buses and trucks. Light trucks are not commonly used as passenger cars in China, but increasingly, minivans and sport-utility vehicles are being marketed to the Chinese consumer as automobiles; two of the U.S. firms operating in China do produce sport-utility vehicles.

It is also important to clarify what is meant by “cleaner” technology. An automobile can be made “cleaner” through a combination of three measures: reducing tailpipe emissions of air pollutants, improving fuel efficiency, and using cleaner fuels. Tailpipe emissions of common air pollutants including nitrogen oxides (NO\textsubscript{x}), carbon monoxide (CO), and hydrocarbons (HC) are usually controlled through catalyst technology and on-board diagnostic (OBD) systems. Cleaner fuels – such as unleaded or low-sulfur fuel, or compressed natural gas – can also contribute to reducing some of the harmful emissions of pollutants from an automobile. Emissions of the key greenhouse gas, carbon dioxide (CO\textsubscript{2}), can be reduced to some extent from switching from petroleum-based fuels to compressed natural gas (which contains less carbon in relation to its energy content); and net carbon emissions can also be reduced by using alcohol fuels derived from biomass (which removes as much carbon dioxide from the atmosphere...
when it is growing as it releases when it burns). Electric vehicles and vehicles powered by fuel cells operated on hydrogen are sometimes described as being completely clean, but thinking about the entire systems leads to the conclusion that their overall cleanliness depends on how the electricity or hydrogen is obtained. Hydrogen today is mainly produced from natural gas (with an associated release of the greenhouse gases to the atmosphere), and most electricity in China is generated by burning coal. Of course, whatever the origin of the primary energy for vehicle propulsion, increasing the energy efficiency of the automobile can reduce emissions per mile.

Finally, the term, “technology transfer” must be defined. Technology is understood to encompass both tangible goods or products, such as machinery, and tacit information, such as skills and knowledge (Grubler 1998). International technology transfer is thus the transfer of hardware, such as tooling for factories, and also the transfer of intangible assets such as product design and the capability to manufacture a product. Brooks argues that technology transfer is “a way of linking knowledge to need,” and that it is a process of cumulative learning (Brooks 1995, 83). This succinct definition of technology transfer illuminates several important characteristics of technology transfer. It affirms that technology should be conceived as knowledge (Kranzberg 1986), and that technology transfer is a process of communication and education on the part of all parties involved. Martinot, Sinton, and Haddad agree that “technology transfer is fundamentally a process of learning” (Martinot, Sinton, and Haddad 1997, 362).
Most of the empirical data were gathered through extensive interviews in the United States and China with government officials, firm representatives, and relevant experts. In total, from 1999-2003, 90 people were interviewed, occasionally multiple times. All but two of the interviews were conducted in person, and the exceptions were conducted by telephone. The majority of the interviews were conducted during the summer of 2002, at which time the relevant factories in China were visited. In China, interviews were conducted in Beijing, Tianjin, Shanghai, Chongqing, and Shantou. In the United States, interviews were conducted in Detroit and Ann Arbor, Michigan, Cambridge, MA, and Washington, DC. As a rule, interviewees with Chinese citizenship are not identified by name for confidentiality’s sake, but the date and location of the interview and affiliation of the source are usually provided. Numerical data about the automobile industry in China were usually obtained from the China Automotive Research and Technology Center (CATARC), based in Tianjin. Government documents, newspaper and magazine articles, and scholarly books and articles are also heavily referenced.

This research is interdisciplinary in nature. Technology transfer from industrialized to developing countries can be analyzed from many disciplinary perspectives including economics, political science, international relations, sociology, history, law, science, and engineering. For example, economics confirms that the acquisition of technology is necessary for economic development, and that there are
many economic barriers to technology transfer. The political science discipline notes that institutions can strongly affect the nature and extent of technology transfer, and this discipline, among others, poses questions about the appropriateness and effectiveness of certain technologies for development. These questions posit whether the need for such technology creates a dependency on potentially domineering, richer countries, and whether such a dependency represents an unacceptable power imbalance between countries. Historians disentangle the causes of technology transfer and draw lessons from past experience that can be taken into consideration in the future. International relations theorists consider why there may be interests in technological cooperation or in withholding technology to balance power or to foster alliances. Lawyers formulate ways to facilitate technology transfer through international rules, private contracts, and domestic laws, for example, enhancing intellectual property rights or inhibiting transfer by erecting formidable legal barriers. There are also physical constraints that factor into the ability to transfer technologies, such as the quality of fuels available for use in automobiles. This analysis utilizes all of these disciplinary perspectives.

1.5 ORGANIZATION OF STUDY

The economic, energy-related, and environmental dimensions of automobiles in China are explored in Chapter 2. In Chapter 3, a history of the role of foreign technology in the development of China’s automotive sector is provided. Then, three case studies of technology transfer in the Sino-U.S. automotive joint ventures are presented in chronological order, based on when they were established. Chapter 4 is a case study of
Beijing Jeep, established in 1984; Chapter 5 is a case study of Shanghai GM, established in 1997; and finally, Chapter 6 is a case study of Chang’An Ford, established in 2001. In each case study, historical information about the joint-venture partners is provided, and technology transfer within the joint venture is documented and discussed. Chapter 7 begins with a comparison of the three cases in terms of environmental performance, fuel efficiency, and technological cooperation. Then, the main research questions are answered in turn, before turning to the question of which are the most important barriers to, and incentives for, “leapfrogging” to cleaner automotive technologies in China. This study concludes in Chapter 8 with a discussion of the implications of the findings for policy and theory, as well as some directions for future research.
Chapter 2

THE ECONOMIC, ENERGY-RELATED, AND ENVIRONMENTAL DIMENSIONS OF CARS IN CHINA

Ask almost any urban Chinese citizen if he or she would like to own a car, and you will surely get an affirmative answer. In the last decade, the prospect of attracting millions of Chinese car buyers has propelled both foreign and domestic auto manufacturers to pour billions of dollars into developing a vibrant automobile industry in China. Yet, as automobile production surged upward during the 1990s, questions started to arise, both within China and internationally, about the implications of such explosive growth in the Chinese automobile industry (World Bank 1997; Shao and Zhang 2001; EIA 2001a). In particular, the connections and trade-offs among economic development, energy use, and environmental quality began to be discussed. This chapter will explore these three areas of concern in detail.

Although few Chinese can actually afford to purchase a car now, the potential exists for substantial demand for automobiles in the near future. Indeed, there was an unprecedented spike in demand for cars during the first six months of 2002 when sales increased a whopping 40 percent compared with the same period in 2001. But today, with 20 percent of the world’s population, Chinese citizens still own just 1.5 percent of the total number of cars in the world. This is in stark contrast to the situation in the United States where with only 5 percent of the world’s population, U.S. citizens own 25 percent of the world’s cars. In other words, China currently has about the same number of cars per person as the United States did in 1913 (Davis and Diegel 2002).
2.0 IMPLICATIONS OF AUTOMOBILE USE IN CHINA

Economic Development Dimensions

China’s economy is now about one-tenth the size of the U.S. economy with a GDP of US$1.3 trillion in 2002, when converted at market exchange rates (Economist Intelligence Unit 2003). In purchasing-power-parity terms, China’s economy is now half the size of the U.S. economy (World Bank 2002).¹ The Chinese economy is among the world’s fastest growing, with an average annual growth rate between 1997 and 2002 of 7.8 percent (Economist Intelligence Unit 2003).² In China, during the past twenty years, an estimated 208 million people benefited from this economic development and were lifted out of poverty. According to the Chinese government, the total number of people living in poverty there was reduced to 42 million in 1999 (Xinhua 1999).³ A major driver of this impressive economic performance has been the development of the manufacturing sector.

Undoubtedly, the Chinese government’s decision to make the automobile sector a mainstay of the economy has greatly contributed to economic development in China. There were 1.5 million Chinese employed by this industry as of 2001.⁴ The value added by the Chinese auto industry was US$12 billion in 2001, representing five percent of the

¹ According to the World Bank, “Purchasing power parity (PPP) rates provide a standard measure allowing comparison of real price levels between countries, just as conventional price indexes allow comparison of real values over time.” In the year 2000, China’s gross national income (GNI) was US$1.1 trillion and its PPP GNI was US$4.95 trillion. That same year, the United States GNI was US$9.6 trillion and its PPP GNI was also US$9.6 trillion.
² Some analysts have questioned the reliability of the economic data reported by the Chinese government (EIA 2002).
³ The World Bank’s 2000-2001 World Development Report on poverty estimated that in 1998, there were 60 million people below the poverty line in China (World Bank 2000).
⁴ The “Chinese auto industry” here includes the automobile, motorcycle, engine, and parts & components industries.
total value added of manufacturing in China in 2001, a near doubling of this percentage
from its level in 1990 (CATARC 2002).

During the 1990s, China received more foreign direct investment than any other
developing country (US$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. At the beginning of 2001, it was estimated that there
were more than 800 Chinese companies in automotive-related industries that had
received foreign direct investment (FDI); this investment was valued at US$12 billion
(Zhang 2002).

Foreign direct investment in the automobile sector has contributed to the
economic success of this industry in China in a number of ways. First, it has created
desirable and stable jobs for Chinese workers in the joint-venture firms. Second, this
investment has strongly benefited the wider economy because the Sino-foreign joint
ventures have created a strong source of demand in China for raw materials and
automotive parts and components. In 1994, the Chinese government imposed
“localization” requirements on the Sino-foreign joint ventures, which forced them to use
a certain percentage of Chinese-made parts in their automobiles. Many of the Chinese
suppliers were initially unable to meet the standards of the foreign firms, so the
foreigners worked with Chinese suppliers to improve the quality of their products. Once
the suppliers learned how to enhance their products, they began to export them to other
markets, which allowed them to expand production and lower unit costs. Overall, these
“backward linkages” from the Sino-foreign joint ventures and the Chinese automobile

5 Most foreign investment goes to industrialized countries. In 2001, 65 percent of total foreign direct
investment went to developed countries, not including Central and Eastern Europe (UNCTAD 2002).
industry in general are increasingly contributing to economic growth in China. By the mid-1990s, the Chinese auto industry was providing the demand for 5-6 percent of total steel production, 80-90 percent of petroleum products, 14-16 percent of machine tools production, 50 percent of tempered glass production, 45 percent of tire production, 15 percent of engineered plastics production, and 15 percent of paint production (CATARC 2001).

On the other hand, it has been shown that in general, FDI is not always positive for the receiving developing country. For example, one study concluded that foreign investment rarely stimulates new economic development because FDI usually tends to follow, not instigate, success. Perversely, there appears to be an inverse correlation of domestic skill formation with regard to foreign investment in developing countries: high levels of FDI are associated with low levels of domestic skill formation (Amsden 2001).

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. At this time, Chinese companies are still quite reliant on their foreign partners for advanced technology. But FDI cannot bear the entire brunt of the blame because the Chinese government’s policies toward 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.

China’s entry into the World Trade Organization (WTO) will force its 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 there is still
some government protection left. For the purely Chinese manufacturers, the outlook is rather daunting because most cannot even compete in the domestic market against the joint-venture firms.\(^6\) If many of the domestic 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 have thus not achieved technological independence. Unshielded exposure to the international market will probably condemn China’s domestic auto manufacturers to technological 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 1994 requirement that joint ventures produce automobiles containing 40 percent local content.

It is certainly in the government’s interest to insure that its automobile sector industry survives China’s entry into the WTO. The U.S. auto industry claims that auto manufacturers and related industries provide one out of every seven American jobs (including jobs dependent on the industry) and contribute five percent of annual “private sector GDP” to the U.S. economy (Alliance of Automobile Manufacturers 2003). 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. If Chinese auto manufacturers could somehow become leaders in

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\(^6\) Purely Chinese-made cars represents small fraction of passenger vehicle production. At most, 19 percent of the total number of passenger vehicles produced are estimated to be made by firms without foreign affiliations (CATARC 2002). All of the major Chinese passenger car producers have formed joint ventures with foreign firms.
their own right without using technology transfer in the joint ventures, however, a greater share of the profits (that would otherwise be lost to the foreign companies) could be retained and re-invested in developing more capabilities in the auto sector. While this 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 and security-related costs of automobile use may offset some of the economic benefits. State Environmental Protection Agency (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 Beijing 2000). Air pollution from motor vehicles is a growing source of these costs.

In addition, the economic costs of substantial oil imports cannot be ignored. These economic costs include the actual costs of oil imports, the effect of increased demand on world oil prices, and the potential reduction in domestic economic productivity due to higher energy input costs. Oil imports themselves are already expensive for China. According to the Economist Intelligence Unit, imported petroleum (and related products) cost China US$15.6 billion in 2002, making petroleum-related imports the fourth-largest category of import behind industrial machinery, textiles, and electrical machinery (EIU DataServices 2003).\(^7\) In January, China posted its first trade deficit since 1996, and the Chinese government attributed most of this deficit to the

\(^7\) Total Chinese imports in 2002 were valued at US$295 billion, making oil imports account for about five percent of total imports (EIU DataServices 2003).
higher price of imported oil. At the same time, the Chinese government announced that it intended to build a strategic petroleum reserve, which is estimated to cost US$10 billion over ten years (Markus 2003). If China became a huge importer of oil, world oil prices would probably rise in response to such a vast increase in demand, which would have economic repercussions in many oil-importing countries.

Noting that conventional market forces do not determine the international supply of oil, Bohi and Montgomery argue that there are three “destabilizing effects” of increased world oil prices. First, increased oil prices can cause an increase in the amount of wealth transferred abroad. Second, they can reduce domestic production of goods and services as a consequence of lower oil consumption. Third, increased oil prices can reduce total domestic output, because non-oil market prices cannot adjust efficiently to the higher price of oil (Bohi and Montgomery 1982). A study of the causes of the U.S. economic recession during the 1970s supports the second effect identified by Bohi and Montgomery. “The slowdown of sectoral productivity growth after 1973 is partly a consequence of the sharp increase in the price of energy relative to other productive inputs,” and, “the fall in sectoral productivity growth after 1973 is the primary explanation for the decline in productivity for the U.S. economy as a whole” (Jorgenson 1982, 27). Yet, the potential economic cost of an oil shock can be offset for an oil-importing country if the oil-exporting countries (i.e., Organization of Petroleum Exporting Countries) buy more goods and services from the importing country using their increased revenue from the higher oil prices. It has been shown, however, that in practice, OPEC producers typically initially spend only a fraction of their additional oil
income (Lienert 1982). Finally, some believe that an increase in the price of imported oil can affect the value of the currency of the oil-importing country (Banks 1980).

*Energy Dimensions*

Automobiles do not currently consume very much energy in China, as there are still relatively few cars on the road; most of the related energy concerns arise when one thinks of *future* automotive oil consumption. As of 2002, the entire transportation sector only consumed 7 percent of commercial energy supply (EIA 2002). In 2001, motor vehicles consumed 1.0 million barrels per day, about one-fifth of total Chinese oil consumption (CATARC 2002; EIA 2002).8

Any visitor to one of China’s big cities cannot help but notice that these cities are already jammed with automobiles. Most of China’s eight million passenger cars are used in cities. In fact, 17 percent of all of China’s cars are located in just four cities: 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.

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8 Industry consumes about 80 percent of China’s oil, and electricity generators consume about 12 percent (LBNL 2001).
Rising oil consumption emerged as a concern after China became a net oil importer in 1993, as shown in Fig. 2.1. China is not well endowed with oil reserves, so traditionally oil was mainly used in industrial boilers and a few power plants. Because of the rising popularity of automobiles, both oil consumption and oil imports grew rapidly during the 1990s. By 2000, total Chinese automobile oil consumption equaled total oil imports at about 1.2 million barrels per day (Xu 2002).

As of 2002, imports had risen to a net 1.4 million barrels per day (compared with 10.4 million barrels per day for the U.S.) making China the eighth-largest oil importer in the world (EIA 2003). China already imports a greater percentage of its oil from the Middle East than the United States. Almost half (48 percent) of China’s current oil imports come from the Persian Gulf region compared with just one quarter of U.S. imports. Given its increasing dependence on the Middle East, China has predictably signed major oil exploration and production contracts with a number of foreign countries including Peru, Sudan, Iraq, Venezuela, and Kazakhstan during the past ten years to
assure itself of oil supplies into the future (Xu 2000b). These deals are worth at least US$5.5 billion (Yergin, Eklof, and Edwards 1998).

In this chapter a number of scenarios about future automotive oil consumption are explored in order to provide a very general range of estimates about Chinese vehicular oil consumption in 2020. These scenarios are based on three simple variables: the number of people who will purchase cars, the fuel efficiency of the automobiles that are purchased, and the number of miles the cars are driven each year. Figure 2.2 offers a presentation of these scenarios and depicts how those three variables can interact with each other. The scenarios can be grouped into three main categories:

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

1. China’s annual growth in automobile sales is considerably slower than it was on average during the 1990s (18 percent on average), perhaps because good public transportation alternatives are provided;
2. If Chinese fuel efficiency doubles from 2002 average U.S. fuel economy to 50 mpg by 2020 (the level of commercially-available hybrid-electric cars); and,
3. Chinese drivers drive only 5000 miles each year, significantly less than their Japanese counterparts, who drive 7500 miles a year.

**Mid-range scenarios.** China’s automotive oil consumption could be between 1-5 million barrels per day in 2020 if:

1. The growth in Chinese automobile sales stays fairly constant from its average during the 1990s until 2020; and,
2. Either fuel efficiency improves or the number of miles driven is held to at least 5000 miles per year. The table shows that different combinations of levels of fuel economy and number of miles driven result in different amounts of total automotive oil consumption.

**High-growth scenarios.** China’s automotive oil consumption could be large by 2030 if:

1. The annual rate of growth in the number of Chinese automobiles is 20 percent, half as fast as it was between 2001 and 2002. Or, if there are as many cars per person in China in 2020 as there were in the United States in 2002;
2. The average fuel economy of Chinese cars in 2020 remains the same as the 2002 average fuel economy of U.S. cars; 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, would be 24.8 million barrels per day.9

These scenarios illustrate that China’s future oil consumption from automobiles is highly dependent, at the very least, 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.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Number of Cars (Million)</th>
<th>Average Fuel Economy (mpg)</th>
<th>Miles Driven Per Year</th>
<th>Oil Consumption (M bbls/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Growth, High Efficiency, Low Miles</td>
<td>45</td>
<td>50</td>
<td>5,000</td>
<td>0.3</td>
</tr>
<tr>
<td>Low Growth, Medium Efficiency, Medium Miles</td>
<td>45</td>
<td>35</td>
<td>7,500</td>
<td>0.6</td>
</tr>
<tr>
<td>Low Growth, Low Efficiency, Medium Miles</td>
<td>45</td>
<td>24</td>
<td>7,500</td>
<td>0.9</td>
</tr>
<tr>
<td>Medium Growth, High Efficiency, Low Miles</td>
<td>110</td>
<td>50</td>
<td>5,000</td>
<td>0.7</td>
</tr>
<tr>
<td>Medium Growth, Medium Efficiency, Medium Miles</td>
<td>110</td>
<td>35</td>
<td>7,500</td>
<td>1.5</td>
</tr>
<tr>
<td>Medium Growth, Low Efficiency, Low Miles</td>
<td>110</td>
<td>24</td>
<td>5,000</td>
<td>1.5</td>
</tr>
<tr>
<td>Medium Growth, Low Efficiency, Medium Miles</td>
<td>110</td>
<td>24</td>
<td>7,500</td>
<td>2.2</td>
</tr>
<tr>
<td>Medium Growth, Low Efficiency, High Miles</td>
<td>110</td>
<td>24</td>
<td>11,000</td>
<td>3.3</td>
</tr>
<tr>
<td>High Growth, High Efficiency, Low Miles</td>
<td>245</td>
<td>50</td>
<td>5,000</td>
<td>1.6</td>
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<td>245</td>
<td>35</td>
<td>7,500</td>
<td>3.4</td>
</tr>
<tr>
<td>High Growth, Low Efficiency, Medium Miles</td>
<td>245</td>
<td>24</td>
<td>7,500</td>
<td>5.0</td>
</tr>
<tr>
<td>Very High Growth, High Efficiency, Low Miles</td>
<td>830</td>
<td>50</td>
<td>5,000</td>
<td>5.4</td>
</tr>
<tr>
<td>Very High Growth, Medium Efficiency, Low Miles</td>
<td>830</td>
<td>35</td>
<td>7,500</td>
<td>11.6</td>
</tr>
<tr>
<td>Very High Growth, Low Efficiency, High Miles</td>
<td>830</td>
<td>24</td>
<td>11,000</td>
<td>24.8</td>
</tr>
</tbody>
</table>

Source: Author's calculations

Notes
Low Growth: (10% annually) is slower growth in the number of passenger cars sold annually in China than the actual average 1990s growth, which was 16 percent.
Medium Growth: (15% annually) is slightly less than the actual average 1990s growth
High Growth: (20% annually) is half as fast as the growth rate from 2001-2002 in China, which was 40 percent
Very High Growth: there are as many vehicles per person in China in 2020 as there were in the U.S. in 2001
Low Efficiency: the fuel economy in China in 2020 is equal to U.S. average fuel economy in 2002
Medium Efficiency: two percent annual improvement in fuel efficiency until 2020
High Efficiency: average fuel economy is twice what it currently is in the U.S. for light duty vehicles (cars, SUVs, and light trucks combined) and approximately what commercially-available hybrid-electric vehicles are in 2002
Low Miles: fewer miles than currently driven on average each year in Japan
Medium Miles: the approximate number of miles currently driven each year in Japan
High Miles: the approximate number of miles currently driven each year in the U.S.

9 Note that it is estimated by CATARC that the average number of miles driven each year by private passenger cars is 18,640 (Wu 2003)
Aside from these three variables, there are other factors that will affect China’s future oil consumption, such as the price of fuel, and the degree of usage of alternative methods of transportation. For the sake of comparison, it is helpful to look at other estimates of future Chinese oil consumption. The U.S. Energy Information Administration’s International Energy Outlook 2002 projects China’s total oil consumption (including automotive 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 2002a). Narrowing in on motor vehicles more specifically, a 2001 Argonne National Laboratory study estimated that Chinese vehicles would consume between 225-330 million metric tons (about 4.5-6.6 million barrels per day) of oil by 2020 (He and Wang 2001). Similarly, a separate analysis forecasts Chinese automotive oil consumption in 2025 to range between 2.4 and 6.2 million barrels per day (Kobos, Erickson, and Drennen 2003).

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 China becomes extremely dependent on oil from the Middle East, it will also 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. This new interdependence will require close cooperation between China and each of these three giants. China is also likely to become increasingly territorial about oil and gas reserves off its coast and in the South China Sea. The rights to some of these possible reserves have long been in dispute with some of China’s neighbors.
Health and 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 during the 1990s, coal was mostly replaced by natural gas for residential uses in the biggest cities.\(^\text{10}\) Power plants are still a significant source of urban air pollution as well, but many plants 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 city where the 2008 Olympics are scheduled to take place, 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 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 (Shanghai S&T Commission 2002).

In general, mobile sources 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 that are actually in use are 5

\(^{10}\)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.
to 10 times higher and 2 to 5 times higher for NO\textsubscript{x} than those factors in developed countries (Fu, Hao, He, He, and Li 2001).

The high emissions from autos in China are the result of inadequate emissions-control regulations. Prior to 2000, emission standards for automobiles did not exist, leaded fuel was still widely used, and catalytic converters were not installed on cars. Starting in 2000, China banned the use of leaded fuels, required the installation of catalytic converters, required that all automobiles contain electronic fuel-injection engines, and adopted the European system for controlling automobile emissions. Beginning in 2000, all new automobiles must be able to meet EURO I standards, which were required of European automobile manufacturers in 1992 (see Fig. 2.3). Automobiles sold in the big cities, such as Beijing and Shanghai, are required to meet EURO II standards. In 2004, China will require automobiles to meet EURO II standards, which was the European level in 1994. Thus, Chinese air pollution standards lag European levels by ten years. They lag U.S. levels even more, because air-pollution emission standards are more stringent in the U.S. than in Europe, especially with respect to diesel emissions.

<table>
<thead>
<tr>
<th>Country, Year</th>
<th>CO</th>
<th>HC</th>
<th>NO\textsubscript{x}</th>
<th>CO\textsubscript{2}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euro I, 1992</td>
<td>4.05</td>
<td>0.66</td>
<td>0.49</td>
<td>none</td>
</tr>
<tr>
<td>China, 2000</td>
<td>4.05</td>
<td>0.66</td>
<td>0.49</td>
<td>none</td>
</tr>
<tr>
<td>Euro II, 1994</td>
<td>3.28</td>
<td>0.34</td>
<td>0.25</td>
<td>none</td>
</tr>
<tr>
<td>China, 2004</td>
<td>3.28</td>
<td>0.34</td>
<td>0.25</td>
<td>none</td>
</tr>
<tr>
<td>Europe 1995*</td>
<td></td>
<td></td>
<td></td>
<td>187</td>
</tr>
<tr>
<td>U.S. Tier 1, current</td>
<td>2.6</td>
<td>0.16</td>
<td>0.37</td>
<td>none</td>
</tr>
<tr>
<td>Euro III, 2000</td>
<td>2.3</td>
<td>0.2</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Euro IV, 2005</td>
<td>1</td>
<td>0.1</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>U.S. Tier 2, 2007\textsuperscript{a}</td>
<td>1.3</td>
<td>0.01</td>
<td>0.04</td>
<td>none</td>
</tr>
<tr>
<td>Europe 2008\textsuperscript{b}</td>
<td></td>
<td></td>
<td></td>
<td>140</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Separate and voluntary standard. \textsuperscript{b} There are different “emission bins” for the NO\textsubscript{x} standard but the fleet has to average at the number provided. There is an interim NO\textsubscript{x} standard of 0.3 g/mile that eases the transition until 2007, and it is gradually phased out between 2004 and 2007. Data sources: (Beardon 1999; EC 2001; SEPA Official 2002).
One of China’s most ambitious initiatives to address automobile pollution is the national Clean Vehicle Action program. This program was established in 1999 by SEPA and MOST 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 CNG or 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 (Zhao 2002). In Shanghai, adoption of LPG fuel has been widespread among the taxis, because the government subsidized the price of LPG fuel to make it cheaper. Ninety percent of the 42,600 taxis in Shanghai are retrofitted 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\textsubscript{x} emissions (Shanghai S&T Commission 2002). So, to the extent that the alternative-fueled vehicles cannot even meet the minimum air pollution standards for regular automobiles, this program cannot be considered a success.

Another significant concern related to automobiles and the environment is carbon dioxide emissions, a potent greenhouse gas believed to cause global climate change (Watson 2001). Industrial and automotive emissions have already made China the second-largest emitter of greenhouse gases, after the United States. This environmental problem has less immediacy for China’s citizens right now, because it does not directly affect them as obviously as the urban air pollution of NOx, CO, and HC. But over time, climate change will probably pose one of the biggest challenges to automobile use in China (and the rest of the world). The only 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. Unlike other common air pollutants, carbon emissions cannot be reduced by a catalytic converter in automobiles. China currently has no fuel efficiency standards, although they are reportedly under development. To calculate potential carbon emissions, the oil consumption scenarios from earlier in the chapter were used to determine a range of possible carbon emissions from Chinese passenger cars in the future. In the best-case scenario, if oil consumption was only 0.3 million barrels per day in 2020, annual carbon emissions from cars would be 13 million metric tons. In the worse-case scenario, if oil consumption was 24 million barrels per day in 2020, annual carbon emissions from passenger cars would be 1,051 million metric tons – one and a half times more than China’s total carbon emissions in 2000. Using a mid-range scenario of 3.3 million barrels of oil per day, annual carbon emissions from passenger cars in China in 2020 would be 144 million metric tons.11 Another study forecasts carbon emissions from Chinese passenger cars in 2025 to range between 89 to 231 million metric tons of carbon (Kobos, Erickson, and Drennen 2003).

As Chinese policymakers and research institutes develop 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. automobiles 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.

11 Author’s calculations as follows: $X \text{ million bbls/day} \times 6 \text{ GJ/bbl} \times 20 \text{ kgC/1 GJ oil} \times 365 \text{ days/year} \times \frac{1000 \text{ metric tons}}{1 \text{ GgC}} = X \text{ million metric tons C}$. China’s annual carbon emissions were estimated to be about 700 million metric tons in 2000.
Because Chinese consumers have limited disposable income, they rate fuel economy among their top concerns when they are purchasing an automobile. Their concern provides the main incentive for auto manufacturers to produce more fuel-efficient cars at this time in China. GM actually introduced a more fuel-efficient Buick luxury sedan in order to make its product more competitive in China (Murtaugh 2002). No other foreign manufacturer purports to have improved the fuel efficiency of any auto models once they have been put into production in China. Two U.S. manufacturers introduced the following, notoriously inefficient, sport-utility vehicles (SUVs) to China: the Jeep Cherokee and the Chevrolet Blazer. On the bright side, U.S. manufacturers are also introducing small, compact, fuel-efficient cars as well, such as the Ford Fiesta and Buick Sail.

In summary, there are numerous implications of increased passenger car use in China. Passenger cars are already causing a number of problems, including increased urban air pollution, emissions of greenhouse gases, and oil consumption and imports. The Chinese automobile industry, however, is an important sector in the Chinese economy, and it contributes positively to economic growth, to job creation, and to the development of national technological capabilities. Ideally, the problems can be diminished and the benefits enhanced through effective public policy measures and the contributions of foreign investors.
Chapter 3

FOREIGN TECHNOLOGY IN THE DEVELOPMENT OF CHINA’S AUTOMOTIVE SECTOR

Foreign technology has influenced the development of China’s automobile sector since its inception, but foreign influence has been most pronounced during the last decade, the only period of substantial growth in the history of this sector. In 1963, China produced a grand total of eleven cars and twenty years later, China was still only producing fewer than 10,000 passenger cars per year (Harwit 1995). Another twenty years later in 2002, with the auto market raging “like the burning fire in winter,” (NBS 2002) Chinese auto companies collectively produced a million cars for the first time.

In order to make this profound transformation from producing eleven cars in 1963 to the current million or more annually, China had to acquire quickly the necessary knowledge and technological capabilities for automobile production. Starting all over again after the Cultural Revolution from practically nothing in the way of equipment and know-how, China was faced with a classic “make or buy” technology dilemma. Should it try to develop these capabilities internally or was China too far behind the world leaders for this ever to be feasible? What could China hope to obtain from foreign providers of technology? A historical perspective reveals that the Chinese government has been highly inconsistent regarding these questions.

Amsden (2001) provides a typology of technological capabilities that developing country industries must acquire to become competitive in the world market: production, project execution, and innovation capabilities.¹ Production capabilities include being

¹ See also (Dahlman, Ross-Larson, and Westphal 1987).
able to oversee the operation of established facilities, production engineering, repair and maintenance of physical capital, troubleshooting, and adaptation of products and processes as needed. Project execution capabilities include personnel training, pre-project feasibility studies, project management, project engineering, procurement, plant construction, and start-up of operations. Innovation capabilities include the skills necessary to create new processes and products (ranging from basic science to product development).

After World War II, and then again after the Cultural Revolution, China lacked all of the automotive capabilities described above: Chinese firms had no production, no project execution, and no innovation capabilities at all. This chapter will describe how China has sought to acquire these capabilities from foreigners historically. A chronology of automobile industry-related events is available in Appendix B.

3.0 PRE-WAR INFANCY

An important pre-condition for successful economic development in “late-industrializing” countries like China was the acquisition of manufacturing experience before World War II. Such long-term manufacturing experience provided many obvious benefits for late-industrializing countries and also built confidence among foreigners that their investment would pay off (Amsden 2001). Just before World War II, pockets of manufacturing expertise cropped up along the eastern coast of China. These areas were most concentrated in the Northeast part of China (known then as Manchuria and under Japanese control from 1931) and in the handful of free-market “treaty ports” carved out
by foreigners (Fairbank 1951). The manufacturing experience that accumulated in these areas in China was closely linked with the knowledge brought by the Japanese in Manchuria and the Europeans (especially the British) and Americans in the treaty ports. To cite one example, in the 1930s, historic mining centers in northeast China inspired the Japanese to develop China’s first heavy industry complex during their occupation of Manchuria, including the mining industries of coal, iron ore, and oil shale, as well as large-scale factories for the production of iron, steel, industrial machinery, and transportation equipment (Rawski 1989). Chinese workers in these factories began to accumulate knowledge about how to produce such products.

With respect to the automobile sector in particular, China had meager pre-war manufacturing experience. In the early twentieth century, automobiles initially were imported from abroad, mostly from the United States. Imports served the Shanghai market and were driven by the Chinese business and political elite. For example, famous revolutionaries Sun Yat-sen and Zhou Enlai were both known to have driven Buicks during that time. It was expensive for foreigners to ship these products to China, so parts and components companies sprang up in Beijing, Tianjin, and Shanghai to provide some elements of the automobiles, such as the heavy bodies. This development led to the construction of a few crude assembly plants to put these Chinese-made parts together with the other imported components (Harwit 1995). Predictably, these three cities later became centers of automotive expertise in the late twentieth century. For the most part, however, foreign auto companies did not invest in China during the early twentieth century to the extent they did 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 they would later apply to the automobile sector. The current Chinese manufacturer, Chang’An Automobile Group, was originally founded as the Shanghai Western-Style Artillery Bureau in 1862. It was established as part of the Qing Dynasty’s “westernization” experiment, and its artillery was used during China’s war of resistance against Japan. The company was moved three times, from Shanghai to Suzhou, then to Nanjing, and eventually to its current location in the western city of Chongqing. Using its experience with artillery production, Chang’An gradually began producing other types of machinery, and was re-named the State-Owned Chang’An Machine Building Plant in 1953. The plant produced its first automobile in 1958 using technology imported from the Soviet Union.2

Before World War II, most foreign companies were content to export automobiles to China. For example, although Dr. Sun Yat-sen wrote to Henry Ford in 1924 asking him to help build an automobile industry in China, Ford merely opened a sales and service branch in Shanghai. In Sun Yat-sen’s letter to Ford, he wrote, “I have . . . read of your remarkable work in America. And I think you can do similar work in China on a much vaster and significant scale. It is my sense that your work in America has been more individual and personal, whereas here in China you would have an opportunity to

2 Chang’An is but one of many automobile producers who sprang from the weaponry industry. As of 1995, the government-owned China National Ordnance Industry Corporation (CNOIC) owned 120 automakers in China. The automotive divisions accounted for 60 percent of CNOIC’s output value, and 90 percent of the profits of the whole weaponry sector. (FBIS 1995)
express and embody your mind and ideals in the enduring form of a new industrial system” (Ford 2002, 2).

For its part, the Chinese government appeared to be content to import automobiles from abroad due to its lack of real initiative to establish a domestic industry at that time. To be sure, the Chinese government was in constant turmoil during the first half of the twentieth century (Fairbank 1951). This was a time of inconsistent policy and little economic development in China, indeed chaos, because of leadership struggles and successions, the war with Japan during the 1930s, and then the long civil war in concert with World War II.

3.1 THE EARLY POST-WAR YEARS

After the triumph of Chairman Mao Zedong’s communist revolution, Chinese society began a radical transformation through industrialization. China relied heavily on its northern neighbor and ally, the Soviet Union, for technical assistance. The People’s Republic of China (PRC) decided it wanted to develop an automobile industry for the purposes of transporting rural products and the military. Thus, the Soviets transferred the first real automotive knowledge and hard technology to China. They are known, for example, to have helped start China’s First Auto Works (FAW) in 1953 in the northeastern 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 design for a smaller all-terrain utility vehicle to China,
following up with careful training of Chinese workers to ensure that they could actually manufacture the design. Amazingly, this same basic design – dating back half a century – is still in production at the joint venture between DaimlerChrysler and Beijing Jeep.

Regarding passenger cars, FAW produced its first Hongqi (Red Flag) black sedan, based on Daimler Benz’s 200 model, in 1958 to serve as limousines for the government elite. Also in 1958, Shanghai Automotive Assembly Plant (now Shanghai Automotive Industry Corporation – SAIC) produced its first passenger car, the Phoenix. These developments suddenly stopped after the Sino-Soviet split of 1960 halted all foreign technology transfer and assistance for the Chinese automobile sector 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 at that time; Nissan produced only 865 passenger cars in 1950 (Halberstam 1986).

3.2 STUNTED DEVELOPMENT

Even before the 1960 Sino-Soviet split, automotive industrial development was hindered by central government policies, especially the Great Leap Forward campaign (1958-1960). Instead of consolidating companies and taking advantage of economies of scale with mass production, as European and American auto companies were doing, the Chinese government’s aim (against the advice of the Soviets) was to stimulate a small-scale industrialization of all the rural areas. This approach proved to be unfeasible and ultimately caused a huge famine. But a related tradition of small-scale enterprise endures
in the automotive sector in China, which might explain why there are still 118 passenger-car manufacturers, some of which are very small, still operating to this day around the country.

After the Great Leap Forward, the “Third Front” campaign was promulgated to promote self-reliance and develop an inland industrial and military base beginning in 1964. During the Third Front years, heavy industry was decentralized and dispersed around the country to make factories more resistant to attack. Entire factories were torn down and re-built in remote mountainous regions. By 1969, there were 33 automobile factories producing a grand total of 150 cars (Harwit 1995). As many as half the Third Front factories are still in place, including the Shiyan Number Two Automobile Factory in Hubei province (Shapiro 2001), later known as Second Auto Works (SAW) and currently known as Dongfeng Automobile Company. The remote Sichuan and Shanxi Auto Works companies also began construction of factories in this period. All of these factories produced primarily medium-sized trucks (Zhang 2002).

Production of passenger cars essentially ceased during the Cultural Revolution (1966-1971) and there was no investment in the automobile industry. Sedans were regarded as luxury articles, so they were not produced, and most factories entirely shut down their automobile production (FBIS 1994). SAW began construction of its factory in 1967, but it did not start operation until 1975. Chang’an completely stopped producing its cross-country vehicle in 1962 and shifted to the manufacture of other goods. According to government statistics, there was also no investment at all in the automobile industry during the 1970s (CATARC 2002). Coincidentally, these were the golden years of the U.S. automobile market, a time when U.S. auto plants were each
producing 200,000-400,000 units a year. Meanwhile, all of China’s automobile factories combined produced less than 700 automobiles annually during that same time (Harwit 1995). The lost opportunity in terms of auto industry-related technological and economic development to the Chinese might have been enormous. All this time while the Europeans, Americans, and Japanese were producing hundreds of thousands of automobiles each year, profiting and “learning-by-doing” to increase their innovative capabilities, the development of Chinese manufacturers was stunted. For example, during the 1950s, the U.S. automobile industry represented nearly 20 percent of the gross national product of the United States (Halberstam 1986).

3.3 A SECOND INFANCY

China’s automobile industry experienced a second infancy after China re-opened its doors to the world after the Cultural Revolution in the late 1970s. For years, automobile production had essentially been at a standstill. Not only had expertise been forgotten or lost, but also there had been no development of new technologies, cultivation of skilled and innovative workers, or acquisition of technological capacity during the 1960s. Realizing that they needed automobiles, but not wanting to become totally reliant on imports, China’s government imposed restrictions on auto imports and reached out to foreign companies through technology licensing and the formation of joint ventures. Initially, China asked the Japanese for help. The Japanese exported a large number of trucks and agreed to provide some technical assistance to the Chinese during the early 1970s (Harwit 1995). But the Japanese were wary of generating potential competitors to
their own automobile companies, so the extent and duration of their technology transfer was limited.

The first major manufacturing joint venture of any kind to be established between a Chinese company and a foreign firm after the Cultural Revolution was an automotive joint venture. This was the Beijing Jeep Corporation (BJC) joint venture signed between state-owned Beijing Automobile Industry Corporation (BAIC) and American Motors Corporation (AMC) in January 1984 (see Chapter 4). In this joint venture, AMC was to provide all the new technology for Beijing Jeep. The Chinese government had decided to limit foreign ownership to no more than 50 percent for automobile joint ventures, and AMC duly took a minority stake. For this first joint venture, technology was transferred in the form of “complete knock-down” (CKD) kits. CKDs are sets of automotive parts that are packaged in one country, and then exported to another for assembly. For the Beijing Jeep joint venture, Jeep Cherokee CKD kits were packaged in the United States by AMC, sold to Beijing Jeep, and then exported to China for assembly by the BJC Chinese workers.

Shortly after the establishment of Beijing Jeep (BJC), a second joint venture was established between the Shanghai Automotive Industry Corporation (SAIC) and Volkswagen in October 1984. Volkswagen took a 50 percent stake. In the long run, Shanghai VW has proved to be much more successful than Beijing Jeep. It has been by far the largest annual producer of passenger cars ever since the mid-1980s.

Chinese auto companies also licensed technology from foreign firms in these nascent years. One prime example is acquisition of technology for the ubiquitous compact cars used as taxis in many large cities. Tianjin Automotive Industry Corporation
(TAIC) licensed technology from Daihatsu in 1986 to produce the Xiali (Charade) mini-sedan often seen in use as red taxis in Beijing and Tianjin. In another example, 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). These subcompact sedans are still in production today, virtually unchanged from their original model.

To help create a market for these new automobile joint ventures, the Chinese government officially permitted private ownership of automobiles starting in 1984. For at least the first decade thereafter, however, government officials would provide most of the demand for new automobiles.

3.4 TRYING TO LEARN FROM FOREIGNERS

After the flurry of activity in the 1980s, the government began to reconsider its automotive industrial strategy. China had not gained much knowledge from the foreign firms who 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, and there were no specific stipulations on technology transfer. For example, while the government wished to increase the production and availability of passenger cars, as late as 1990 very few were actually being produced. At this time, the output of automobiles still only accounted for less than ten percent of total motor vehicle output (Zhang 2002).
Meanwhile, two new joint ventures were formed: one in 1990 between VW and First Auto Works, to produce Jettas, and the other between French Citroen and Second Auto Works (now Dongfeng Auto Company), to produce the *Fukang* compact in 1992.

There were many differing views within the government at this time about whether China should try to foster its own domestic industry or whether it was too late for China to possibly catch up with the foreigners. After all, if the foreigners were willing to manufacture and sell the cars in China, then at least China benefited from the jobs and tax revenues associated with those joint ventures. Yet, there were those who believed that China should model itself after the Japanese and Koreans, who had both managed to develop world-class automobile companies after World War II that were now challenging or even surpassing the U.S. and European companies.

3.5 1994 AUTO POLICY

China’s government officials finally came to agreement and issued the first real industrial policy for the automobile industry in 1994, more than ten years after the announcement of the first joint venture and subsequent formation of three other major joint ventures. This policy took a radically different approach from the *de facto* policy of the 1980s in three 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’ (*San Da, San Xiao* - three big firms and three smaller firms) arrangement and it intended to 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 the joint ventures) from
international competition by establishing import quotas and stiff tariffs (80-100 percent) on both vehicles and parts. It continued to limit foreign ownership in joint ventures 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.

3. Market creation. To stimulate the market, the government re-affirmed its encouragement of private ownership for passenger cars. China officially permitted the private ownership of vehicles in 1984.

These new 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 firm. In the end, General Motors made the largest single foreign investment ever in China as of 1997 when it established its joint venture, as discussed in great detail in the case study on Shanghai GM. Also in 1997, Honda took over Peugeot’s troubled joint venture with Guangzhou Automotive Manufacturing Company, and then Ford entered into negotiations with Chang’an in 1999.

There was a veritable flood of investment into the Chinese auto industry during the 1990s from both Chinese government and foreign sources. According to government statistics, total investment into the motor vehicle and related industries from all sources totaled nearly US$60 billion during the 1990s. To put this in perspective, total investment in the vehicle sector from 1953 to 1989 equaled only US$1 billion, and 88 percent of that amount was invested during the mid to late-1980s (CATARC 2002).
3.6 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 by the entire industry, 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. In other words, passenger car production was doubling about every two and a half years. Preliminary reports for 2002 suggest a 40 percent increase in total production over 2001 levels. For a few companies, the growth has been even more dramatic. As of December 2002, sales had grown 43 percent for FAW-VW, 67 percent for SAIC-Chery, 91 percent for Shanghai GM, and 57 percent for Dongfeng Citroen (CATARC 2003).

It is easy to be impressed by such numbers because new retail automobile sales in the United States grew on average only 0.3 percent each year during the 1990s (Davis and Diegel 2002). But total production numbers remind observers that the industry is still young. In 2000, only 612,000 cars were produced in China compared with the 17.2 million new cars that were registered in the U.S. and the total automobile stock is still very small in China. By the end of 2001, there were only an estimated 8.5 million passenger cars in China compared with 179 million in the United States (including SUVs). Most automobile companies in China still produce fewer than 100,000 automobiles a year.

In retrospect, the 1994 automobile industry policy had mixed results. The consolidation of the automobile industry into a handful of big firms was not realized.
Instead of six major firms, there are still 13 out of a total of 118 total 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 because so few automobiles are being exported to foreign markets and all producers worry about whether they can compete against the flood of imports expected now that China has joined the WTO. Today, only a handful of passenger cars are actually exported from the country and of those exports, the majority goes to developing countries although in 2002, 256 Chinese cars were actually exported to the U.S. through American Automobile Network Holdings (Ibison and McGregor 2002). Most manufacturers in China ruefully admit that their cars are much more expensive and of inferior quality than the foreign competition. According to GM China’s Philip Murtaugh, “We have no plans whatsoever to export to Europe or North America. We're not (cost) competitive with cars produced in North America or Europe” (Zoia 2001).

On the other hand, the 1994 policy effectively forced manufacturers to use a high percentage of Chinese-made parts and components, creating thriving related industries. For example, in 1994 only 24 percent of the VW Jetta parts were made by Chinese companies, but by 2000, 84 percent of the parts were Chinese-made (Huang 2002).

3.7 THRUST INTO THE UNFETTERED FREE MARKET

The latest major policy development for China’s automobile industry is the result of China’s entry into the World Trade Organization (WTO) in 2001. As China begins the liberalization of its trade barriers because of its entry into the WTO, the Chinese
The automobile industry is expected to undergo more upheaval than any other sector of the Chinese economy with the exception of agriculture, which has been projected to lose 9.6 million workers (Li and Wang 1998). This projection is due to the fact that highly protected sectors like agriculture and automobiles will contract significantly, while labor-intensive open sectors such as textiles and clothing will be the main beneficiaries.

In order for China to become a member of the WTO, it had to negotiate a bi-lateral concession agreement with any member country that requested one, as well as negotiate a multilateral protocol of accession with all WTO members as a group. Not surprisingly, the United States requested a bi-lateral concession agreement from China, and these negotiations became known as the Permanent Normal Trading Relations (PNTR) negotiations in the United States. The negotiations were so named because if China entered the WTO, the U.S. Congress would be required to stop its annual review of Most-Favored Nation (MFN) status. Any provisions that China agreed with any individual country automatically would apply to all WTO member countries because of the WTO’s non-discrimination rules (WTO 2003).

The PNTR agreement was concluded in November 1999, upheld by the U.S. House of Representatives in May 2000, and passed by the U.S. Senate in September 2000. Entering into force in November 2000, the PNTR agreement contained many specific concessions regarding the automobile industry in China. First, it specified that import tariffs for complete automobiles would be reduced from 80-100 percent to 25 percent by July 1, 2006. Import tariffs for parts and components would be reduced from 35 percent to 10 percent by the same date. Import quotas on automobiles would be decreased 15 percent per year until they are cancelled in 2005. Import licenses would
also be phased out by 2005. Upon China’s accession to the WTO, non-Chinese bank financial institutions would be permitted to provide financing for automobiles without any limitations. Also upon accession, China would no longer condition importation or investment approvals on whether any competing domestic suppliers exist, or performance requirements of any kind, such as export performance, local content, technology transfer (author’s emphasis), offsets, foreign exchange balancing, or research and development. Foreign and domestic businesses would be taxed uniformly, and majority ownership limits on foreign manufacturers for engines would also be eliminated (ITA 2003a). Also, provincial governments would be given the authority to approve foreign direct investment projects up to US$150 million by 2005. Until 2002 when it was raised to US$60 million, the limit was US$30 million, giving the central government great influence over the terms of FDI agreements (Huang 2002). China became the 143rd member of the WTO in 2001. Thus, many of these provisions have already entered into force – most notably the provision that all technology transfer requirements are now illegal.

It is hard to predict whether exposing the industry to the world market through entry into the WTO will help or hurt China’s auto industry. Given the state-owned Chinese firms’ historical resistance to reform and change, it may have been a deliberate strategy on the part of the government to cede its protections of this industry. Whether the industry can withstand the withering competition from abroad is an open question, but it seems almost inevitable that Chinese companies will become even more reliant on their foreign partners for advanced technologies and management expertise once confronted
with foreign competitors. Thus it appears that the Chinese government may once again have reversed course with respect to its industrial policy.

At the same time, the Chinese Government’s 10th Five-Year Plan (2001-2005) for the automobile industry somewhat feebly still tries to assert some independence from the world market. The plan states that the guiding principles for the development of automotive industry will be to persist in opening to the outside world while “boosting independent development capabilities;” stepping up the “readjustment and upgrading of the product mix” with the parts and components sector as the foundation and economy cars as the priority; optimize the organizational structure of the industry and achieve economies of scale; to accelerate the creation of a state-level technical center for strengthening Chinese technological innovation capacity and product development; to improve the market environment, reinforce legislation and promote fair competition; and, to sharpen the “competitive edge” of China’s industry (Asia Pulse 2001).

3.8 RECENT CONSOLIDATION OF INDUSTRY

As of 2003, ten foreign-invested joint ventures dominate the Chinese domestic passenger car market, with about a hundred small firms on the periphery. The joint ventures account for most of China’s passenger car production. In 2002, there was a major merger within the Chinese automobile industry when Tianjin Automobile Xiali Company (TAIC), which had formed a joint venture with Toyota, merged with First Auto Works. Therefore, as can be seen in the table Sino-Foreign Joint Ventures in the Chinese Automobile Industry (Appendix C), there are currently ten major Sino-Foreign joint ventures: Shanghai VW, FAW-Volkswagen, Shanghai GM, Dongfeng Citroen,
Guangzhou Honda, Chang’An Suzuki, Chang’An Ford, Beijing Jeep, Beijing Hyundai, and FAW-Tianjin-Toyota. It is also reported that a joint venture between Dongfeng and Nissan is under development.

3.9 CONCLUSION

This brief history demonstrates that Chinese government policy for the automobile industry has flip-flopped several times since World War II, and that its policy signals with respect to foreign investors have been highly inconsistent. Initially, the government sought technology and training from the Soviet Union to create a foundation for China’s own automobile industry. Because of the Sino-Soviet split, the government sealed itself away from the influence of foreign technology for two crucial decades when the U.S. and Japanese auto industries were innovating and realizing tremendous growth in production. During this period of isolation, the Chinese government fragmented the industry geographically, and eventually passenger production actually ceased.

Upon opening to the world in the 1970s, the industry was re-born, starting from essentially nothing except what remained of the old 1960s Soviet technology. No formal plan or set of policies for the auto industry was issued except to use any means possible to acquire more advanced technology. The government-owned auto firms both licensed technology from the Japanese and negotiated joint ventures with U.S. and European auto companies during that time. After several major joint ventures had been signed, the Chinese government apparently reconsidered this strategy because it wanted to cultivate indigenous technological capabilities so that Chinese companies could compete in the world market. This new approach was enshrined in the 1994 Auto Industry Policy, and it
resulted in the Chinese government’s erecting even higher trade protections for its industry and making more stringent demands of foreign investors with respect to technology transfer. In a final reversal of policy, China decided to enter the WTO. The terms of China’s entry mean that almost all of the requirements placed on foreign investors in 1994 must be lifted, and trade protections must be dismantled, all of which amounts to yet another complete turnaround of Chinese policy for the auto industry.

Such inconsistency has hindered the development of the Chinese auto industry. In Japan and Korea, government played a strong role in developing their auto industries through consistent protections, subsidies, and performance policies (Amsden 2001).³ After the opening in China, the government seemed unable to decide whether it really wanted to have its own industry or whether it would be content to import vehicles as it had done early in the 20th century. Once the government realized that their weak requirements of the foreigners had resulted in the Chinese industry becoming mere assemblers, it issued a landmark policy that finally imposed real technology transfer requirements on the foreign investors. Yet this policy only endured for about five years because as China negotiated its entry into the WTO, it promised to remove all of these requirements as a price of entry.

It is somewhat ironic that the first period of rapid expansion in automobile production in China during the late 1990s coincided with the policy of more stringent technological requirements on foreigners. Now that these requirements are being

³ Amsden (2001) cites Mahn-Je Kim, President of the Korea Development Institute, who stated that, “Korean automobiles faced severe market competition in the export frontiers. However, it was not market competition that stimulated the industry to grow strong enough to venture into the world market. I am not arguing that market competition was useless. Rather, I would like to point out that the environment was provided in which the private sector’s creativity and responsibility could be maximized” (Amsden 2001, 140).
eliminated, China’s industry will be scrambling to become more competitive, but it is quite possible that China’s auto industry will be again limited to automotive assembly due to its comparative advantage in low-cost labor. Without aggressive innovation on the part of the Chinese auto companies, they will be unlikely to be able to challenge the foreign companies. On the other hand, the increased competition inside the Chinese market certainly contributed to a sudden modernization during the late 1990s of automotive technology as producers scrambled to put more attractive products on the market.

The next three case studies will show how Chinese government policies strongly affected the nature of the Sino-U.S. joint ventures, the degree to which technology and knowledge were transferred within the joint ventures, and the factors contributing to their ultimate success or failure. Each case begins with a brief history, is followed by a section on technology transfer in the joint venture, and concludes with a discussion.
Chapter 4

CASE STUDY OF BEIJING JEEP

Top executives in big companies only see China as a market to sell automobiles. They don’t see China as a place to develop automobiles. — Chinese Employee of Beijing Jeep

4.0 HISTORY

Beijing Jeep Corporation (BJC) was the original trailblazer for Sino-foreign automobile joint ventures in China. In fact, it was the very first Chinese manufacturing joint venture signed with any foreign company after China re-opened to the West in the late 1970s. As will be discussed in this chapter, the pioneering spirit once associated with Beijing Jeep is flagging, and the joint venture continues to be troubled even though DaimlerChrysler AG signed a new 30-year contract agreement with Beijing Automobile Industry Corporation (BAIC) in June 2002.

The U.S. firm that originally initiated the Beijing Jeep joint venture was not Chrysler, but actually American Motors Corporation (AMC). AMC was the owner of the Jeep sport-utility (SUV) brand, and it was also the last independent U.S. original-equipment manufacturer to be absorbed by the Big Three automakers. During the early 1980s AMC was struggling financially, though gaining access to the Chinese market was viewed as a coup unrivaled by any other U.S. automobile firm. Not only did AMC beat its own U.S. competitors to be the first company in the Chinese market, but AMC also beat out all the Japanese competitors. AMC’s investment in China came at a time when
U.S. companies were perceived to be losing out to the Japanese auto manufacturers. To illustrate how optimistic Wall Street was about the Chinese market, AMC’s stock jumped 40 percent just after the announcement of the joint venture was leaked to the press in 1983 (Mann 1989). Yet, the euphoria surrounding the investment failed to acknowledge some of the huge challenges that this new joint venture company would face.

American Motors Corporation was founded in 1954 by a final consolidation of several of the smaller independent car companies, specifically Nash-Kelvinator Corp. and Hudson Motor Car Co. During 1979, French car company Renault bought a minority stake of AMC with an agreement that AMC would sell Renault models in the United States. Almost a decade later, in 1987, Renault sold its stake to Chrysler. Chrysler 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. DaimlerChrysler’s ancestors date back about a century, to 1883, when Benz & Co. was formed, and 1908, when Walter P. Chrysler produced his first automobile. Headquartered in Stuttgart, Germany, DaimlerChrysler currently owns a number of automotive brands including Chrysler, Dodge, Jeep, Mercedes-Benz, Maybach, Smart, AAV, a 37.3 percent stake in Mitsubishi Motors Corporation of Japan, and a 10 percent stake in Hyundai Motors of Korea. As of 2002, the company had 372,000 employees with annual revenues of US$136.3 billion (Standard & Poor's Register of Corporations 2003a). Aside from its automotive interests, DaimlerChrysler is also currently in the aircraft, navigation, semiconductor, plastics, rubber, space, and missile businesses.

1 Nash and Kelvinator, and Hudson and Studebaker had recently merged into the two respective companies that then they merged to become American Motors Corp.
The Chinese partner has remained unchanged throughout the 20-year history of the joint venture. From the beginning, Beijing Automotive Works (BAW) was the owner of the Chinese share. BAW was a subsidiary of Beijing Automotive Industry Corporation (BAIC), and the Beijing Municipality owned BAIC. A reorganization of the businesses has resulted in the creation of a new firm called the Beijing Automotive Industry Holding Company (BAIHC), which has taken over BAIC’s role. Thus, the Chinese partner was, and still is, a state-owned enterprise.

Beijing Jeep is literally located in the heart of downtown Beijing. It is a five-minute taxi ride from the China World Trade Center and only a slightly longer distance from Zhongnanhai, the compound where former President Jiang Zemin and many of the top Chinese leaders live and work. Such close proximity assures the joint venture of special scrutiny, but at times the high visibility of this company has also played to BJC’s advantage because no government leader, thus far, has been willing to let the first symbol of China’s modernization and cooperation with the West completely perish. This situation has resulted in a paradox for Beijing Jeep. It continues to be strangled by its conservative state ownership, yet is kept alive by Beijing’s reluctance to let it fail.

The motivation for the joint venture was compelling for both companies back in the late 1970s. At the time, the Chinese were producing the BJ212 (now the BJ2020), the technology of which was donated to China by the Soviets back in the 1950s and transferred to Beijing Auto Works after the Cultural Revolution. This World War II-era utility vehicle was dated and ill suited for the Chinese military’s needs. In the early 1980s, the military was eager to obtain modern, soft-top, four-wheel-drive vehicles especially designed to meet Chinese specifications. In addition, the Chinese government
wanted to modernize China’s automobile industry. Since its own companies were so far
behind the world-level in terms of technological capability, the government felt that it
had to turn to foreigners to acquire modern technology. The government hoped that the
Chinese companies would learn from their foreign partners and acquire enough
capabilities to produce a 100-percent Chinese-made all-terrain vehicle before too long.

As it entered into negotiations with BAW, American Motor Corporation was in
financial trouble at home. It was on the verge of failure in 1979 when Renault, France's
state-owned automaker, bought a 46 percent stake in the company. Almost 10 years
later, in 1987, Chrysler bought Renault’s stake for US$1.1 billion in cash and Chrysler
stock. Although AMC had only cost US$200 million in cash, it became a heavy burden
for Chrysler, especially after the stock market crashed, because Chrysler had assumed
about US$700 million in debt and approximately US$300 million worth of un-funded
pension liabilities (Ingrassia and White 1994).

When AMC began negotiations in 1979, it was also losing market share at home,
in part because its gas-guzzling Jeeps were undesirable for consumers who were suddenly
interested in fuel economy after the two oil shocks of the 1970s. The entire U.S.
industry, in fact, was discovering that it lacked products that were competitive with the
small, fuel-efficient Japanese cars. With a certain amount of hubris, it never seemed to
occur to AMC that it might create a competitor by transferring technologies to a Chinese
firm. The Japanese were more hardnosed. In fact, Toyota entered into negotiations with
Beijing Auto Works, but it was unwilling to actually transfer the technology to
manufacture automobiles in China; Toyota was only interested in exporting automobiles
directly to the Chinese mainland. In contrast, American Motor Corporation saw the
potential of a vast market, incredibly low labor costs, and a potential export base for East Asia (Halberstam 1986; Mann 1989). Of course, American Motors Company was not the first U.S. firm to fall prey to the alluring idea of a boundless, untapped market for U.S. goods in China. This misconception dates back at least two centuries, as noted by John Curtis Perry:

As the nineteenth century wore on . . . [Americans] were, at least in a commercial sense, prepared to accept the Chinese myth that China, the Middle Kingdom, formed the center of the world. Americans believed that to command the trade of the Orient, potentially the world’s most lucrative commerce, would be to capture global economic primacy (Perry 1994).

Jim Mann (1989) discerned three misleading myths that were accepted by AMC during its joint-venture negotiations with the Chinese. These myths were that: (1) since there were a billion people in China, there must be a large market, (2) foreign companies should establish a presence there, and, (3) firms should be prepared to stay there for the long-term. According to Mann, these assumptions were wrong because even though China had a billion people, almost none of them could afford to buy a car, much less a 4-wheel-drive Jeep. Also, as time wore on, simply having a presence in the market did not automatically curry favor with the Chinese government, which was intent on winning the best terms from any firm that could be negotiated. The foreign companies failed to realize that the primary Chinese interests were to modernize their industry, and to protect it from too much competition while doing so. Last, most foreign firms that entered the Chinese automobile market seriously underestimated how long they would have to invest money without earning any substantial returns.
On May 5, 1983, AMC accepted a minority stake in the joint venture for a term of twenty years. Of the total US$51 million in equity, Beijing provided US$35 million (mostly in equipment assets worth 69 percent), and AMC provided US$16 million (half of which was the contribution of technology). There were to be seven Chinese to four Americans on the board, and a Chinese executive would become Chairman of the Board. For the first three years, an AMC representative would serve as President and CEO, and then the job would alternate between appointees of the Chinese and U.S. companies (Mann 1989). The plan was to continue production of the BJ212s for the first five years to keep a revenue stream going, to introduce AMC’s Jeep Cherokee XJ model, and to develop the canvas-top military vehicle explicitly designed for China (to be introduced at some future date). The Cherokees were to be initially assembled from complete knockdown kits (CKDs) that would be imported from the United States. It was agreed in a memorandum that the parts for the Cherokee would be gradually localized – i.e., made by Chinese suppliers (Harwit 1995). An internal technology center was established (see Fig. 4.2), staffed almost entirely by Chinese engineers. As of 2002, there were approximately 200 Chinese engineers and only one foreign engineer employed there.

A major point of contention during the negotiations was how AMC would develop the new all-terrain vehicle with a soft canvas top. Although the contract called for development of the new model, it was short on specifics. The Chinese had yielded to AMC’s insistence that this model would take millions of dollars, as well as years of
design work, and agreed to accept the Cherokee as a stop-gap vehicle for the interim period (Harwit 1995). The problem with this concession was that it provided few incentives for AMC to design a new vehicle. Indeed AMC’s profit incentive was to simply sell as many kits of the Cherokee as possible to Beijing Jeep for assembly. The saving grace, if there was one, was that AMC still had an incentive to localize parts to save money on shipping the parts. After further exploration of the idea, AMC estimated it would take between US$700 million and US$1 billion to develop such a vehicle. Since the entire joint venture was only worth US$51 million, AMC privately concluded that designing and developing a new vehicle was completely out of the question (Mann 1989).

Production and sales got off to a rocky start, and the entire joint venture 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. The contract had specified that Beijing Jeep would earn foreign exchange by exporting its products, but the Beijing Jeep products were uncompetitive in quality and price on the world market, so no Jeeps had been exported. The Chinese government had established a policy that limited how much currency could be converted. After intervention by future Premier Zhu Rongji, the government eventually struck a secret deal in 1986 with Beijing Jeep alone to establish a special US$120 million fund to supply the necessary foreign exchange because it feared its model joint venture would fail. Once it recovered from this crisis, Beijing Jeep’s production and sales of both the old BJ2020 and the Cherokee rose to a combined peak of 81,000 in 1995. After 1995, sales and production declined precipitously, falling to a rock-bottom low of 9,052 in 2002, a level lower than the number of vehicles that were produced at Beijing Auto Works before AMC entered the picture in 1983 (CATARC...
During this time (and through 2002) sales of the vintage BJ2020 have consistently exceeded sales of the much newer Cherokee. The soft-top military vehicle desired by the Chinese was never designed or produced, although hundreds of Chinese engineers employed by Beijing Jeep persist in plodding along, trying to solve this vexing problem without foreign assistance.

A number of explanations exist for the astonishing decline of Beijing Jeep’s production levels during the late 1990s. The most persuasive is that the original 20-year contract was ending in 2003, and it seemed unlikely that Chrysler was going to renew the contract. After all, Chrysler closed its Beijing office in 1997, saying that China’s sluggish automobile market offered few opportunities for new projects (Bloomberg News 1997). That same year, BJC posted a 53 percent decline in sales from 1996 (NYT 1998). Aside from Beijing Jeep, Chrysler’s only other international operations were located in Canada. Chrysler was unhappy with the joint venture in China, and perfectly content to let the old AMC contract it had not negotiated expire. Once Daimler-Benz AG merged with Chrysler, it became clear that DaimlerChrysler had a completely different attitude. The German company was quite international in its orientation, and had been trying to break into the Chinese market for some time. Aside from some involvements producing small numbers of trucks and buses in China, in 1995 Mercedes-Benz AG agreed to invest US$1 billion in a joint venture with Nanfang South
China Motor Corp. to produce minivans, a car concept invented by Chrysler (Economist 1995).²

Once DaimlerBenz and Chrysler merged in 1999, prospects for Beijing Jeep perked up. DaimlerChrysler immediately dispelled all the rumors that the company was going to pull out of China. It insisted that the Chinese market mattered to DaimlerChrysler and that the company was determined to commit to China. DaimlerChrysler quickly entered into contract negotiations with BAIC, and announced a new 30-year contract in May 2002. Ownership under the contract is 42.4 percent held by DaimlerChrysler Corporation-DaimlerChrysler (China) Ltd. and 57.6 percent held by Beijing Automotive Industry (Group) Company. Beijing Jeep currently has 3,800 employees (DaimlerChrysler 2002).

At the end of 2002, Beijing Jeep announced that, in addition to the old products, it would also produce the Mitsubishi Challenger Pajaro Sport (otherwise known as the Montero) at the Beijing plant beginning in 2003.³ In 2001, Beijing Jeep had introduced the Grand Cherokee, a luxury SUV, so the Pajaro fits into the SUV product portfolio above the Cherokee and below the Grand Cherokee. Mitsubishi already has four models in production in China. It has arrangements with the South East (Fujian) Motor Corporation Ltd., Dongfeng Liuzhou Motor Co. Ltd., and Harbin Hafei Motor Co. Ltd. to assemble the Freeca, L300 Delica, Delica Space Gear, and Mirage Dingo models (Mitsubishi Motors Corporation 2002).

² This joint venture never materialized.
³ In 2000, DaimlerChrysler had entered into a strategic “alliance” with Mitsubishi. DaimlerChrysler Group (as a whole) is Mitsubishi’s largest shareholder, owning 37.3 percent of Mitsubishi’s stock as of March 2002.
Beijing Jeep has never succeeded in securing permission from the government to produce regular sedan-sized passenger cars. This is an explicit goal for DaimlerChrysler, and it seems it may only be indirectly realized because in late 2002, a new joint venture between Beijing Auto Industry Holding Company (BAIHC) and Korean Hyundai Motor Company was announced to produce sedans (initially the Hyundai Sonata). The total investment by 2003 will be US$400 million dollars with equal ownership. Hyundai became a “strategic partner” with DaimlerChrysler in 2000, meaning that DaimlerChrysler owns 10.46 percent of Hyundai.\(^4\) Hyundai was established in 1967 in Korea, and it has grown into the eighth largest automaker in the world (Hyundai Motor Corporation 2002).

4.1 TECHNOLOGY TRANSFER IN THE JOINT VENTURE

Before 2001, the bulk of the technology transfer in Beijing Jeep occurred just after AMC and BAW launched their joint venture in the mid-1980s. From the start, both sides agreed to produce BAW’s existing BJ212 (which was renamed the BJ2020) for five years while the Cherokee was introduced. As it turned out, the old BJ212 proved to be quite profitable for Beijing Jeep. The technology might have been of 1950’s vintage, but it continued to sell fairly well, especially to the Chinese military, which bought several thousand per year. Later, the engine and some other components from the Cherokee were adapted for the BJ2020, although it outwardly remained essentially the same in appearance (Clark 2002). The Americans continued to sell it even though they had no

\(^4\) Mitsubishi Motors also owns 2.84 percent of Hyundai as of 2002.
responsibility for the technology, while Beijing Jeep could reap the profits, convert them into dollars, and purchase kits from Detroit. As Jim Mann notes:

> It was the ultimate irony: An American corporation that originally expected to reap huge profits by bringing modern technology to China and by selling its superior products to the Chinese found itself surviving, indeed thriving, by selling the Chinese old Chinese products (Mann 1989).

Somewhat surprisingly, the Chinese technical engineers employed at the BJC Technical Center staunchly support the old BJ2020, considering it to be “their” model. The BJ2020 is the only model that they have ever been allowed to tinker with (and learn from), and its existence justifies their own existence (Beijing Jeep Chinese Employee 2002).

AMC introduced its Cherokee Jeep XJ to China in 1984, which had recently been launched in the United States and was proving to be quite popular there. At the time, the Cherokee produced in China was identical to the U.S. version (Clark 2002). Initially, Beijing Jeep purchased Cherokee kits from AMC and then assembled those kits at Beijing Jeep for subsequent sale in China. AMC did not really make any money from selling the vehicles in China, profiting instead from the sale of the kits to BJC. This structure reduced the incentive for AMC to transfer any knowledge about the technology, because it was in AMC’s financial interest to keep the design secrets in Detroit.

The Chinese government soon realized that there were two major problems with this arrangement. First, the purchase of the kits was a major drain of China’s foreign currency, because the kits had to be bought with U.S. dollars and BJC was not earning any foreign exchange since it could not export due to the high cost and poor quality of the
automobiles. Also, the technology transfer was limited because the Chinese workers did not have to learn anything except how to assemble the parts that were sent to them.

In response, the Chinese government issued a policy that BJC would not have to apply for import licenses for the CKD parts if the automobiles contained 40 percent local content. This incentive spurred AMC to work with local suppliers to bring the quality of the Chinese-made products up to an acceptable standard. By 1993, Beijing Jeep had achieved 61 percent localization for the Cherokee parts and components (Harwit 1995). Thus, one could argue that the main technological contribution of AMC’s Cherokee was not the Cherokee technology itself, but its resulting backward linkages into China’s parts and components industry. In the end, Beijing Jeep eventually did manage to localize a good deal of the parts and components for the Cherokee, and today, more than 90 percent of all Cherokee parts are made by suppliers in China (Soh 2002). In the new 2002 contract with DaimlerChrysler, the Chinese were granted full rights to the Cherokee, which is no longer produced in the United States or anywhere else in the world.

The Cherokee technology was not always updated or refreshed in tandem with updates to U.S. models after being introduced to China in 1985. The original engine dated back to 1968, although it was updated significantly over time. Some of the functional changes made in the United States were maintained in China, such as the electronic fuel-injection engine, brake improvements, and distributorless ignitions. But other updates were not made. For example, in 1997, the U.S. Cherokee had a major refreshing, but some of the 1997 updates were not made in China, such as the new body sheet metal, new interior, new fenders, and new grille (Clark 2002).
In 2000, when EURO I standards took effect, the Chinese government required all new cars to be installed with electronic fuel-injection devices and catalytic converters. Zhu Yunde, general manager of Beijing Jeep at the time emission standards were issued, estimated that meeting the new standards for the BJ2020 and certain Cherokee 7250 models would cause sales of those models to drop by 15 percent until the company could bring those models into compliance (China Business Information Network 1998). As of 2003, all of Beijing Jeep models meet the EURO II standards required in the cities, and the Jeep Grand Cherokee purportedly meets EURO III standards, according to Beijing Jeep sources.

Beijing Jeep officials offer several reasons for the stagnation of the technology in China up until the late 1990s. First, if a component or system had been localized in China (a Chinese firm was supplying the part), sometimes the old version was maintained in China only, as in the case of the 1997 updates that were not transferred to China. Second, if production volume is too low, it is nearly impossible to recover the capital costs of re-tooling the equipment and introducing new designs. One official said that a million automobiles must be produced before the investment in the tooling is paid off, so at their current production rate of less than 10,000 automobiles per year, it would take more than a century to be able to recover their capital investment and re-tool. Third, since no other similar autos in the Chinese market were really competing with BJC, there was little incentive to introduce newer technologies until recently.

Aside from the lack of competition in this market segment, the last explanation proffered by a Beijing Jeep official for the dated vintage of the technologies was that since the Chinese government does not want to hurt the purely domestic companies,
especially the smaller ones, it is slow to require changes of all the companies. One U.S. employee commented that technical change was all driven by government in the United States, so if the Chinese government put policies in place to require the use of advanced technologies, the companies would somehow find a way to do it, and the foreign companies would “certainly” transfer the necessary technologies. The fact that sales were dropping off so steeply at Beijing Jeep only worsened the dilemma because less and less money was available for investment (Clark 2002).

Despite the enormous dissatisfaction on the Chinese side that they still have not obtained a new soft-top all terrain vehicles, it does not appear that much has changed since the introduction of the Cherokee. For fifteen years, Beijing Jeep essentially manufactured the same Cherokee model (albeit with some updates) and the old BJ2020 (with the updates from the Cherokee) year after year. Finally in 1998, Beijing Jeep introduced a long-wheel base (LWB) Cherokee to the market because it added more features and comfortable legroom for passengers in the back seat (many Chinese owners hire drivers and ride in the back). In 2001, Chrysler introduced a new model, the luxurious Grand Cherokee, the first new model in 17 years (Treece 2002). Finally, in May 2003, Beijing Jeep introduced a new Cherokee model to replace the old Cherokee called the Jeep 2500. The interior, exterior, major systems (such as the 4-wheel disk brakes and transmission) were all updated and are “up to current world-wide automotive standards” (Clark 2002).

In terms of the environmental performance of Beijing Jeep’s products, DaimlerChrysler is below average due to the relatively poor fuel efficiency of the models. All of Beijing Jeep’s models meet the basic Chinese EURO II standards required by the
big cities. The Jeep Grand Cherokee meets EURO III standards. In terms of fuel efficiency, the various Jeep models get between 14-21 miles per gallon, which is significantly worse than most other models produced by other U.S. manufacturers.

4.2 DISCUSSION

Although Beijing Jeep is the oldest automobile joint venture in China, Chinese engineers employed at the company still feel they have not been able to acquire any advanced technological capabilities. One Chinese engineer working there lamented, “I’m not even sure that we are even where Chrysler was in 1980,” adding that, “the only way to close the gap is for DaimlerChrysler to send engineers to China to work with us.” When the company was healthier financially, Chrysler sent some Chinese engineers to Detroit for training, but there has been no exchange like this since the mid-1990s. Even then, the training was “piecemeal and short” according to one trainee. The Chinese would be shown around and then given easy things to do, isolated from the rest of the company. To really learn, in this trainee’s opinion, the Chinese should be sent for a longer time and sent to work in each division so they can learn about what each does and how they work together as a team (Beijing Jeep Chinese Employee 2002).

A long-standing frustration for the Chinese engineers is that the U.S. side has never permitted any deviation from the precise specifications provided for the Cherokee. The positive aspect of this rule is that they learned a lot by working with the parts suppliers to get the specifications met, but since Chrysler has been so inflexible, no creativity or innovation on the part of the Chinese engineers has ever been encouraged or
rewarded. A high-ranking Chinese engineer at Beijing Jeep commented, “The top executives in the big companies only see China as a market to sell automobiles. They don’t see China as a place to develop automobiles” (Beijing Jeep Chinese Employee 2002). Indeed, the Vice President for Special Projects, BJC Sales and Marketing, at DaimlerChrysler China asserted, “We are here to make money – that means with the proper business model in making the joint venture profitable – and in the meantime perform respective training” (Soh 2002).

Today, technology transfer works primarily through the localization process. DaimlerChrysler will provide specifications to Beijing Jeep for new products, and it is Beijing Jeep’s job to try to localize them. The Chinese engineers study the specifications at their technical center until they think they fully understand them, and then the engineers go to a supplier to make sure the supplier understands the specifications perfectly. Then, the supplier tries to make the part and usually runs into all kinds of problems. First, it might realize that it has the wrong tools or equipment, or maybe it does not have the right materials, or it discovers that it simply does not know how to produce the part. So then, the BJC engineers have to go back to DaimlerChrysler to figure out what they are doing wrong. In the end, the BJC engineers learn a lot through this “learning-by-doing” process, but it is slow, frustrating, and costly (Beijing Jeep Chinese Employee 2002). Thus, knowledge about how to produce the Cherokee parts to specification is being transferred from DaimlerChrysler to BAW, but how to put the parts together (or design new interrelated parts) appears still to be beyond the reach of the Chinese engineers at Beijing Jeep.
Chinese engineers at Beijing Jeep’s technology center have repeatedly tried to develop their “100 percent Chinese-made” vehicle. In their latest attempt, they assembled a concept car called the “Heroec,” so named because they wanted to display it at the Beijing Auto Show in 2000 and had chosen the name to represent the pride of the team that designed it. In Chinese, they call it the Beijing Er (second generation), because it was their second try at developing a new vehicle (Beijing Jeep Chinese Employee 2002). The Heroec had a new body, but essentially used many Cherokee technologies under the hood. The vehicle design was completed, but was cancelled due to the lack of financial feasibility (Clark 2002). In 2002, the BJC Technology Center engineers displayed its latest concept car called the Yong Shi (brave soldier), which is, not surprisingly, a soft-top jeep geared for military use.

To visit the Jeep factory, one must negotiate the downtown streets of Beijing, which are teeming with people, taxis, bicycles, vendors, and trucks. Upon arrival, one expects to find just as much activity on the inside of the gate as on the outside. Yet, on two separate visits during the summer of 2002, the entire factory was at a standstill. Workers were nowhere to be seen, the cluster of buildings was eerily silent, and two visitors were able to cross the entire campus without encountering a single person aside from a solitary, elderly street sweeper. Entering the stamping factory was especially a shock because the gigantic machines were poised motionless, bereft of any workers even doing maintenance on them during this downtime. When inquiring why the factories were still, visitors could only extract vague explanations about “supply and demand” problems. If this was a sign of the times, prospects indeed seem grim for Beijing Jeep.

Still, Tong Zhiyuan, Executive Vice President of Beijing Jeep, announced in June 2003
that the company is beginning to earn a slight profit for the first time in years because it cut nearly 5,000 employees (SinoCast 2003).
Chapter 5

CASE STUDY OF SHANGHAI GM

“We did everything we promised to do.”
– Philip Murtaugh, Chairman and CEO of GM China

“The foreign companies are not good teachers, but the Chinese companies are not so clever.” – Chinese National Working for GM China

5.0 HISTORY

General Motors’ (GM) influence in China dates back nearly as long as the company has been in existence. In 1922, GM cars began to be exported to China, and by the 1930s one out of every six vehicles on China’s roads had a Buick nameplate. Most of these cars were motoring around Shanghai, a city more accustomed to foreign influences than most in China because of its status as a treaty port during the late Qing Dynasty (1644-1911). Thus, in 1999 when Buick sedans started rolling off production lines at the Shanghai GM (SGM) plant in Pudong, the older Shanghaise were already familiar with the Buick name.

Of the U.S. Big Three automakers, only GM has secured a solid foothold in China. This achievement can best be explained by GM leadership’s high-risk, aggressive approach and strong, public commitment to manufacturing automobiles in China. When GM first entered the Chinese market, it brought the most modern technology to date of any foreign investor, it established one of the best working relationships of any Sino-
foreign joint venture with its Chinese partner, Shanghai Automotive Industry Corporation (SAIC), and GM set new standards of technology transfer that other foreign companies scrambled to match due to the increasing competitiveness of the market.

General Motors, the largest automobile company in the world, is headquartered in Detroit, Michigan. It also is the world’s largest company in terms of revenue and number of employees – in 2002, GM had 365,000 employees and revenue of US$177 billion – a sum equal to 9 percent of China’s gross domestic product that same year (Standard & Poor's Register of Corporations 2003b).\(^1\) Aside from its automobile-related businesses, GM is also a producer of electronics, locomotives, and space products.

Shanghai Automotive Industry Corporation (SAIC) is known as China’s top passenger car producer. In 2002, SAIC sold 462,083 passenger cars, dominating the Chinese market with 45 percent of the total market share (CATARC 2003).\(^2\) SAIC formed its first joint venture with a foreign company in 1984, when it joined forces with Volkswagen. SAIC currently has 60,000 employees and a total sales revenue of 98 billion RMB (US$11 billion) in 2001 (SAIC 2003).

There was some ambivalence within GM in the early years about whether there would be a sufficiently big market, developing fast enough, in China to warrant a significant investment there. At one international policy committee meeting, a Chinese working for GM did a presentation on what it would take to produce cars in China. The then CEO reportedly asked the man how many cars he expected to produce in the first few years. The analyst replied, “After several years, about 20,000-30,000 cars.” The CEO replied that the estimated level was not interesting, and that was the end of the

\(^1\) Author’s calculation.
\(^2\) This includes cars produced in SAIC’s joint ventures with SGM and SVW.
meeting (Frosch 2002). This estimate, by the way, is exactly how many cars Shanghai GM did produce in its first two years.

But GM’s current Chairman, John Smith, apparently had a very different attitude towards China during the 1990s. At the signing ceremony for Shanghai GM, Smith declared, “This project is a critical element in GM’s total network” (Bloomberg News 1997). As a result, strong and capable executives have been leading GM’s effort in China since the mid-1990s.

Once GM decided to get into the Chinese market, it did so with vigor. Other foreign manufacturers including American Motors Corporation (taken over by Chrysler) and Volkswagen had been in the marketplace for ten or more years before GM signed its passenger car joint venture contract with SAIC in 1997. In 1994, GM opened a China office in Beijing, and in 1995, GM began negotiations for a major passenger car joint venture. During his visit to China in 1997, Vice President Al Gore witnessed the signing of GM’s US$1.52 billion deal to create Shanghai GM. It is often reported that GM’s investment represents the largest single U.S. foreign direct investment in China (Faison 1998; GM 2001). GM and SAIC each contributed US$350 million in cash, and together they were responsible for $820 million in bank loans, of which GM was responsible for half in the event of a default (Murtaugh 2002).

GM was anxious to win the joint venture with SAIC because it believed SAIC was the “best automobile company in China” (Green 2002). Indeed, SAIC had many advantages, including that it was reputed to be the most profitable Chinese automobile company and that it had been publicly chosen by the Chinese government be the primary Chinese passenger car producer. SAIC was also known to have a good sense of the
passenger car market – a reputation that was only enhanced by its location in Shanghai, where the locals are renowned for their business acumen and attention to detail. The one, potentially large disadvantage was that SAIC was already involved in a major joint venture with Volkswagen called Shanghai VW (SVW). This joint venture produced the most passenger cars of any entity in China, and held 54 percent of the market share at that time (CATARC 2000).

GM was quite attractive to the Chinese simply because it is the largest automobile company in the world. Matching this world powerhouse with China’s leading passenger car producer was undeniably appealing to the Chinese. Although many foreign companies bid on the joint venture with SAIC, GM’s main competition was Ford Motor Company. Toyota bid on the SAIC project, but it dropped out due to an unwillingness to meet the technology-transfer requirements desired by the Chinese government. Germany’s Volkswagen was already in alliance with SAIC, and the French firm, Citroen, had just signed a joint-venture contract with Dongfeng Automobile Company in 1992. In the end, GM China’s Philip Murtaugh believes that GM won the partnership with SAIC because the Chinese company simply liked GM’s products better, but the joint venture could just as easily have gone to Ford (Murtaugh 2002).

Although Shanghai GM is GM’s flagship operation in China, GM formed three other joint ventures across China during the 1990s and made a number of indirect investments as well. Two of the other joint ventures are for automotive manufacturing: Jinbei GM in Sheyang, Liaoning Province, and SAIC-GM-Wuling in Guanxi Province. Jinbei GM was actually GM’s first joint venture in China, and from the start it has

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3 In 1996, the total number of passenger cars produced was 370,821. SVW produced 200,031, 54 percent of the total (pg. 36).
struggled. Jinbei GM began operation in 1992, shut down from 1995 to 1998, and restarted its production of Chevy Blazers in 1998. Jinbei GM continues to flounder for two main reasons. First, the ownership of its partner firm has changed several times. Second, although Jinbei GM is only allowed to produce sport-utility vehicles (SUVs), urban Chinese consumers are simply uninterested in SUVs as passenger cars, viewing them as trucks for the rural areas. Even so, GM plans to introduce the Chevrolet Trailblazer and Tahoe SUV models in 2003 (Business Daily Update 2003). The SAIC-GM-Wuling joint venture was established in 2002, and it is GM’s most recent and smallest investment in China. Wuling is one of the most prominent manufacturers of minibuses in China, so this investment widens GM’s product portfolio.

During the joint-venture negotiations over Shanghai GM, the Chinese government insisted that GM had to establish a technical center with SAIC. This desire had been expressed to other foreign companies in the past, but GM was the first company to actually agree to establish one. Therefore, GM established a separate US$50 million joint venture with SAIC called the Pan Asia Technical Center (PATAB), with equity split equally between partners. The purpose of PATAB is to provide engineering support to Shanghai GM and other auto companies in China. Although PATAB is separate from Shanghai GM, most of its business comes from its sister joint venture. PATAB currently
has 400 hundred engineers, and 80 percent of its work is done for Shanghai GM (GM China Chinese Employee B 2002).

It should also be noted that GM has some indirect investments in China. Aside from stakes in parts and components companies, GM’s biggest indirect investment is through its 20 percent stake in Suzuki, which has a joint venture in Chongqing with Chang’An Automobile Corp. Chang’An also has a separate joint venture with Ford (see Chapter 6). Finally, like other foreign firms, GM has tried to export autos to China with limited success. In December 2000, GM registered only its ten-thousandth-export sale to China.

For the opening day of production at Shanghai GM in December 1998, GM Chairman Jack Smith flew to China and personally drove the first automobile, a Buick Xin Shi Ji (New Century) luxury sedan off the production line (see Fig. 5.3). The sedan was priced at about 330,000 RMB (US$40,000). At the time, there was little competition for luxury automobiles in the domestic market. There was the imported Audi 200, the old domestically-produced Audi 100, and the Red Flag (Hongqi) sedan produced by First Auto Works that was lower than the Buick in price and not really a competitor. Once the luxury Buick entered the market, Audi responded with its Audi A6, which is priced above the Buick, and Honda began producing its Accord in Guangzhou at a slightly lower price of 280,000 RMB (US$34,000), eventually forcing SGM to lower its

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4 This luxury model is now called the Buick Regal in China.
prices to 280,000 RMB as well. Finally, VW introduced its Passat, which was priced directly against the Buick and the Honda Accord.

SGM started production of the Xin Shi Ji with 47 percent of the parts made by local Chinese suppliers, in accordance with the Chinese requirement of 40 percent local content. In 1997, Larry Zahner, President of GM China, predicted that SGM would buy US$1.6 billion dollars worth of parts and services from the United States during the next five years (China Business Information Network 1998). In 1999, 20,000 Buick sedans were produced, and by 2000 SGM had localized 60 percent of the parts, importing only US$140 million worth of parts annually from the United States (Graham 2000). As of 2002, SGM was the third-largest joint venture in China, selling more than 110,000 autos (including some new models), and it had achieved 11 percent of the total market share for passenger vehicles (CATARC 2003).

Only two years after introducing its inaugural luxury sedan, which was targeted at government officials and the wealthy, Shanghai GM launched a compact sedan called the Buick Sail (Sai Ou). This car was targeted at private consumers in the burgeoning Chinese middle class (see Fig. 5.4). Priced at about 100,000 RMB (US$12,000) initially, this compact was put into the market against the VW Jetta and Tianjin Xiali (and also against the VW Santana, which is a bigger car but is sold at a similar price). The Sail is based on the Brazilian Chevrolet Corsa, which was based on the original German Opel Corsa, versions of which are sold in 80 countries around the world. It has dual air bags and antilock

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5 Sai Ou means “compete with Europe.”
brakes as standard features, a first for a compact car in China (Leicester 2000). There are two versions of the Buick Sail: one is a compact sedan (see Fig. 5.4) and the other is a hatchback called the Sail-RV.

Early in 2003, SGM announced that it was going to introduce a new model, the Buick Excelle (based on a GM Daewoo platform), to compete directly against the SVW Santana (Agence France Presse 2003). SGM also has one last model in production: a GL8 minivan, which is not a focus of this study.

As of 2003, Shanghai GM had risen to be the third-largest producer of passenger cars in China, behind Shanghai VW and First Auto Works-VW. In only four years, SGM captured 11 percent of the Chinese market, and the Shanghai GM factory in Pudong was producing at its maximum capacity. Sales of GM products grew 325 percent between 2001 and 2002 (Business Daily Update 2003). Because demand for SGM vehicles continued to be so strong, and because it needed additional production space, SGM bought a separate factory in Yantai, Shandong Province in December 2002 in order to be able to double its production of Buick sedans (Fackler 2002). As of 2000, Shanghai GM had about 2,500 workers (Leicester 2000); the average employee earned about US$4,000 a year, four times the national average income (Graham 2000).

5.1 TECHNOLOGY TRANSFER IN THE JOINT VENTURE

Since Shanghai GM’s inception in 1997, all of its passenger car models were transferred to China using the same technology transfer process: GM develops the automotive technology and manufacturing design, and then transfers it to Shanghai GM
for production. By internal accounts, the technology transfer processes themselves have been very efficient and without major difficulties (Green 2002). The product adaptation for the Chinese market was done entirely by GM for the luxury sedan, but for the Sail, PATAc and SGM did most of the product adaptation.

According to Murtaugh, the Buick luxury sedan being produced in China (see Fig. 5.3) is a completely different car than its equivalent produced for the U.S. market. The Chinese New Century Buick is based on two models sold in the U.S. market: the Buick Century and Buick Regal. SGM made approximately 600 changes to these U.S. designs, seven of which were major, to the luxury sedan before and during the first three years of production. The engine was “designed new” for China by GM Powertrain. The engine in the U.S. had two options, a 3.1-liter V6 60° engine and a 3.8 liter 90° engine. GM took the 60° version and re-stroked it to 2.98 liters to meet Chinese government requirements that all government officials who are provided passenger cars must have a 3.0-liter engine or smaller. Because fuel economy turned out to be important to Chinese consumers, SGM later introduced a second engine with 2.5-liter displacement. The suspension is entirely new and the interior seats were re-designed for the Chinese body-type. SGM put new door pads on, and upgraded the interior from gray cloth to tan leather. In addition, a sunroof was added and significant improvements were made in noise reduction (about US$70 of the price of each car is for noise reduction alone). In Murtaugh’s opinion, the Chinese version has some better performance characteristics, better fuel economy, and better noise levels than the U.S. model (Murtaugh 2002).

Shanghai GM was the first Sino-foreign firm to make significant changes to a model once it was in production in China. Previously, the Sino-foreign joint ventures
would just keep the same old model in production interminably until it seemed woefully outdated. Then, a new model would be introduced for a higher price, but the old one would continue to be produced at a lower price. At the beginning in 1998, SGM produced three versions of the New Century luxury sedan: the GL, GLX, and XSJ. After six months, SGM released the GS, which had the new suspension system and also a new monotone exterior without chrome. In another six months, SGM put in the 2.5 L engine, upgraded the interior to leather, and added the sunroof. Thus, the Chinese Buick in production today is quite different from the original version that was produced in 1998. The principal reason why SGM continued to introduce improved technologies was because of increased competition in the marketplace. SGM raised the bar by introducing a relatively modern automobile into the domestic market, but then paid the price when its competitors responded with similarly modern and attractive sedans (Honda Accord, Audi A6, and VW Passat). As Murtaugh noted, “SGM both had to improve its product and lower price a little because of increased competition. This will be true for other companies as well, and you can already see it in the Passat and Honda Accord” (Murtaugh 2002).

SGM launched the Buick Sail (see Fig. 5.4) in a great rush to meet the rising demand for more economical sedans. GM realized they had to choose a model that could be introduced to China quickly. According to Murtaugh, the most important consideration in choosing the model was speed, so this is the main reason why the Opel Corsa was picked. SGM did not want to lose market share to other firms like the Tianjin Automotive Industry Corp. (TAIC), which was introducing compact sedans such as the Xiali 2000, using Toyota Echo technology. The Corsa had already been introduced into
developing-country markets such as Brazil, Mexico, and Spain, so the design work was in Murtaugh’s words, “90 percent done.” The Corsa is currently manufactured at eight locations in the world – thus, it is not a new technology. Because the design work was mostly complete, it was both cheaper and faster to introduce the Corsa than any other GM model.

Even so, SGM had to modify the suspension, engine calibration (because of Chinese fuel quality), exterior styling, grill, headlamps, and side fascia. By this time, PATAc had acquired enough product-adaptation capabilities to do most of the modifications by itself. SGM started production of the Sail in 2001 with 70 percent local content, the highest level ever for a joint venture in China. This achievement was possible because SGM had already developed relationships with parts and components suppliers through the manufacture of the New Century, and also because Shanghai VW also had cultivated local suppliers in Shanghai. These suppliers had learned to produce parts and components to the relatively high standards of the Sino-foreign joint ventures.

The Sail’s competition originally was the Jetta, Citroen/Dongfeng Fukang, and the Xiali 2000. Shortly after the Sail blew into the market, Shanghai VW responded by introducing its new Polo, apparently a version of the Golf, which appears to be much more modern than the VW’s Jetta or Santana, both of which are old designs.

In both of its automobile models, Shanghai GM introduced a more modern product than was being produced by Shanghai VW and by most of SGM’s other competitors. And, in both cases, the competitors either upgraded their product or brought in an entirely new model in response to SGM’s product. For example, Shanghai VW responded to the Buick luxury sedan with a new Passat, and SVW responded to the Sail
with the Polo. Since GM has the same domestic partner as VW, one can’t help but wonder how loyal SAIC is to GM. According to Murtaugh, GM was originally worried about VW but by the end of the 1997, this concern had become a “non-issue” because they had cultivated such a close working relationship and trust was high. Intellectual property rights have been “no real problem” according to Murtaugh, although there have been some “normal” amounts of leakage akin to what would be found between companies in the U.S. or Europe (Murtaugh 2002). It is clear that the threat of GM’s products pushed VW to transfer better technology to SAIC and to upgrade SVW’s production lines. This increased competition between SGM and SVW clearly is benefiting the Chinese consumer because better products, at lower prices, are being offered. Yet, SAIC may have stronger loyalties to SGM than SVW because SAIC owns a bigger equity stake in SGM (50 percent) versus SVW (25 percent).

5.2 DISCUSSION

SAIC apparently drew lessons from its experience with Volkswagen to guide its joint-venture negotiations with GM. During the negotiations, both GM and SAIC agreed that the correct way to run the joint venture was to focus on the benefit of the joint venture itself, instead of mainly profiting from supplying parts to the joint venture. GM could have focused on selling complete knock-down kits (CKDs) to the joint venture, and SAIC could similarly have focused on selling its own Chinese-made parts to the joint venture, but GM and SAIC agreed to make the priority to reduce costs at the joint-venture level (Murtaugh 2002). Otherwise, like other foreign firms before it, GM might have
been content to export CKD parts to the joint venture and earn money from the sales of
the kits.

Similarly, GM appears to have learned from the experience of other foreign firms
in China. From the start, GM displayed an aggressively committed and cooperative
attitude towards China. A pyramid-shaped graphic containing GM’s goals and principles
in China was displayed at the signing of the SGM joint venture. At the top of the
pyramid was the vision: to grow the business to be among the top three in market share
(achieved in 2002), to be number one in customer satisfaction, and to localize the
management. The core values were: customer enthusiasm, integrity, teamwork,
innovation, and continuous improvement. With respect to principles, GM stated that it
would actively engage in technology exchange and foster Chinese managerial and
professional development, and that GM’s partnership with China would be long-term and
win-win (Green 2002).

Murtaugh believes that the joint venture has been successful because GM and
SAIC’s goals are completely in alignment and because they have worked hard to make
the relationship a good one. Each decision has been made with the goal of making the
joint venture more successful. The good working relationship that emerged between
Murtaugh and SAIC President Hu Maoyuan at the top levels was modeled at lower levels
(Kraar 1999).6 Asked why there appeared to be such a high level of trust between GM
and SAIC, Murtaugh responded, “We did everything we promised to do,” adding in jest,
“That, and we’re just nice guys” (Murtaugh 2002).

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6 Hu Maoyuan was originally the first president of Shanghai GM, but he was later promoted to the positions
of President and CEO of SAIC overall.
In terms of technology transfer, few barriers within the actual process have emerged. From GM’s point of view, the biggest problem with the technology transfer process was how to measure it so that SAIC could be sure it was not getting cheated. SAIC was exceedingly worried based on its prior experience (and that of other Chinese companies) that GM would put hurdles in the way of technology transfer. The Chinese came up with a measurement scheme that classified technologies into a number of categories such as outline drawings, assembly drawings, detailed specifications, and so forth. Eventually, GM was able to convince SAIC that specifications and drawings simply didn’t exist for every aspect of production. Some of the technology, or knowledge, was just inside the heads of the engineers who work for GM. SAIC lacked the experience and knowledge to realize that much of the technology they were trying to acquire was tacit. Although the technology transfer process contained few barriers, it was not without cost. The process is expensive, especially because of the need for engineering support from experts in the United States, and this is a key inhibitor to more advanced technology transfer (GM China Chinese Employee A 2002).

There is evidence that GM has indeed followed through on its promises to exchange technology and foster Chinese managerial and professional development. Still, the Chinese have not acquired significantly enhanced technological capabilities through their joint venture with GM; for example, SAIC still lacks good design capabilities. This outcome is attributable to the simple lack of incentives for SAIC to be more motivated to acquire better capabilities and for GM to teach its partners anything beyond what is needed to get the models into production and manufacture them well. As one Chinese manager working for GM commented, “The foreign companies are not good teachers, but
the Chinese companies are not so clever” (GM China Chinese Employee A 2002). He argues that in general, the Chinese automotive firms need to work on finding good teachers. “As a parent, you know that if your child stays home and tries to read and learn, she will make progress, but not as much as if she has a really good teacher, so you try to find her a good teacher and get her into that school.” This Chinese employee said that if he were the boss of a Chinese company, he would try to find the best teachers internationally. Of course, the main purpose of the joint venture is to manufacture automobiles in China. One Chinese employee pointed out that the SGM joint venture is for manufacturing alone, not for technology development (his emphasis). The development of technology is clearly separate from Shanghai GM, and if SGM wants more advanced technology then it will come from GM, but at a cost, because all new technology transfer is negotiated and paid for separately (GM China Chinese Employee A 2002). Outside of the SGM joint venture, GM does invest in applied research projects that are conducted by Chinese universities and institutes, and such projects support the development of Chinese capabilities in academia. Since 1996, GM has invested nearly US$2 million in such projects (Green 2002).

It must also be noted that SAIC has been slow to exert itself to enhance its own technological capabilities. Under significant pressure from the Chinese government, SAIC finally set up an R&D center of its own called the Automotive Engineering Academy of SAIC in August 2002, the first of its kind for a Chinese manufacturer. SAIC said that the center symbolized the beginning of China’s efforts to develop automotive technology independently (CIIC 2002).
GM’s environmental performance in China has been average. Like most other foreign joint ventures, SGM produces EURO II-compliant vehicles to meet the current Chinese government’s emission standards for the big cities.\(^7\) These standards lag behind U.S. standards by nearly a decade (see Fig. 2.3), so it cannot be said that GM transferred best-available environmental technologies to China. GM has been somewhat proactive in working with the Chinese government to promote understanding about air-pollution control in vehicles (SEPA Official 2002). GM paid for a State Environmental Protection Administration (SEPA) study on how to phase out leaded fuel, for example, sponsored a workshop on on-board diagnostic technology, donated an electric car to the Ministry of Science & Technology (MOST)’s electric-vehicle demonstration project in Shantou, and helped to set up an emissions testing center at PATA. In terms of fuel efficiency, the SGM cars are also average. Even so, GM deserves credit for introducing a more fuel-efficient model to meet consumer demand. The fuel efficiencies of the Chinese models seem roughly comparable to their model counterparts in the United States or Europe.

In summary, GM has been the most successful by far of all the U.S. investors in penetrating the Chinese market and in cultivating a reasonably good working relationship with its Chinese partner. GM has not tried to cultivate its Chinese partners’ technological capabilities beyond what is currently needed to make the manufacturing operation efficient and profitable, but it is investing in a substantial number of applied research projects at Chinese universities and institutes. Its environmental performance is average, but not remarkable.

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\(^7\) SGM puts an 80,000 mile guarantee on the car’s ability to meet the EURO II standard.
Chapter 6

CASE STUDY OF CHANG’AN FORD

“Ford should be more open technologically because there would be mutual benefit.” – Chinese Engineer at Chang’An Auto Company

6.0 HISTORY

Ford Motor Company has thus far taken a more risk-averse approach to China than the other U.S. companies who have invested there. Of the Big Three, Ford was the last to manufacture a passenger car in China, and thus it has the weakest reputation there.

Ford’s involvement in China dates back to 1913, when a small number of Model T Fords were exported to China. A year before his death in 1925, Dr. Sun Yat-Sen wrote to Henry Ford, inviting him to help build an automotive industry in China (see Chapter 3). Ford shipped its first automobile to China in 1927, and opened a sales and service branch in Shanghai in 1928, but never set up any manufacturing plants. After that period (possibly because of the turmoil in China and the Great Depression at home), Ford focused its attention on the U.S. market and elsewhere, until the reform period in the late 1970s in China. At that time, Deng Xiaoping personally met with Henry Ford II, prompting Ford to set up an Office of China Affairs at their headquarters. But it was not until 1992 that Ford opened a representative office in Beijing, long after American Motor
Corporation (AMC) and Volkswagen had begun producing automobiles on the Chinese mainland. Even then, Ford failed to land a joint-venture agreement with a Chinese partner for another nine years.

Ford Motor Company, the second-largest auto company in the world, is headquartered in Dearborn, Michigan. Founded in 1903, it had annual sales of US$170 billion and employed 345,175 people worldwide in 2001 (Standard & Poor's Register of Corporations 2002). Aside from the Ford-brand vehicles, its other automotive brands include Lincoln, Mazda, Mercury, Land Rover, Aston Martin, Jaguar, and Volvo. Its automotive-related services include Ford Credit, Quality Care, Hertz, and Motorcraft.

In the early 1990s, the Chinese government decided to open up its largest domestic producer of passenger cars, Shanghai Automotive Industry Corporation (SAIC), to foreign investment. Both Ford and GM bid on the joint-venture partnership, and ultimately, Ford lost. After its bid was rejected, Ford waited to pursue other partners since it felt the Chinese government was unlikely to approve another major foreign investment soon after the SAIC joint venture. Meanwhile, Honda took over Peugeot’s investment in Guangzhou, and Fiat Auto of Italy, Kia Motor of South Korea, and Yulon of Taiwan (25 percent owned by Nissan) all formed new joint ventures with Chinese firms.

After losing the SAIC opportunity, Ford invested in six joint ventures related to manufacturing parts and components in China, but these businesses were spun off in 2000 (Hu 1999). In 1995, the company established Ford Motor China Ltd. That same year, Ford bought a 20 percent stake in Jiangling Motors Corporation, and licensed the relevant technology to China for production of a small bus, known internationally as the

Ford has also 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 Co (FCH) since June 2001 and the Mazda 323, known as the Familia, since July 2002 (Kyodo News Service 2002). Mazda plans to have its Mazda 6 mid-sized sedan assembled in China starting in 2003 (AFX European Focus 2002).

Meanwhile, like many other foreign firms, Ford was only marginally successful in overcoming the high Chinese import tariffs, exporting a total of only 15,000 cars to China since 1990. Mostly, Ford has exported the Mondeo Ghia-X from its plant in Taiwan to China, but it has also exported the Lincoln Towncar, Ford Taurus, and Ford Windstar minivan to China (Asia Pulse 2002; Avery 2002).

While Ford was casting about for an opportunity to enter the Chinese passenger-car market, the U.S. government was engaged in negotiations with the Chinese government regarding Permanent Normal Trading Relations (PNTR) status and the related terms of entry for China’s accession to the World Trade Organization (WTO). These negotiations would have great bearing on any joint venture that Ford might negotiate thereafter, because the U.S. Trade Representative (USTR) was pressing China to loosen or eliminate many of the restrictions traditionally placed on foreign investors, particularly in the automotive sector. The bi-lateral PNTR negotiations were concluded in 1999, long before Ford signed the deal with Chang’An for its first major automotive joint venture. The U.S. Congress subsequently approved the PNTR agreement, and it entered into force in 2000. As discussed in Chapter 3, the agreement specified many changes in
Chinese government policy for the automobile sector, including the elimination of conditions on foreign direct investment, such as requirements on technology transfer, local content, and export performance. Ford has actively called for the elimination of restrictions on foreign direct investment in the name of the free market. In a 2002 speech in China, Ford President Nick Scheele asserted, “If foreign auto companies, such as Ford Motor Company, are allowed to hold more than 50 percent interests in joint ventures in China, Chinese autos will become more competitive internationally” (ChinaOnline 2002).

After PNTR was signed into law, Ford finally, in April 2001, concluded negotiations for a US$98 million joint-venture agreement with Chang’An Automotive Company, which will be based in Chongqing, Sichuan Province. The ownership of the joint venture is split equally between the U.S. and Chinese partners. Chang’An agreed to invest US$23.5 million in the joint venture using cash and other assets, and its parent, Chang’An Automotive Group Liability Co. Ltd. agreed to contribute the remainder of the investment on the Chinese side. Ford agreed to contribute US$49 million worth of cash and assets (Dow Jones International News 2001). Chang’An Ford’s annual production capacity is currently limited to 50,000 automobiles, a number that could be increased later if there is sufficient demand.

Chang’An was founded in 1862 as the Shanghai Western-Style Artillery Bureau in the treaty port of Shanghai, but eventually was moved to its current location in Chongqing (see Figure 6.2). Using its experience with artillery production, Chang’An gradually began producing other types of machinery. It was re-named the State-Owned Chang’An Machine Building Plant in 1953, and it produced its first automobile in 1958 using technology imported from the Soviet Union. This first vehicle was a World War II-
era off-road light truck akin to a Jeep, and one of these army-green colored jeeps is still parked in a rear corner of Chang’An’s display room at their headquarters. Chang’An produced 1,390 of these light trucks between 1959 and 1963, at which time the factory was closed down. After the Cultural Revolution, this light-truck technology was transferred to Beijing Automotive Company, future partner of American Motor Corporation (and now DaimlerChrysler).

Chongqing Chang’An Automobile Group Co. Ltd. (Chang’An) fluctuates between being the fourth- and fifth-largest automobile company in China, and it is the largest producer of minibuses and minitucks in China (Xinhua Economic News Service 2002). In 2001, it sold 197,301 vehicles, up 17 percent over 1997. Chang’An is a subsidiary of the China Commission of Science, Technology, and Industry for National Defense (COSTIND), which reports directly to the State Council. Chang’An is the parent of six vehicle manufacturers including: Nanjing Chang’An Automotive Co., Hebei Chang’An Shengli Automotive Co., Chang’An Kuayue Vehicle Co., Chang’An Automotive Co. (which is listed on the Shenzhen stock exchange), and the Ford and Suzuki joint ventures (Dow Jones International News 2001; Chang'An Automobile Group 2002).

In 1983, Chang’An commenced automotive production after the Cultural Revolution, licensing minibus technology from the Japanese company, Suzuki.
Chang’An has since become one of China’s largest producers of the minibuses, nicknamed *mianbiao* (breadloaf) by the Chinese due to their resemblance to the shape of a loaf of bread, and minitrucks, which are versions of the minibuses that have open truck beds in the back. Thus, Chang’An is probably most famous for its production of these minis, and when it produced its millionth vehicle on July 21, 2001, it was a minibus. All of Chang’An’s minibuses and minitrucks are produced at its headquarters, a large facility located in the heart of an urban district of Chongqing. The headquarters comprise stamping, welding, and assembly plants, as well as testing facilities, company offices, and the R&D center. Workers on the assembly line appeared busy and well trained during the summer of 2002, starting up the production line after a brief rest upon the entrance of visitors to the plant. When the visitors arrived, the workers had been taking a break in orange plastic chairs that were bolted down around square tables with matching teacups and a bouquet of flowers all along the line. These workers receive about US$3,000 per year, with additional housing assistance.

In 1993, Chang’An formed a manufacturing joint venture to produce subcompact cars with Suzuki called Chongqing Chang’An Suzuki Automobile Company. The initial registered capital of Chang’An Suzuki was US$59.98 million, and this was later increased to US$70 million (CATARC 2002b). The two cars produced by Chang’An Suzuki are the Alto hatchback (now SC7081) and small Gazelle sedan (now SC7130). The hatchback costs between 43,800-61,920 RMB (US$5,342-$7,551), depending on options. The sedans, widely used as yellow taxis in Chongqing, each cost between 74,800-135,582 RMB (US$9,122-$16,534).
Ford was interested in Chang’An both because it is one of the largest car companies in China, and because the other major Chinese companies had already formed joint ventures with other competitor foreign firms. Ford knew that the Chinese government would look upon the joint venture favorably for four reasons. First, the government was on a campaign to attract foreign investment in the West. Second, the government was anxious to convert military companies into civilian entities. Third, Ford could introduce alternative-fuel technologies that would capitalize on China’s natural gas reserves found predominantly in areas around Chongqing. Fourth, Chang’An’s management and general track record with respect to working with foreign companies was favorable (Davey 2003).

Chang’An Ford is initially aiming to break into the small to mid-sized car market in China. Dale Jones, Vice President of Marketing, Sales, and Service at Ford China announced in June 2002 that Chang’An Ford is targeting the burgeoning upper-middle class consumer with a low-priced car that is “tailored for the family owner and small business entrepreneur” (Avery 2002). The goal, according to one proud Chang’An official, is to “directly compete with the Buick Sail,” which is produced by Shanghai GM (Chang-An Employee 2002). The price of the new Ford Fiesta ranges between US$10,725 and US$15,435, depending on the engine and transmission, and it is being marketed to people 25-35 years old (Bradsher 2003). Chang’An Ford is also scheduled to begin production of the Mondeo mid-sized sedans in 2003.

Ford’s new joint venture with Chang’An is to co-exist with the Chang’An-Suzuki joint venture. Interestingly, General Motors owns a 20 percent stake in Suzuki, so
Chang’An will be a partner, albeit indirectly, to the two firms most directly competitive in the U.S. market.

6.1 TECHNOLOGY TRANSFER IN THE JOINT VENTURE

Ford is transferring all of the automotive technology, along with the design of the manufacturing plant, to Chang’An. Together they are building a new set of facilities in the new high-tech industrial area near the airport in Chongqing. Workers have been trained in Ford’s India plant, and production of the Ford Fiesta commenced in early 2003. According to sources from both Chang’An and Ford, the technology-transfer process for the Ford Fiesta was smooth. The relative ease of the technology transfer was attributed to mutual interests in getting the Fiesta into production as quickly as possible (Chang'An Employee 2002).

Early on, there were conflicting accounts of exactly which model was chosen for China, but all essentially led toward Ford’s basic small car designed for the international market: a “Fiesta-based” Ikon model. In the end, the Fiesta was chosen as the model name. Reports from the Indian media indicate that the model is actually a version of the Ford Ikon, which is based on the Fiesta platform, and in production at the Ford India plant in Chennai. David Friedman, Managing Director and President of Ford India said in June 2002 that the workforce (in the Chinese plant), “needs to be taught how to make the Ikon,” and that Ford India is helping in these training efforts (Ramakrishnan 2002). Interestingly, when he announced the joint venture in April 2001, Chang’An President Yin Jiaxu denied that the chosen model would be the Ikon (Gong 2001).
Friedman of Ford India said, “Almost 99 percent of the car will be the same as that made here [in India]. There will be minor changes to the grille, especially to suit the local taste. The Chinese also prefer a different kind of seat fabric” (Ramakrishnan 2002). The only major change from the India model is that the car must be adapted for left-hand drive. According to other reports, Ford has made more than 200 changes (some probably very small) to the model to adapt it for Chinese conditions, including adoption of an automatic transmission (Auto Asia 2002). It is, therefore, the first Ford car on a Fiesta platform to use an automatic transmission (Treece 2002).

The Ford Fiesta was launched in the United States in 1973, in the wake of the first oil shock, as Ford’s first front-wheel drive compact car. Until that time, Ford’s leadership had been adamantly opposed to the production of smaller cars (Halberstam 1986). No longer produced in the United States, modified versions of the Fiesta continue to be produced in and for foreign markets. A new Fiesta model was introduced in Europe in 2000, but the versions produced in South Africa, India, and China date from older generations.

Thus, the Ford Fiesta technology is not necessarily “old,” but neither is it particularly “new.” Indeed, it appears that Ford is bringing more modern technology to Chang’an than it ever received from Suzuki, but the Fiesta is far from the “cutting-edge.” Initially, it was estimated that 62 percent of the parts for the model would be made domestically in China (ChinaOnline 2001). Most of the other parts will be imported into China from India and shipped three days up the Yangtze River from Shanghai to the western province of Sichuan, where the plant is located. 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. Ford India also exports completely knocked down kits (CKDs) of the Ikon to South Africa, Mexico, and Brazil (Business Line 2002).

The size of the Fiesta’s engine is restricted to certain specifications because in order for Chang’An Ford to technically avoid competition with the Chang-An Suzuki joint venture, it must produce cars with engines larger than 1.3 liters. All the Chang’An Suzuki cars have engines that are smaller than 1.3 liters. Thus, the Fiesta is being produced with a 1.6-liter engine. An ironic twist to these fine distinctions is that since Suzuki is 20 percent owned by General Motors (producer of the Shanghai GM Buick Sail which has a 1.6 liter engine), the two joint-venture partners are indirectly competing with each other anyway.

The technological capabilities of Chang’An appear to be limited to manufacturing capabilities, and most of Chang’An’s knowledge about the manufacturing process was acquired through its partnership with Suzuki. Before establishing a joint venture with Suzuki, Chang’An initially licensed Suzuki’s technology in 1983, beginning production in 1984. However, the technology was dated and of undetermined 1970s vintage. Once a formal joint venture was established in 1993, Suzuki transferred all the relevant automotive technology to Chang’An to produce a small sedan with a 0.8-liter engine called the Alto (the 7080 model). This technology was also of late 1970s to early 1980s vintage, which Chang’An Suzuki modified very slightly with changes to the ignition and front-end body structure over the years. In 1998, Suzuki transferred a newer model to replace the Alto, called the Lingyiang (Gazelle). There are two versions of this model, one of which has a 1.0-liter engine (F Series) and one has a 1.3-liter engine (G Series).
Thus, through its joint venture with Suzuki, Chang’An has acquired solid production capabilities, but according to one engineer there, it is still “behind” in design and experimentation. He said that they now know more about what they don’t know, and this gave Chang’An more bargaining power in its negotiations with Ford. When Chang’An first negotiated with Suzuki, it received, “very low levels of technological content because we didn’t know anything” (Chang’An Employee 2002). This same engineer believed that Chang’An was getting relatively current hard technologies from Ford, but so far the workers had received much less training than they previously received from Suzuki.

The Chang’An representative expressed hope that Ford would learn from Suzuki because in his opinion, “Suzuki kept its promises.” He added that Chang’An would like to collaborate in a joint R&D center for Chongqing with Ford but that so far, this had not been negotiated. Ford China said they agreed to develop plans for longer-term capability within the joint venture, based on specific business needs. In the past, other companies may have been mandated to establish technical centers up front, but Ford knew that WTO rules prohibited the Chinese government from requiring technology transfer (Davey 2003). It seems especially unlikely that Ford will agree to such a center because Ford recently established its first research center in Asia (and fifth in the world), the Design and Research Center at Ford Lio Ho Motor Co. in Taiwan, worth NT$10 billion (US$287 million) (China Post 2002).

On the other hand, Ford has a history of investing in Chinese technological capabilities that dates back to the historic meeting between Henry Ford and Deng Xiaoping in the late 1970s. At that time, a Ford Visiting Scientists program was
established with the goal of annually bringing 5-10 Chinese scientists to Dearborn, Michigan for up to two years. Since the 1990s, at any given time Ford has been investing in fifteen to thirty basic and applied research projects at Chinese institutes and universities. Ford does not make similar investments in its joint-venture partners, but it does do training for workers to facilitate the manufacturing process, including management know-how for professional and technical staffs (Davey 2003).

According to the Director of Business Strategy for Ford’s Asia Pacific and Africa regions, there are a number of reasons why Ford might invest more seriously in Chinese technological capabilities in the future. First, investment in local technological capability is an important factor in understanding market needs, recruiting talented people, understanding government regulations, and so forth. Second, as long as there is a significant cost advantage to investing in researchers in Chinese academic institutions, it makes sense to develop more capabilities in China. Third, Ford believes that the Chinese market could be as large as the North American market by 2020, and Ford has always believed that one should build where one sells because every market has unique characteristics, and salaries and wages earned in developing countries and building automotive products creates higher demand for those same products (Davey 2003).

Thus, aside from the technology transfer that Chang’an negotiates from its foreign partners, Chang’an will have to continue to rely on its own technical expertise for innovation. This center receives 3 percent of annual sales for its budget totaling 333 million RMB (US$38 million) in 2001 (Chang'An Employee 2002).

Ford has not yet encountered any intellectual property rights issues in its joint venture with Chang’an. From Ford’s point of view, this is partly because the Chinese do
not yet have sufficient capabilities to reverse engineer an entire car, and also because Ford and Chang’An are establishing a relationship of trust with a shared understanding of the value and competitive advantage of protecting technology. In other sectors such as motorcycles and parts, when the technological content is lower, there is greater leakage of intellectual property (Davey 2003).

Environmentally, all of the automobiles produced in the Chang’An Suzuki joint venture are purportedly capable of meeting EURO II air pollution standards, which are required in China’s largest cities. Chang’An installs catalytic converters that they developed with the Netherlands on all their cars. Similarly, the Ford Fiesta being produced by Chang’An Ford is advertised to meet EURO II standards. Also, since the Fiesta is a small and lightweight car, it is reasonably fuel-efficient. One Ford official commented that the Chinese Fiesta’s fuel efficiency was 10-15 percent worse than the European Fiesta, mainly reflecting differences in fuel quality between China and Europe (Davey 2003). Yet, according to company public relations materials, the Ford Fiesta is advertised as getting 26 miles per gallon in Europe for urban driving, and 32 miles per gallon in China for urban driving – but these comparisons are hard to make without independent testing using the same driving cycle.1

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1 For data elaboration and sources, see Fig. 7.2.
Chang’An’s domestic R&D group is working on hybrid-electric vehicle development as part of a high-tech research program established by the Ministry of Science and Technology (MOST) to develop cleaner automotive technology for China without any assistance from Ford or Suzuki. Initially, Chang’An was not included in the government program, but after proving a serious interest, they were admitted. A Chang’An engineer said that Chang’An funds 70 percent of their clean research and 30 percent is funded by MOST. They also closely collaborate with Tsinghua and Liaoning Universities on technology development. Chang’An plans to use the Suzuki Gazelle as a platform for its hybrid vehicle. Suzuki has agreed to help with technology development, but has not done so thus far. Chang’An is also working on the development of natural gas-based vehicles in order to take advantage of the rich reserves of natural gas in the region. Chang’An approached Ford about cooperating on this technology, but, so far, they have not reached agreement.

6.2 DISCUSSION

The Ford Fiesta in production at the new Chang’An Ford plant in Chongqing, Sichuan is neither new nor old. It is more modern than the technology previously in production at Chang’An’s domestic minibus and Suzuki plants, and it could be characterized as “mid-life” technology. Yet, Ford’s China car is far from the cutting-edge, and quite behind U.S.-levels in terms of pollution-control equipment. It does not contain any advanced fuel-economy technologies, although because of its size, it is a reasonably fuel-efficient car in comparison with larger conventional sedans.
Ford’s primary aim is to establish a local manufacturing base in China to produce compact cars for the domestic market alone. It might become an export base in the future because of good labor costs and the supply base that is already in place. Ford’s other plants in Taiwan and India are more likely to export to other markets than its China plant. Ford does not view its partner as a source of innovation, but rather as a partner in manufacturing.

In this case study, a number of barriers exist for transfer of cleaner advanced technology to China. Neither Chang’An nor the Chinese government (at either the municipal or central level) asked for significantly more advanced technologies, and Ford felt no obligation to transfer them. In addition, Ford initially had real concerns about leakage of intellectual property, although in reality, Ford has encountered few intellectual property problems.

It is too soon to know if Ford will update and refresh the technology it transfers to China. Unless Chang’An asks for more advanced technologies and acquires enough bargaining power to persuade Ford to make the transfer, there seems to be little motivation for Ford to do so, other than to strengthen its position in the Chinese market. Incentives for more advanced technology transfer, from Ford’s point of view, have more to do with competition and the preferences of the Chinese consumer than the requests for more advanced technology from its Chinese partner. Ford is entering a fairly competitive market in the compact class with a number of small cars already on the streets, namely, the Toyota Vios, the Buick Sail, the domestic Geely sedan, and the VW Polo. This competition for discerning consumers seems to be the most likely incentive for technological improvement in Chang’An Ford’s products. For example, fuel economy is
a top concern for the Chinese consumer, and as a Ford representative commented, “Fuel economy is driven by competition in China.” Another incentive for technology transfer is the increasing availability of higher quality and low cost parts and components in China. If automotive parts can readily be sourced locally, then the costs of technology transfer can be reduced, which eliminates one barrier for technology transfer.
Chapter 7

FINDINGS AND ANALYSIS

7.0 INTRODUCTION

If the Chinese wish to deploy cleaner automobiles in China, they face a fundamental choice about the extent to which they “make” or the extent to which they “buy” the cleaner technologies. Historically, the Chinese were forced to buy conventional automotive technologies from abroad because their own technological capabilities were limited. The idea was that they would learn through technology transfer and gradually acquire their own technological capabilities, eventually attaining some self-sufficiency (Harwit 1995). China finds itself in a similar predicament today because it lacks the technological capabilities needed for clean-vehicle development and deployment. Based on its past experience, is it wise for China to rely on a strategy of technology transfer to acquire cleaner automotive technologies from abroad? If so, which cleaner technologies should China purchase from abroad, and which ones should China try to make domestically? To answer these questions, lessons can be derived from analyzing the three U.S.-China automobile joint ventures from 1983-2002: Beijing Jeep, Shanghai GM, and Chang’an Ford. Based on the empirical evidence from these cases, there are four main findings that emerge from this research:

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1 Whether the Chinese truly want cleaner vehicles is a provocative question, which will be addressed in this chapter (see Section 7.2.3).
• U.S. firms transferred outdated automotive pollution-control technologies to China.

• To some extent, U.S. foreign direct investment helped to deploy cleaner automotive technologies in China than those that were in use before, but the potential environmental benefit of the newer technologies is being offset by the growth in the number of cars on the road.

• Automotive technologies that were transferred were not necessarily updated in tandem with updates made to equivalent foreign models.

• U.S. foreign direct investment in the automotive sector did not strongly contribute to improving Chinese technological capabilities because little knowledge was transferred along with the product.

One further important implication can be drawn from this study: leapfrogging to substantially cleaner automotive technologies through technology transfer from foreign firms is likely to be quite challenging for the Chinese automobile industry.

This chapter first will provide in Section 7.1 a brief comparative analysis of the three cases in terms of environmental performance, fuel efficiency, and technological cooperation. Then, each main research question will be addressed in turn. In Section 7.2, the question of the extent to which U.S. firms transferred clean technologies will be answered. In Section 7.3, the question of how technology transfer has affected human health and environmental quality in China will be addressed. Then, in Section 7.4, the question of whether technology transfer through FDI is contributing to economic development in the Chinese automobile industry is explored. The most important barriers and incentives to cleaner automotive technology transfer will be identified in Section 7.5 before turning in Section 7.6 to the question of the implications for leapfrogging. Throughout the chapter, the findings will be compared with the current
state of thinking in the academic literature. Implications of these findings for policy will be drawn in Chapter 8, the concluding chapter.

7.1 COMPARATIVE ANALYSIS

This section will compare the environmental performance, fuel efficiency, and technology cooperation in Beijing Jeep, Shanghai GM, and Chang’An Ford. As mentioned in the introduction, an automobile can be made “cleaner” through a combination of three measures: reducing tailpipe emissions of air pollutants, improving fuel efficiency, and using cleaner fuels. Tailpipe emissions of common air pollutants including nitrogen oxides (NO\textsubscript{x}), carbon monoxide (CO), and hydrocarbons (HC) are usually controlled through catalyst technology and on-board diagnostic (OBD) systems. Cleaner fuels – such as unleaded or low-sulfur fuel, or compressed natural gas – can also contribute to reducing some of the harmful emissions of pollutants from an automobile. Emissions of the key greenhouse gas, carbon dioxide (CO\textsubscript{2}), can be reduced to some extent from switching from petroleum-based fuels to compressed natural gas (which contains less carbon in relation to its energy content); and net carbon emissions can also be reduced by using alcohol fuels derived from biomass (which removes as much carbon dioxide from the atmosphere when it is growing as it releases when it burns). Electric vehicles and vehicles powered by fuel cells operated on hydrogen are sometimes described as being completely clean, but thinking about the entire systems leads to the conclusion that their overall cleanliness depends on how the electricity or hydrogen is obtained. Hydrogen today is mainly produced from natural gas (with release of
greenhouse gases to the atmosphere), and most electricity in China is generated by burning coal. Of course, whatever the origin of the primary energy for vehicle propulsion, increasing the energy efficiency of the automobile can reduce emissions per mile.

The finding that U.S. manufacturers transferred outdated automotive pollution-control technologies mainly applies to the tailpipe emission control technologies, because the situation with respect to fuel economy is unclear due to the lack of independent, standardized data.

7.1.1 Environmental Performance

Each of the U.S. auto manufacturers examined in the case studies transferred outdated automotive tailpipe pollution-control technologies to China and continues to do so (see Fig. 7.1). The automobiles produced by the joint ventures all abide by current Chinese law, but would fail to meet current air-pollution-control standards in the United States, Japan, or Europe. In other words, none of the U.S. firms transferred pollution-control technology that is equivalent to the equipment installed in cars sold to U.S. consumers. The pollution-control technology transferred to China by the U.S. manufacturers is about one decade behind that used in Europe and the United States.

As noted in Chapter 2, Chinese regulations for tailpipe-emission control were first set in 2000, the same year that the Chinese government banned leaded fuel and required catalytic converters to be installed in all new automobiles. China adopted the European
Union’s system of regulating automotive air pollution, such that as of 2000, all automotive manufacturers in China were required to meet EURO I standards (required in Europe as of 1992 – see Fig. 2.3). In the biggest cities, China now requires new automobiles to meet EURO II standards, which is the level required in Europe as of 1994. In interviews and in their public relations materials, Shanghai GM and Chang’An Ford representatives declared that all their vehicles met EURO II standards. Beijing Jeep officials said that their vehicles were EURO II compliant, except for the Jeep Grand Cherokee, which they report meets EURO III standards. China, like most other developing countries, does not regulate carbon dioxide emissions.
7.1.2 Fuel Efficiency

China does not currently regulate fuel efficiency in automobiles, although such standards are reportedly under development (Xu 2002). Manufacturers in China are not required to report the fuel efficiency of the vehicles they produce, which makes it nearly impossible to gather reliable and standard data. In interviews or through public relations material, fuel-efficiency data were obtained directly from the manufacturers, but these data could not be independently verified or standardized. An attempt has been made to standardize the data so that all numbers are based on an urban driving cycle, but the results can only be considered preliminary until better data are available (see Fig. 7.2).

<table>
<thead>
<tr>
<th>Model</th>
<th>Fuel Efficiency in Chinese Model in Urban Driving (mpg)</th>
<th>Fuel Efficiency in U.S. or European Equivalent Model for Urban Driving (mpg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buick New Century*</td>
<td>18-21</td>
<td>20</td>
</tr>
<tr>
<td>Buick Sail*</td>
<td>23-26</td>
<td>27.2</td>
</tr>
<tr>
<td>Jeep Grand Cherokee&quot;</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Jeep Cherokee#</td>
<td>18-21</td>
<td>16</td>
</tr>
<tr>
<td>Jeep BJ2020#*</td>
<td>17</td>
<td>no equivalent</td>
</tr>
<tr>
<td>Ford Fiesta@</td>
<td>32</td>
<td>26</td>
</tr>
</tbody>
</table>

*The U.S. figures are as rated by EPA in 2002 (except for Ford Fiesta and Opel Corsa) in miles per gallon (mpg). When Chinese data were reported using constant high speeds (such as 60 km/hour), they were adjusted to be 40 percent less efficient for “city” driving.

*The U.S. equivalent to the Chinese New Century is the Buick Century 2002. The Chinese New Century has a 2.5-liter engine and the U.S. model has a 3.1-liter engine, both with 6 cylinders. The Buick Sail’s EU equivalent is the 5-door U.K. Opel Corsa Elegance, which has a 1.4 L engine compared with the Sail’s V4 1.6L engine.

#The Jeep Grand Cherokee in China and the U.S. are both automatic V8 4.7 L engines but the Chinese version is AWD and the U.S. version is 4WD. The China Jeep Cherokee (2.5L manual) is no longer produced in the U.S. so a 2002 Jeep Liberty 4WD manual V6 3.7L model was used for comparison. The BJ2020 model is a manual transmission with a V6 2.4L engine.

@The Ford Fiesta is not sold in the U.S. so a U.K. model was used for comparison. Both have auto 1.6 L engines.

In an interview, one Ford official said that the fuel efficiency of the Chinese Fiesta is 10-15 percent worse than its European equivalent due to fuel-efficiency differences.


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Taking these data limitations into account, it appears that the fuel efficiency of each automobile produced in China is roughly similar to its foreign model equivalent, with the possible exception of the Ford Fiesta. Without independent and standardized testing, it is not possible to analyze this further. There is one instance where the fuel efficiency of a Chinese model was purportedly improved after being released to the Chinese market: Shanghai GM introduced a more fuel-efficient Buick New Century to meet consumer demands. Shanghai GM claims that its Chinese model is actually slightly more fuel-efficient than the U.S. equivalent, but this assertion was not possible to verify.

The story with respect to greenhouse-gas carbon dioxide is the same. The greenhouse-gas emissions of U.S. and Chinese equivalent models appear to be quite similar, with the possible exception of the Ford Fiesta.

7.1.3 Technology Cooperation

The three joint ventures vary considerably in terms of the extent of their technological cooperation (see Fig. 7.3). All three joint ventures have established some form of a technical center, but none of the Sino-foreign joint ventures actually do research together. In every joint venture, the U.S. and Chinese partners are working together on product adaptation as well as localization of parts and components. Beijing Jeep and Chang’An Ford’s technical personnel are internal to their joint ventures. At Beijing Jeep, the technical center is entirely staffed by Chinese engineers and co-directed by one Chinese and one U.S. manager. Shanghai GM opted to establish a separate joint venture for its technical center, the Pan Asian Technology Center (PATA
cen). This center is not explicitly tied to Shanghai GM, although 80 percent of its work is contracted by
SGM. PATAC helped to adapt the Opel Corsa to the Chinese market in its reincarnation as the Buick Sail (Green 2002). U.S. and Chinese engineers jointly manage PATAC, although there is a ratio of 20 Chinese engineers for every one U.S. engineer. U.S. engineers manage seven of the 11 major departments at PATAC. The Chinese managers run the human resources, marketing, purchasing, and testing departments. U.S. managers run the body, chassis, powertrain, interior, design, electrical, and HVAC divisions (GM China Chinese Employee B 2002).

<table>
<thead>
<tr>
<th>Figure 7.3</th>
<th>Comparative Analysis of Technological Cooperation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beijing Jeep</td>
</tr>
<tr>
<td>Technology Center?</td>
<td>Yes, internal</td>
</tr>
<tr>
<td>Capability level of Chinese partner according to U.S. firm</td>
<td>product adaptation, localization</td>
</tr>
<tr>
<td>U.S. firm funds other research in Chinese universities or institutes?</td>
<td>No</td>
</tr>
<tr>
<td>Number of Chinese vs. U.S. engineers</td>
<td>200 Chinese 1 U.S.</td>
</tr>
<tr>
<td>Management of Tech Centers</td>
<td>1 Chinese, 1 U.S.</td>
</tr>
<tr>
<td>Funding</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Although none of the technical centers is doing R&D internally, this circumstance does not mean that the U.S. firms are not investing in R&D in China. To the contrary, both GM and Ford are investing in research projects, but not in their joint venture
partners. Instead, both firms invest in Chinese universities and academic institutes. Since 1996, GM has invested a total of US$1.97 million in different projects at a number of top Chinese universities (Green 2002). GM did a study to determine which universities possessed the best capabilities, and GM distributes about US$20,000-$30,000 for each project to these top universities. U.S. firms are already assessing the cost-advantage of Chinese researchers. The former Executive Director of Regional Science & Technology for GM Asia Pacific, noted that GM has estimated that for “time on target” (time purely devoted to the research project), Tsinghua University researchers cost “one-fifth” as much as U.S. university researchers. But Chinese university researchers are only being funded to do applied research projects, not basic research. According to Green, “GM funds no basic science in China.” So, there already appears to be an emerging cost-advantage to funding applied R&D projects in China, and this is especially significant because GM’s overall research budget is proportioned heavily in favor of applied R&D (80 percent). Thus, Chinese university researchers could increasingly supplant U.S.-based R&D. Green said that projects would be chosen in Asia “based on cost, quality, and geographic clustering.” (Green 2002).

Ford China has also chosen to directly invest in Chinese universities and institutes, without channeling this investment through their joint venture. This investment has been done in coordination with the National Science Foundation of China. The Director of International Research and Technology, Asia Pacific, South America, and South Africa for Ford Research Laboratory declined to be interviewed for this study, so further comparative analysis is not possible.
Beijing Jeep has not chosen to invest in research in China. To some extent, DaimlerChrysler invests in product development and adaptation for localization purposes. According to one DaimlerChrysler manager, “For high-end premium SUVs with relatively small volume niches, it would be a definite challenge for the manufacturer to invest heavily in research and development in localizing high content levels of both parts and components. We must have enough market volume (in China) to justify high local content of parts and components” (Soh 2002).

To underline the point made above, none of the U.S. firms is actually funding automotive R&D projects within its own manufacturing joint venture. Instead, the companies are choosing to fund research projects at Chinese universities. This finding implies that Chinese technological capabilities are better in the universities than in the Chinese automotive firms, and it raises interesting questions about China’s national automotive-innovation system. If the best technological capabilities reside in the universities, what is the connection between the Chinese universities and Chinese firms? Anecdotally, there was little evidence for substantial interaction between the firms and universities, but this question is ripe for future research.

7.2 WHY DID U.S. FIRMS NOT TRANSFER CLEANER TECHNOLOGIES TO CHINA?

The first key finding from this research is that all of the U.S. firms transferred outdated automotive pollution-control technologies to their partners in China. The main reason cleaner technologies were not transferred is that there simply were no compelling incentives for the U.S. firms to do so. The Chinese government issued no foreign-
investment policies that directly required cleaner technologies to be transferred. Nor did the government pass environmental laws that required significantly cleaner technologies to be introduced into China to meet Chinese domestic standards. This lack of incentives in either law or policy can either be attributed to a vicious circle related to domestic competitiveness or a marriage of convenience between the Chinese government and foreign auto companies. In addition, the Chinese joint-venture partners (which are all either owned by local or central-government authorities) did not demand advanced environmental technologies during the joint-venture negotiations. Lastly, the U.S. auto companies knew that the quality of the Chinese fuels was so poor that, if they were to transfer more advanced air pollution control technologies, these would be rendered ineffectual by the low-quality fuel. Each of these explanations will be now explored in more detail, along with the evidence.

7.2.1 Lack of Policy or Legal Incentives

Presently, Wei-Ming Soh of DaimlerChrysler China is sufficiently uncertain that the Chinese government will impose complex environmental standards (to the extent that they would be difficult for DaimlerChrysler to meet) that he, “doesn’t even think about it at this point in time” (Soh 2002). This outlook was reflected among all three U.S. manufacturers because none of them were at all concerned that Chinese environmental policy would become a technological challenge or barrier for their joint-venture operations. If Chinese environmental policy did mandate stricter controls on automotive emissions or fuel economy, there is little question that the U.S. firms would immediately comply. As Kristen Zimmerman of GM noted, “If there is an environmental policy
already in place then GM, by all means, will comply. But GM would choose first to
work with the Chinese government to develop an environmental policy based on the
progress and learning mechanisms inherent in voluntary initiatives rather than develop an
environmental policy based on reactive measures in response to mandatory, binding
targets” (Zimmerman 2002).

The complete lack of apparent concern on the part of the U.S. manufacturers
about being able to comply with Chinese environmental laws demonstrates that
environmental factors not only rank low on the list of U.S. investor concerns about
China, but also that foreign firms do not anticipate that Chinese environmental policy will
be a future constraining factor for them. In other words, the U.S. firms simply feel no
policy or legal pressure to transfer more advanced environmental technologies. Chinese
standards for automotive emissions control do not provide sufficient incentive for U.S.
firms to transfer cleaner automotive technologies.

The literature contains at least four theoretical explanations that might bear on
why U.S. multinational firms might transfer outdated automotive pollution-control
technologies to a developing country like China: the “pollution-haven,” “race-to-the-
bottom,” “stuck-in-the-mud,” and “pollution-halo” hypotheses. The pollution-haven
hypothesis posits that multinational corporations will relocate to developing countries
because of lower environmental compliance costs. The race-to-the-bottom hypothesis is
that developing countries will weaken their environmental standards to attract foreign
direct investment (FDI), placing pressure on the industrialized countries to weaken their
standards as well, in order to compete with the developing countries. A variation on this
theory is the “stuck-in-the-mud” hypothesis (Zarsky 1999b), which argues that
developing countries will not raise environmental standards for fear of losing FDI to other countries. In contrast, the pollution-halo hypothesis asserts that FDI will bring cleaner environmental technology and improved environmental-management practices to developing countries.

Despite the finding that U.S. firms are not transferring their best available environmental technologies, the Sino-U.S. joint ventures do not appear to be examples of the pollution-haven or race-to-the-bottom hypotheses. This study finds no evidence that China’s relatively weaker air-pollution standards affected any of the U.S. firms’ decisions to invest there. Instead, U.S. companies primarily invested in China because they wanted to gain access to the Chinese market (which was virtually closed to imports when they invested), not because Chinese environmental standards were lax. This finding is in accordance with other studies that have found no evidence for a pollution-haven in developing countries (Chudnovsky and Lopez 2002). As Zarsky notes, “Differences in environmental standards and/or abatement costs have apparently not made a significant difference to firm location decisions” (Zarsky 1999a, 19). There is also no evidence for the race-to-the-bottom hypothesis because the Chinese have not lowered their standards to attract FDI. To the contrary, the Chinese government has already announced a tightening of national emission standards for air-pollution control to the EURO II level, starting in 2004. For the same reason, there is also no evidence for the stuck-in-the-mud hypothesis. Chinese government officials do not appear to be particularly concerned about how the regulations might affect the international competitiveness of their firms. This lack of concern could be because China is not exporting any significant number of automobiles. The government is more concerned about competitiveness in the domestic
market (see “vicious circle” discussion). Yet, it is possible to imagine that environmental policies could get “trapped in the mainstream,” such that Chinese officials might hesitate to promulgate regulations that go beyond the levels in industrialized countries, especially if such actions were perceived by China’s competitors to be non-tariff barriers to trade under WTO rules. In fact, if the Chinese government were pushing the technological frontier with its environmental policies, it would likely encounter substantial resistance from foreign and domestic firms alike.

Finally, there is no compelling evidence of a “pollution halo” in the Chinese automobile industry either. U.S. firms did bring cleaner environmental technology to China than was in production there before, but the technology was only marginally better, and it was not transferred until Chinese law required better environmental performance.

7.2.2 Weak Bargaining by Chinese Firms

This research shows that the Chinese government-owned automobile firms undermined themselves in joint-venture talks with the foreign companies when negotiating for advanced technologies, especially cleaner technologies. This is the biggest enduring puzzle. Why did China not demand more advanced technologies, and especially cleaner technologies, given its current concerns about urban air pollution and oil imports? With respect to U.S. firms, however, their concerns about intellectual property rights and creating future competitors would mitigate against volunteering state-of-the-art technology to their Chinese partners. Yet there was significant variation among the U.S. firms in terms of the modernity of the technologies transferred, and this variation deserves exploration.
There are six main explanations that emerge from this research for why the Chinese auto firms did not bargain harder during their joint-venture negotiations as listed in Fig. 7.4.³ First, there was inconsistent government policy guidance during the times each joint venture was negotiated, and this mainly explains the variation among the three cases. Second, there is evidence that at times the Chinese firms did not really know what to ask for from their foreign partner. Third, the Chinese knew that their own technological capabilities were weak, and so in some cases they either felt they had no right to ask for more advanced technologies. Fourth, they often felt so powerless in the joint-venture negotiation that they dared not ask for more. Fifth, in one case, the Chinese correctly believed it was illegal to demand technology transfer because of WTO rules. Sixth, it has also been argued that Chinese firms owned by local governments tend to undermine the larger interests of the national industry during joint-venture negotiations by only considering their more narrow commercial interests rather than the industrial interests of the nation as a whole (Harwit 1995; Bowditch 1998). There is some evidence for this argument about the influence of local governments as well.

³ Bowditch (1998) argues that fragmentation in the industry eroded China’s bargaining position for technology transfer because the local governments were predominantly concerned with winning the foreign investment in the short term, rather than building a national industry for the long term. She writes, “China’s bargaining leverage in the automobile industry was largely squandered owing to competition among localities to reap the returns of a lucrative industry” (Bowditch 1998, 158). There was not much evidence for this conclusion in this study, with the possible exception of Chongqing’s bid for Ford’s investment.
In the early case of Beijing Jeep, the Chinese felt that they had virtually no capabilities, and indeed they did not; Beijing Automobile Industry Corp. (BAIC) was totally reliant on the foreign firm for new technology. At the time, the Chinese government had not issued any specific policies for the auto sector and related investment, so BAIC had no government guidance with respect to automotive technology other than the internal directive to obtain a completely new design for a soft-top, military, all-terrain vehicles. Although BAIC asked for the military design, BAIC eventually settled for AMC’s Jeep Cherokee. BAIC did not know which particular technologies to specify for transfer, so it just accepted that the Cherokee would be sent to China on a complete knock-down kit (CKD) basis. Even when DaimlerChrysler re-negotiated its contract with BAIC twenty years later, Daimler felt “no specific request from both the Chinese partner and the government as per which technologies should be transferred.” Instead, according to Wei-Ming Soh, the choice of technology depended more on market demand and the ability of Beijing Jeep to maintain specific quality levels in their products (Soh 2002).

During its joint-venture negotiations, Shanghai Auto Industry Corporation (SAIC) bargained harder than any other Chinese firm to date, with mixed success, for a number of reasons. First, SAIC had not gleaned much technological knowledge from its original foreign partner, Volkswagen, during the previous decade. Consequently, SAIC intended to structure its new joint venture with GM to elicit substantive technology transfer and a real investment in the operations. GM was equally interested in focusing on the success of the joint venture itself. SAIC had real legitimacy when bargaining because it was reputed to be the most profitable Chinese automobile firm, and there were many foreign
suitors anxious to enter into a joint venture with them, including both Ford and Toyota. In addition, SAIC had clear government backing about the imperative for technology transfer. The Chinese government had recently passed the 1994 Automotive Industry Law that placed new and specific requirements on foreign firms regarding technology transfer (see Chapter 3). So, SAIC’s biggest problem was not so much that it did not bargain very hard, but more that it did not know exactly what to ask for from GM.

Somewhere in the middle of this Chinese continuum lies Chang’An Ford. The parent of Chang’An was so anxious to secure a respectable foreign partner and status as one of the top automotive manufacturers in China, that Chang’An felt weak in the negotiations. For Chang’An, it was so important to win Ford’s investment that it was afraid to risk squandering the opportunity by being demanding about technology during the negotiations. Moreover, Chang’An understood correctly that it was illegal to make explicit demands about technology transfer because of WTO rules. Indeed, the Chinese government had conceded that it would not place restrictions on technology transfer during its negotiations with the United States prior to China’s entry into the WTO (see discussion in Chapter 3). Ford did not feel that it had to bow to any governmental demands to establish a technical center, although the government had stated this desire. Currently, Ford is not bringing cutting-edge technology to China, but it did not anticipate that other companies would start to do so either. Competition has been the primary motivator with respect to Ford’s decision to transfer technology, not hard bargaining on the part of their Chinese partner. Chang’An also did not seem to know what exactly to ask for from Ford since at least one Chang’an official believes that Chang’an received relatively current technology, especially in comparison with its old joint-venture partner,
Suzuki. Interestingly, Chang’An Ford’s first product, the Ford Fiesta, has been criticized in the Chinese media for being outdated technology, but it is at least newer than the old Suzuki technology. As a Chang’An authority commented, “Suzuki gave [Chang’An] very low technological content because they [Chang’An] didn’t know anything” (Chang'An Employee 2002).

One last hypothesis proffered by a foreign observer working in China for why the Chinese companies do not bargain harder with their U.S. counterparts is what he called the “good enough phenomenon” (Clark 2002). For many years, and perhaps still today, the Chinese were content just to get access to the product – the car itself. Acquisition of the related technological knowledge was a secondary goal, if even a goal at all. So long as the car was cheap, functional, and sold reasonably well, the Chinese companies were content. Jia Xinguang, analyst with the China National Automotive Industry Consulting and Development Corp., captures the sentiment well in his comment that "In the current Chinese car market, the most important thing for a foreign carmaker is not that its models are old or new, but that they are suitable for local customers. . . . Volkswagen's Santana and Jetta are the two oldest foreign car models being produced in China, but they are still selling well" (Gong 2003).

Until the late-1990s, there was limited competition from glitzy foreign products so Chinese consumers were forced to simply buy what was available to them, even if it was the same, boring, fifteen year-old design. Automobiles like the old Soviet-era Beijing Jeep 2020 were deemed “good enough” for the Chinese market, not just by the U.S. firms but also by the Chinese companies themselves. Ford’s decision to send in a Fiesta (and Chang’An’s acceptance of this model) may be one example of the view that it
was “good enough” for China’s consumers. GM’s decision to rush the Opel Corsa into China instead of designing or adapting a really modern, advanced new car (and SAIC’s apparent acceptance of this decision), may be another example of this phenomenon.

Aside from the explanations identified through this research, a number of negotiation theories can help explain why the Chinese firms failed to bargain harder. One negotiation theorist notes that contrary to conventional wisdom, a less powerful party is not always at the mercy of the more powerful party because power is specific to any given negotiation (Salacuse 1999). The Chinese firms, however, mostly perceived themselves to be powerless in their individual joint-venture negotiations. According to another theorist, negotiating power is the power to convince others through the power of skill, knowledge, commitment, a good relationship, having a good alternative, an elegant solution, and legitimacy (Fisher 1995). The Chinese firms did not seem to recognize these other types of power. Chang’An felt that Ford was the best foreign partner it was likely to attract, and so Chang’An felt a certain desperation to accept Ford’s proposals. Similarly, Tianjin Automotive Industry Corporation (TAIC) felt that it needed Toyota much more than Toyota needed TAIC because TAIC was feeling intense competition from SAIC, which had good foreign partners and better technology. So, in the words of one TAIC employee, “We gave in to everything that Toyota asked” (TAIC 2002). But the Chinese firms may have had more power than they thought. The U.S. firms were very anxious to gain access to the much-vaunted Chinese market of 1.3 billion people. For example, John Smith, GM’s President, noted in 1997, “We’re positioning ourselves to become a major player in all the growth markets of the world – and especially in the Asia-Pacific region. . . . If China’s income growth continues along the path it has been on
for the past fifteen years, consider the potential market for cars we could serve” (Smith 1997). AMC was attracted by China’s potentially huge market, and it felt that firms that established a presence in China would be rewarded in the long term (Mann 1989). SAIC clearly realized that it had some power through alternatives because it made GM, Ford, and Toyota bid for the joint venture competitively. Even though Chang’An was afraid that it might not be sufficiently attractive to Ford, it is possible that Ford was just as anxious to woo Chang’An: all the other major foreign manufacturers had already invested in an automotive joint venture in China, and Ford was perceived as late-to-market.

7.2.3 A Relatively Weak Environmental Movement

Since this study shows, rather bleakly, that very few cleaner automobiles have actually been deployed in China through international technology transfer or otherwise, one must step back and ask whether the Chinese really wanted the deployment of cleaner automobiles in China? Maybe they did not bargain harder for cleaner technologies because they did not really care about them. After all, China faces pressing demands to alleviate poverty, develop the economy, industrialize, and compete with other countries.

Chinese attitudes toward environmental protection are as varied and diverse as they are in any other country. As noted by Yi-Fu Tuan, “Among the complex purposes and demands of the real world, attitudes to environment are no more likely to be consistent than attitudes to people whose company we enjoy on one occasion and find irritating on the next” (Tuan 1973, 412). Ultimately, since the Chinese government controls environmental advocacy organizations, the power and interests of the automobile
industry (which is mostly owned by local governments) currently overwhelms any environmental sentiment that might exist in China.

It has been noted that “Most environmental problems have roots in human relationships and are ultimately social, political, and cultural problems” (Shapiro 2001, 1). Thus, there is something to be gained by considering Chinese cultural traditions and how they might affect attitudes toward environmental protection in China today.

Historically, there have been differing and sometimes contradictory philosophies about the human relationship with the natural environment in China. Taoism, Buddhism, Confucianism, and Communism are four of the most prominent influences in Chinese culture. As one of the oldest continuous civilizations, Chinese society has a long-standing relationship with the land. Traditional rural practices of tilling, water conservation, sustainable harvesting of forests, and nomadic use of grasslands allowed Chinese farmers to farm the land for many centuries (Shapiro 2001). On the other hand, because of its large population, China has always been resource-intensive. For example, as Fairbank notes, “Chinese society and all its mores and institutions have been based from the beginning upon intensive agriculture, which will take the fullest advantage of human labor” (Fairbank 1951, 28). As land was exploited and degraded in the north, the Chinese population migrated southward in a steady, but protracted, expansion. As a result, all arable land in China has been completely transformed from its natural state for centuries. Natural disasters, such as torrential floods and excruciating droughts, have repeatedly befallen China, making the control of nature a long-standing preoccupation of Chinese leaders.
In ancient China, primitive animism was chiefly concerned with not disrupting or offending the forces of nature. The notion of *feng shui* (wind and water) derives from this ancient tradition, and it was concerned with the proper placement of human artifacts in relation to nature so as to prevent any harmful disruption. Drawing from this animism, Taoism is the most prominent Chinese tradition clearly reverential of nature. The mystical Taoists were skeptical of human reason and logic, in contrast to Europeans, who believed that a perfectly rational God had formulated a code of Nature’s laws that could be deciphered. Taoists believed that until humans learned enough about nature, society could not be properly organized because nature and humans had to co-exist in one system (Needham 1969).

Buddhism was a foreign religion that came to China between the fourth and eighth centuries A.D. Chinese Buddhists made some adaptations to the religion, but preserved its reverence for all living things. Today, for example, the easiest way to explain that you are a vegetarian in China is simply to say that you are a Buddhist. Although there are currently many Buddhist temples in China, the influence of this religion in contemporary China seems limited.

The Confucian philosophy is intensely hierarchical, anthropocentric, conservative, and resistant to the unorthodox. Confucians desired to properly order human relations rather than try to understand nature. Confucianism began as a means of bringing social order out of the chaos of the Warring States period, and the philosophy provided a rationale for a strong government bureaucracy (Fairbank 1951). China’s strong Confucian tradition of government bureaucracy now both hinders and helps environmental protection there. The State Environmental Protection Agency, for
example, is the strongest Chinese advocate for environmental protection, but it is considered to be among the weakest government agencies. In contrast, the State Economic and Trade Commission and the State Development Planning Commission have been two of the most powerful government agencies, and both share the core mission of fostering economic growth and development. Confucianism also suppressed dissent and encouraged order, two themes that were picked up and employed later by Chairman Mao and his Communist regime. Still, there are elements of Confucianism that support sustainable development, such as the Confucian adage that, “The Master fished with a line but not with a net; when fowling he did not aim at a roosting bird” (Waley 1989, 128).

The ancient Mandate of Heaven seems to derive from both Taoist and Confucian ideologies (although it technically pre-dates Confucius), because the imperial ruler’s mandate to rule derived from his ability to maintain a good relationship with nature. To not offend the heavens, the superior ruler maintained order and carefully observed the proper rituals, such as making an annual visit to the Temple of Heaven to offer sacrifices in exchange for a bountiful harvest. If natural disaster befell China, the ruler was seen as lacking virtue, losing his mandate to rule, and subject to a popular revolution.

The Communists took a strictly utilitarian approach to nature, primarily concerned with the exploitation of natural resources to meet social goals. Early Communism in China was dominated by Chairman Mao Zedong, who articulated an extremely adversarial approach to nature in his slogan that “Man Must Conquer Nature” (Ren Ding Sheng Tian) (Shapiro 2001). Many of Mao’s policies caused significant environmental stress or harm. For example, Mao dictated that with many people,

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4 These two agencies were combined into a new State Reform and Development Commission in early 2003.
strength is great, so the Chinese people were ordered to bear children to cause China’s population to swell and thus deter foreign attacks. During the Great Leap Forward (1958-1960), Mao wanted to catch up to the British in steel production so he ordered trees to be cut down to fuel backyard furnaces. In 1958 alone, 20 million Chinese peasants were also ordered to dig 110,000 small coal-mine pits to fuel these furnaces. The Great Leap Forward caused a massive famine, so Mao ordered the forests to be cleared and planted with grain, again causing massive deforestation. Later, during the Cultural Revolution beginning in 1966, grain was the only crop farmers were permitted to plant; all other crops had to be destroyed (Shapiro 2001).

In the post-Mao reform period, the move to a ‘market economy with socialist characteristics’ has resulted in a new wave of consumerism in China. Similar to the situation in the United States, the desire among Chinese citizens to own an automobile is widespread. In fact, the bigger, shinier, and more powerful the car, the better. In a recent Newsweek article, Beijing resident Wang Qishun commented, “We’re entering the automobile age – cars are bringing a new culture to China, and I want to explore it” (Liu 2002).

At the same time, there is increasing public and government concern in China about urban air pollution, the crowdedness of city streets, and China’s increasingly high reliance on imported oil. In an effort to contain environmental deterioration, the Chinese government has passed more than 100 environmental laws and regulations since 1980 and has created eight major pollution-control programs (Ma and Ortolano 2000), though enforcement of these laws and regulations is sporadic and weak. In a 2002 survey of Beijing residents, 93 percent of the respondents expressed worry about environmental
changes, such as the recent mild winters, high temperatures in summer, and sandstorms
(Xinhua 2002a). In that same year, Chinese children identified environmental protection
as one of their “28 main anxieties” in a national survey (Xinhua 2002b).

Also, one observes a detachment in China between the individual ownership of
cars and the environmental problems that they cause, similar to the detachment of the
issues in the United States. Most consumers in both countries do not believe that their
car makes any particular difference to air quality or oil imports – after all, what is one
more car? One big difference between China and the United States, however, is that
there is no tradition of powerful environmental advocacy groups in China. Instead, there
are currently a number of “government-organized” nongovernmental organizations
(GONGOs) devoted to environmental protection in China. Although the GONGOs have
been characterized as diverse in terms of their political independence and strength (Wu
2002), most focus their efforts on relatively uncontroversial environmental education.
Environmental advocacy groups in China rarely challenge or criticize the environmental
policies of the Chinese government.

More than anything, one observes an incredible drive toward industrialization and
modernization in China today, and this goal dominates all others. As one researcher
notes, “The high-growth, resource-intensive development strategy China has pursued . . .
[has] no doubt played a critical role in the deteriorating quality of the environment”
(Jahiel 1998, 756). Of course, China’s historical traditions also influence attitudes today,
and in particular, the Maoist legacy is still observable in China:

Mao-era efforts to control humans in nature, and nature in humans, have
set the scene for the current precarious environmental situation, which has
deteriorated with China’s post-Mao push to development. Explosive
economic growth and the rush to industrialize are obvious sources of China’s unfolding environmental crisis. However, the core dynamics . . . are still at work, albeit in attenuated or altered form. Political repressions still marginalizes intellectuals. . . . Urgency still leads to rapid and unsustainable exploitation of natural resources, although now the urgency is to get rich rather than to achieve socialist utopia or continuous revolution. A centralized bureaucracy anxious about its ability to maintain control still promulgates decrees that are formalistically applied at local levels, often to ill effect. And China’s people are still relocating en masse, sometimes forcibly, as in the case of the millions moved for the Three Gorges Dam, sometimes voluntarily. . . . Less obviously, but also significantly, China’s environmental problems are linked to the ideological bankruptcy and disillusionment left by the country’s Maoist experiment (Shapiro 2001).

It is my conjecture that all else being equal, most Chinese would want to buy cleaner automobiles to contribute to cleaner air. Who actually wishes for more air pollution? But, of course, all else is not equal, and the strength of the demand for cleaner automobiles depends on the commitment and power of those asking for such technologies. The Chinese government has asserted that environmental protection is a real priority for China, it has passed laws on air and water pollution, and it is working to improve enforcement of these laws. China has also actively engaged in international negotiations for multilateral environmental agreements (MEAs). In 1999, China hosted its first United Nations-sponsored meeting on environmental protection, the 11th Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. President Jiang Zemin personally came to the meeting at the Beijing International Convention Center to address the delegates. He stated:

The Chinese government has always attached great importance to environmental protection. China regards environmental protection as a basic state policy, has adopted the strategy of sustainable development, has undertaken effective measures for pollution prevention and control and ecological conservation, and has promoted the coordinated development of economy and environment. . . . As a developing country,
China is willing to bear the international responsibilities and obligations appropriate to its level of development on a fair, just, and reasonable basis, and make its contribution to the promotion of global environment and development (Jiang 1999).

Currently, provincial governments own most of the major automobile firms, and the most powerful central government ministries are the ones most concerned with economic development and growth. At the same time, the Chinese government controls the “government-organized non-governmental organizations” (GONGOs). The true desires of the Chinese citizenry are thus masked behind government ownership and organization. The only way that Chinese people can express their preferences is through the market. If they demand cleaner vehicles in the marketplace, Chinese automobile producers may be forced to respond. There is evidence for such demand in Shanghai GM’s decision to make its New Century sedan more fuel-efficient, because it had a reputation for being a gas-guzzler.

7.2.4 A Vicious Circle or Marriage of Convenience

The presence of a vicious circle or marriage of convenience has been identified by this research to partially explain why the Chinese government has not more aggressively regulated the Sino-U.S. joint venture firms. One Chinese official of the State Environmental Protection Agency (SEPA) described in an interview a vicious circle in the Chinese government’s decision-making process that has to do with domestic competitiveness. Chinese environmental law treats both domestic and foreign-invested joint venture auto companies the same. The Chinese government is reluctant to add additional burdens to the struggles of Chinese companies by imposing laws with which they could not easily comply. The Chinese domestic firms lack the advanced
environmental technologies, so the Chinese government holds back from imposing stiffer environmental standards even on the Sino-foreign joint ventures, although it would be relatively easy and cheap for the foreigners to comply. Without the government’s requiring the foreign firms to transfer cleaner technologies through more aggressive regulations, Chinese firms cannot access the technology through the technology transfer process. Since Chinese firms do not have the capability to design the cleaner technologies themselves, they fall even further behind the foreigners. Their ever-increasing backwardness makes it even more difficult for the Chinese government to risk imposing more stringent standards, and the downward spiral continues. One U.S. employee of one of the joint-venture companies made the same observation. He said, “The Chinese government doesn’t want to penalize the Chinese companies, especially the small ones, so it is slow to require changes of all the companies.” Moreover, “if the government put policies in place to require advanced technologies, the Chinese companies/engineers would somehow do it. And, certainly, the foreign companies would transfer the technologies” (Clark 2002).

A more cynical view of this dynamic is that, instead of a vicious circle being the culprit, it could just be a marriage of convenience between the foreign-funded joint-venture firms and the Chinese government. The government knows that restructuring China’s domestic automobile industry will be very painful and difficult, so it keeps delaying the inevitable by moving slowly on environmental regulations. Meanwhile, the foreign-affiliated joint ventures are not exactly demanding that the Chinese government impose more stringent pollution control laws (nor are they imposing more stringent
internal standards for their own operations in China). So everyone lives with the status quo, but human health and environmental quality in China suffer.

There are two ways to break the vicious circle. One is to improve and develop domestic technological capabilities for these cleaner technologies within the Chinese firms. This is exactly what the Ministry of Science & Technology (MOST) is trying to do through its new high-tech research program on clean vehicles (see Chapter 2). The main problem with this program is that MOST has decided to try to leapfrog over all conventional automotive technologies by only investing in component technology for electric, hybrid-electric, and fuel-cell vehicles without any accompanying policies to push these technologies into the marketplace. The other way to break the vicious circle is for the Chinese government simply to issue the regulations and accept that some domestic Chinese firms may suffer or be forced to consolidate. Either way, such steps would actually be in accordance with the Chinese government’s goals for the industry, because the government would like to consolidate China’s auto firms into six big companies akin to the “Big Three” structure in the United States (State Economic and Trade Commission of China 2001). Stringent regulations would force the foreigners to transfer more advanced technology and enable the Chinese firms to demand cleaner technology when they bargain with their foreign partner. If the joint ventures called for higher standards, they could indirectly drive their domestic competitors out of business, and this might be a method of generating a virtuous circle of better environmental standards and increased FDI. The fact that the joint ventures have not called for more stringent environmental standards supports the ‘marriage of convenience’ hypothesis, and it also reveals that the domestic producers are not real sources of competition either.
7.2.4  Poor Fuel Quality

To explain why outdated technologies for automotive air-pollution control have been transferred to China, one important physical constraint must be taken into consideration: China’s poor fuel quality. Recently, China phased out leaded fuel in less than five years, which was an impressive achievement. The sulfur levels of most Chinese petroleum products, however, remain high. A high sulfur level in gasoline limits the ability of catalytic converters in automobiles to lower CO, HC, and NOx emissions. China’s crude oil is characterized as “heavy, low-sulfur and waxy” but most of China’s imported crude is high in sulfur.\(^5\) The resulting sulfur level of refined gasoline available in China is currently about 800 ppm for gasoline. In Europe, gasoline sulfur levels were set at 500 ppm for their EURO II fuel standard, 150 ppm for EURO III, and 50 ppm for EURO IV (Walsh 2003).

U.S. firms often cite the high sulfur levels in Chinese fuels as a barrier to deployment of cleaner automotive technologies. The firms argue that sulfur levels are so high that, even if U.S. firms did transfer cleaner automotive technologies, their effectiveness would be muted, or even undermined, by poor fuel quality. For example, GM believes that it would be very difficult meet EURO III emission standards without an improvement in the fuels (Murtaugh 2002). Why sulfur levels remain so high in Chinese fuels is not the subject of this study, but suffice to say that it would be expensive for China to lower the sulfur levels in its fuels. Technology has been developed and

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\(^5\)Half of China’s crude oil imports come from the Middle East. Middle Eastern crude oil is black, not waxy, and higher in sulfur. (ChevronTexaco Corp. 2003) China’s net oil imports equal 1.6 million barrels per day, equivalent to 32 percent of total oil consumption.
deployed in industrialized countries to reduce sulfur levels in fuels, but this technology would have to be bought by Chinese refiners, another complex technology transfer.

7.3 HOW HAS TECHNOLOGY TRANSFER AFFECTED HEALTH AND ENVIRONMENTAL QUALITY IN CHINA?

To some extent, U.S. foreign direct investment helped to deploy cleaner automotive technologies in China than those that were in use before, but the potential environmental benefit of the newer technologies is being offset by the growth in the number of cars on the road. There is some variation among the three U.S. firms in terms of how much cleaner the technologies transferred actually were. This variation can most readily be explained by differences in Chinese policy at the time when each joint venture was negotiated. When the Chinese government issued policies that created strong incentives for technology transfer, more modern (and therefore, somewhat cleaner) products were transferred. Also, when the Chinese government issued air pollution control regulations, all three U.S. firms readily worked with their Chinese partners to comply.

7.3.1 The Scale Effect

Trade liberalization and foreign direct investment can have three kinds of effects on the environment of a recipient country: technique, scale, and composition (Grossman and Kruger 1991):

First, there is the scale effect... That is, if trade and investment liberalization cause an expansion of economic activity, and if the nature of that activity remains unchanged, then the total amount of pollution generated must increase...
Second, there is a **composition** effect. . . . If competitive advantage derives largely from differences in environmental regulation then the composition effect of trade liberalization will be damaging to the environment. Each country then will tend to specialize more completely in the activities that its government does not regulate directly, and will shift out of production in industries where the local costs of pollution abatement are relatively great. . . .

Finally, there is a **technique** effect. That is, output need not be produced by exactly the same methods subsequent to a liberalization of trade and foreign investment as it had been prior to the change in the regime. In particular, the output of pollution per unit of economic product need not remain the same. There are at least two reasons to believe that pollution per unit of output might fall, especially in a less developed country. First, foreign producers might transfer modern technologies to the local economy when restrictions on foreign investment are relaxed. More modern technologies typically are cleaner than older technologies due to the growing awareness of the urgency of environmental concerns. Second, and perhaps more importantly, if trade liberalization generates an increase in income levels, then the body politic may demand a cleaner environment as an expression of their increased national wealth. Thus, more stringent pollution standards and stricter enforcement of existing laws may be a natural political response to economic growth.\(^\text{6}\)

In the case of U.S. foreign direct investment in China’s automobile industry, the small technique effect from the slightly cleaner pollution-control technologies is being offset by the huge scale effect of the tremendous growth in the sales of new automobiles.

To summarize, in U.S. foreign direct investment into the Chinese automobile industry, there is evidence for a small “technique” effect, but the potential environmental benefit has been more than offset by a large “scale” effect. In other words, even though U.S. and other foreign firms introduced slightly more modern (but hardly state-of-the-art)

\(^{6}\) The second proposition – that if trade liberalization produced economic growth and higher national income, the country would “naturally” respond by imposing more stringent pollution controls and enforcing environmental laws more vigorously – is credited as the first statement of what is now called, the “environmental kuznets curve” hypothesis. The hypothesis is that there is an inverted U-shaped correlation between per capita income and environmental quality. As per capita income increases, environmental quality worsens, but once income reaches a certain level, environmental quality begins to improve. This hypothesis will not be evaluated here with respect to air pollution in China. This footnote is merely to note that Grossman and Krueger’s controversial hypothesis has been the subject of much debate and criticism (Arrow, Bolin, Costanza, Dasgupta, Folke, Holling, Jansson, Levin, Maler, Perrings, and Pimentel 1995; Moomaw and Unruh 1997; Suri and Chapman 1997; and, as reviewed by Stern 2002).
pollution-control technologies to China, the potential benefit in terms of air-pollution reductions was vastly outstripped by the increased air pollution caused by the rapid growth in the production and sales in the Chinese automobile industry. It is not possible to measure exactly how much cleaner the transferred technologies were in comparison with the domestic technologies because no data were collected. But, once the Chinese government imposed its EURO I automotive emission standard, U.S. firms immediately transferred the pollution-control technologies required to meet this standard to their joint-venture partners in China. Before the standard was issued, however, Beijing Jeep did not transfer the pollution-control technology.

Although it cannot be exactly measured, it is clear that the “scale” effect has so far been large in China; indeed, during the last decade, motor vehicles became the largest source of some sources of urban air pollution (NOx, CO, and HC) in China. Air pollution from all sources (including automobiles) is estimated to cause 300,000 Chinese citizens to die prematurely each year (Economy 1999). During the 1990s, the total number of automobiles produced in China grew ten-fold, from less than 100,000 per year in 1991 to more than 1 million in 2002. Such dramatic growth explains why total emissions of certain air pollutants from passenger vehicles have sharply increased even as more modern technology from U.S. and other foreign firms was introduced into China.

7.3.2 Stagnation and Technological Lock-In

Part of the promise of technology transfer is that it brings modern technologies to the recipient country. One would expect that as improved technologies became available,

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7 It is probable that SOx and particulate matter vehicle emissions also increased dramatically, but very little data have been collected in China on these pollutants from motor vehicles.
foreign joint-venture partners would transfer them to China. And, as better environmental technologies were developed, they too would be transferred. In the cases of foreign automobile firms operating in China, vehicle models were not necessarily updated in tandem with updates to equivalent foreign models. An important implication of this finding is that the Chinese auto industry essentially “locked-in” to outdated, inefficient, and polluting vehicle technologies for many years, until competition and regulation provoked the introduction of newer and cleaner technologies in the late 1990s. Although the automobiles themselves have a relatively short lifetime compared with other energy technologies, if the same old technology is in production for a decade or more, then the entire model fleet on the road operates with old technologies. It has been argued that industrial economies have become entrenched in fossil-fuel-based energy systems “through a process of technological and institutional co-evolution driven by path-dependent increasing returns to scale” (Unruh 2000, 817). Such lock-in creates persistent market and policy failures that can inhibit the diffusion of cleaner technologies. In terms of automobiles, China was stuck with sub-optimal technologies that were somewhat path-dependent, and they inhibited the diffusion of cleaner technologies as was discussed in the vicious circle section (Section 7.2.4).

Several case studies of technology transfer from foreign firms to China’s offshore oil industry were conducted in the early 1990s. In cases of successful technology transfer:

The adoption of a new technology did not mark the end of the technology transfer process, but rather for the full benefit of an innovation to be realized, technology was continually changed and improved. The learning process arising from such activities was shown to be improved when

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8 It is not possible to evaluate Chang’An Ford’s performance in this respect because this joint venture began production so recently (February 2003).
suppliers and recipients worked together to modify the technology to suit new problems and conditions (Warhurst 1991, 1070).

Based on this experience, it can be inferred that when there is no process of continually changing and improving technologies once they are in production, technology transfer is less successful because there are fewer opportunities for the two partners to learn from each other.

With the model updates at Shanghai GM in the late 1990s, and the new Beijing Jeep 2500 Cherokee model introduced in May 2003, one can observe a change for the better in recent years. Initially, the concept of ‘new model years’ was not transferred to China along with the initial automotive technologies. Instead, once a model was put into production in China, it remained in production virtually unchanged over a period of many years. If the model became obsolete, the foreign firm would usually introduce a completely new model rather than improve the technology of the existing model in production.

There are six main reasons for the stagnancy of the automotive technology transfer (as listed in Fig. 7.5): first, the cost of updating technologies that were already localized in China was high; second, production volumes were very low for many years, so it was hard to recover the initial capital investment in the manufacturing technology; third, the lack of market competition

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<th>Figure 7.5</th>
<th>Explanations for Stagnation of Technologies</th>
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<td>Explanations</td>
<td>Beijing Jeep</td>
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<tr>
<td>Cost of updating localized technologies</td>
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<tr>
<td>Low production volume</td>
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<td>Lack of market competition</td>
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<td>Lack of policy mandate</td>
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<td>Lack of consumer demand</td>
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<td>The “good enough” phenomenon</td>
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Note: Production at Chang’An Ford began in early 2003 so it is not possible to analyze their performance in this respect as of this date.
provided few incentives for updating technology until the late 1990s; fourth, there were no clear policy mandates to update the technology; fifth, there was limited consumer demand in earlier years; and sixth, the same “good enough phenomenon” (described in Section 7.2.2) applies to this finding. Again, there was variation among the three cases in this regard.

The Jeep Cherokee was the first foreign model to be manufactured by a joint-venture company in China. The Cherokee was introduced in 1985 and it was a current model at that time, as discussed in Chapter 4. The Cherokee was initially assembled from complete knockdown kits (CKDs) that were sent from Detroit. Over time, many of the parts were localized, in part motivated by the 1994 Auto Industry Policy requiring a minimum of 40 percent of parts to be produced by Chinese manufacturers. The Cherokee that was still in production at the Beijing Jeep (until being replaced by the new Cherokee Jeep 2500 in 2003) had experienced some updates since 1984, such as brake improvements, distributorless engines, and installing electronic fuel injection into the automobiles. 9 No Cherokee model is still produced in the United States (it was replaced by the Jeep Liberty model). During the mid-1990s, the Cherokee engine, transmission, and suspension were installed in the old BJ2020 model, and that was the full extent of “refreshing” that the BJ2020 ever received from AMC or Chrysler. This situation proved to be a profitable arrangement for Chrysler. According to a DaimlerChrysler manager, “In a normal circumstance, a manufacturer will launch an entirely new model every five to seven years and a “refresh” (face-lift) every 1.5 years, but BJC did not do that from the period 1984-2002 with the Jeep Cherokee” (Soh 2002). At the end of 2002, however,

9 “Distributorless engines” refer to replacing mechanical, rotating high-voltage distribution mechanisms with static electronically-controlled components for the ignition system. They can be used in conjunction with other electronic functions, such as electronic fuel-injection systems (Adler 1986).
Beijing Jeep finally decided to refresh the Jeep Cherokee by introducing a new model in 2003, the Jeep 2500. Soh promised that for the Grand Cherokee, Mitsubishi Pajero, and others, Beijing Jeep intended to carry out “respective timetables in launching new models and also refreshing all products from 2002 onwards.”

Until the 1990s, Beijing Jeep faced little competition. Initially, the biggest market for Beijing Jeep’s automobiles was the Chinese military, which had a standing order for a certain number of Jeeps per year. BJC had essentially no competition in this market, which was not really a market at all because the government specified how many Jeeps should be produced for the military each year. The only other foreign joint venture established in China during the mid-1980s was Volkswagen’s joint venture with SAIC, signed in 1984. 10 Shanghai VW and Beijing Jeep produced very different products. The first model produced by Shanghai VW was the mid-sized Santana sedan, which was primarily sold in the Shanghai market for use as taxis. The Shanghai government provided market protection for Shanghai VW by mandating that all taxis must have engines of a certain size, conveniently the size of the Santana engine. From the start, there was weak consumer demand for the Cherokee as a passenger car. Government officials preferred to be chauffeured in a sedan, and Cherokees were not used as taxis. Thus, the Cherokee was simply not viewed as a passenger car by the two biggest categories of Chinese consumers at the time.

10 The only Japanese automaker to invest in a joint venture in China until the late-1990s was Suzuki, which established a partnership with Chang’An in 1993, as discussed in Chapter 6. Other Japanese companies were relatively late to the Chinese market in terms of direct investment. Honda took over Peugeot’s failed joint venture in 1997 and began to produce Honda Accords at that factory in Guangzhou. Toyota invested in a new joint venture with Tianjin Automobile Industry Corporation (TAIC) and First Auto Works (FAW) in 2002. During the early 1980s, Daihatsu licensed relatively old compact sedan technology to TAIC, which is still in production in Tianjin.
Because there was relatively little demand for the Jeeps, production volumes remained very low, and this volume made it difficult to justify modernizing the vehicles. Beijing Jeep achieved its peak production in 1995 when 50,000 BJ2020s and 30,000 Cherokees were sold, but by 2002 production had fallen sharply to only 10,000 vehicles for all models. Once it became clear that the Cherokee was not selling well, Chrysler decided to introduce the Grand Cherokee. The Grand Cherokee was introduced in 2001 and it has not sold well either. The rationale for this failure that was provided by the company:

One of the problems with the Grand Cherokee is that it is a high-tech and complex machine. The Jeep Cherokee is relatively much more simple and therefore easy for mechanics to handle. The Jeep Grand Cherokee is so computerized that the mechanics need a lot of training. This is why an after sales network is so important. Thus sales volume on the Jeep Grand Cherokee will increase in conjunction with the establishment of the 3S dealer network facility in China (Soh 2002).

The Shanghai GM and Chang’An Ford cases are quite different. Shanghai GM did make a number of technical changes to its New Century luxury sedan once it was in production, including reducing the size of the engine to improve fuel economy, reducing noise levels, and upgrading the interior. No new model year has been introduced as of early 2003, but SGM officials promise that it is in development. No refreshing of the Buick Sail has been done yet at all, but the Sail was only introduced in 2001. Chang’An Ford started production in February 2003, so it is far too soon to evaluate this joint venture in this respect. By one Ford employee’s account, Ford probably could have done more in terms of the level of technology transferred. Still, all Shanghai GM and Chang’An Ford vehicles meet the same EURO II standard required in China’s biggest
cities, so it is likely that the environmental effect of the technology transfer is about the same.

7.4 IS TECHNOLOGY TRANSFER THROUGH U.S. FOREIGN DIRECT INVESTMENT CONTRIBUTING TO ECONOMIC DEVELOPMENT IN THE CHINESE AUTO INDUSTRY?

The last key finding from this research is that U.S. foreign direct investment in the automotive sector did not substantially contribute to improving Chinese automotive technological capabilities because little knowledge was transferred along with the product. Before elucidating this finding further, let us take a look at the contexts and goals of international technology transfer.

7.4.1 The Contexts of International Technology Transfer

One of the biggest theoretical benefits of foreign direct investment is that technology transfer will accompany it. In the cases of U.S. FDI into China’s automobile industry, technology transfer must be understood to occur within a much broader context (see Fig. 7.6): International policies and institutions, globalization, U.S.-
China bi-lateral relations, and domestic industrial and environmental policies are all interactions that will bear on how or why technology is transferred. International policies and institutions may establish norms, rules, and guidelines that can affect technology transfer. For example, the Multilateral Agreement on Investment (MAI) that was proposed by the OECD – but never enacted – would have established international rules for foreign investment. Forces of globalization are creating pressure for lower trade barriers and greater access to global markets. Bi-lateral foreign relations between the U.S. and China can obviously create conditions for greater or less cooperation between their citizens and private firms. Currently, technology transfer between the U.S. and China is fundamentally a process of U.S. technology innovation and subsequent transfer of marketable technologies to China, primarily through the private sector. Domestic policies in both countries will therefore also affect the choice and degree of technologies transferred.

7.4.2 Technology Transfer as Part of the Innovation Process

Theoretically, technology transfer must be considered in the context of the technological innovation process. A number of models of the innovation process have been proposed and refined during the last century. Initially, these models conceived of innovation as a linear and sequential process, which began with research, proceeded to development, then to demonstration, and finally to production and deployment. Later, this theoretical model was refined to capture two-way or iterative “chain-linked”

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11 Joseph A. Schumpeter distinguished three important phases in tech development: invention, innovation, and diffusion. Invention is the first demonstration of a new solution. Innovation is when a newly discovered material or technique is put into regular production. Diffusion is the wide-spread replication of the technology and its assimilation in a socioeconomic setting (as described by Grubler 1998, 24).
interactions where learning in one phase was linked to the other phases (Kline and Rosenberg 1986). A third model proposed by Ken-ichi Imai described the Japanese practice of merging the research, development, demonstration, and deployment \((\text{RD}^3)\) phases so that there is substantial overlap between each stage. In this last formulation, none of the stages occurs in isolation and the more the stages overlap with each other, the more efficient the “integrated” innovation process (Brooks 1995). Thus, technology innovation is characterized by multiple dynamic feedbacks (Grubler 1998).

Conceptually, technology transfer occurs in the realm of technology deployment or diffusion. Diffusion, “is the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers 1995, 5). Some argue that there is little that is unique about the process of technology transfer to distinguish it from technology deployment in general (Brooks 1995). If this is true, one can explore the theories about technological diffusion as they might apply to technology transfer.
Little has been proven about the causes of technology deployment but two general descriptive models exist: the S-curve or life-cycle model and the learning/experience curve model (see Fig. 7.7). In the life-cycle model, the diffusion and growth of a technology often proceeds along a “S”-shaped or logistic curve: slow growth of technology diffusion at the beginning, followed by accelerating growth that eventually slows when the market is saturated. This model illuminates the point that the rate of technology deployment is often non-linear for some time before reaching a limit or saturation. The learning curve model shows that the unit costs of production often decrease as experience producing the product increases. But, the rate of learning can vary enormously among different sectors and technologies (Grubler 1998; McDonald and Schrattenholzer 2001), and may undergo sudden, discontinuous drops as specific innovations are introduced.\(^\text{12}\)

\(^{12}\) Kenneth Arrow was one of the first to note that one could learn-by-doing because, “the motivation for engaging in the activity is the physical output, but there is an additional gain, which may be relatively small, in information which reduces the cost of further production” (Arrow 1969, 31).
7.4.3 Technology Acquisition, Learning, and Economic Development

There has been considerable debate about the importance of technology transfer and technological diffusion to economic development. The classic Heckscher-Ohlin factor endowment theory of trade assumed that technology did not play a determining role in defining a nation’s comparative advantage.\(^\text{13}\) Indeed, Heckscher-Ohlin attributes comparative advantage only to the relative difference in capital and labor factor abundance between trading partners. Trading on this basis, they postulated, can result in gains from trade and subsequent economic development. Technology was assumed to be equal across nations because it was considered well-defined, free, and perfectly available.

In contrast to the Heckscher-Ohlin theory, in his *Theory of Economic Development*, Joseph Schumpeter proposed an alternative theory of economic development, which explicitly hypothesized the centrality of technological change to economic development. Schumpeter wrote that “new combinations” (in other words, technical change) can be considered a factor of production, and that these new combinations “do not fall from heaven,” but are “created . . . by the individual waves of development” (Schumpeter 1934, 71). For Schumpeter, “The phenomenon characterizing development emerges” when “new combinations appear discontinuously”

\(^{13}\) Eli Heckscher wrote “The Effect of Foreign Trade on the Distribution of Income” in 1919. Then, Bertil Ohlin elaborated on Heckscher’s theory of trade in his book *Interregional and International Trade* in 1933, and the two publications together form the Heckscher-Ohlin theory. This theory of comparative advantage as the basis for international trade made the simplifying assumption that different nations use the same technology. According to one analysis, “The assumption that both nations use the same technology means that both nations have access to and use the same general production techniques” (Salvatore 1993, 108).
(Schumpeter 1934, 66). In other words, technological change is intrinsic to economic development, but it is not an automatic process.14

The idea that technology was equally available across nations endured in the economic development literature for decades after Schumpeter proposed otherwise.15 But increasingly, economists began to accumulate evidence that economic output cannot be explained by labor and capital alone. Robert M. Solow and others showed that there is a “residual” that must be technology’s contribution to economic growth (Solow 1957; Griliches 1996). Thus, technology is now considered to be as essential to economic development as labor and capital.

Although possession of technology is necessary, it is hard to acquire. Many empirical studies have shown that technology is tacit, proprietary, and often expensive. These studies show that the acquisition of technology in late-industrializing economies is a complex process because of these characteristics of technology. Successful acquisition of technology usually requires, *inter alia*, active government involvement and management, selectivity and planning with respect to which technologies to acquire (and in what order), determination and skill on the part of the recipient firm, and specific contractual arrangements between buyer and seller (Dahlman, Ross-Larson, and

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14 To Schumpeter, the concept of “new combinations” in economic development include: (1) The introduction of a new good – or of a new quality of a good; (2) The introduction of a new method of production; (3) The opening of a new market; (4) The “conquest” of a new source of supply of raw materials or half-manufactured goods; and (5) The carrying out of the new organization of any industry, like the creation of a monopoly position or the breaking up of a monopoly position (see Schumpeter 1934, 66). In Grubler’s (1998) helpful discussion of Schumpeter’s other big contributions to the theory of technological change, he notes that Schumpeter had the two important insights that technologies are evolved from within (that technological change should not be exogenous to economic growth models), and that technological change is inherently dynamic and not static.

15 For example, in 1969 Kenneth Arrow wrote, “A production function is defined relative to a given body of technological knowledge” (Arrow 1969, 29).
Although it is difficult to acquire advanced technology for the purposes of furthering economic development, overcoming these difficulties is essential for accelerating the development process of many industrializing countries, including that of China. This study of technology transfer from the United States to China in the automobile industry adds additional empirical evidence to the accumulating body of literature on the difficulties related to transferring technology to industrializing countries and the need for governments and firms in these countries to work strategically to acquire advanced technological capabilities to succeed in a knowledge-based global economy.

A number of barriers to economically efficient technology diffusion in an industrializing country have been identified including: the existence of transaction costs (North 1965), market failures such as imperfect information (Stiglitz 1989), the proprietary nature of technology (Hymer 1976), and the problem that technology is tacit (not outright or explicit). A firm is a bundle of proprietary assets, and these assets include technological capabilities and skills (Amsden 2001). Other barriers include the recipient or buyer’s capacity to absorb technology, the importance of being able to learn by doing, the appropriateness of the technology to its new setting, the costs of the advanced technologies for both acquisition and deployment, indigenous technological capabilities, and uncertainty (Arrow 1962; Baranson and Roark 1985; Dahlman, Ross-

16 Arrow is often credited with the notion that “knowledge underlies the production function” and that “knowledge needs to be acquired,” through the accumulation of experiences because “learning is the product of experience” (Arrow 1962, 155) Arrow’s article recognized the importance of “learning by doing,” but not the particular difficulties an industrializing country might have with learning by doing. If a country has little experience with advanced technologies, it is hard for it to “learn by doing” without possession of enhanced technological capabilities.
Larson, and Westphal 1987; Yin 1992; Xu 2000a; Ohshita and Ortolano 2002). Finally, access to technology cannot be automatically equated with improved technological capabilities that can contribute to economic growth (Reddy and Zhao 1990). All of these market “failures” imply a need for government intervention, in so far as policies and regulations can create incentives for and eliminate barriers to the effective acquisition, absorption, and deployment of technology through technology transfer. One cross-sector study of technology transfer to China noted, “Government plays a critical role in the process of indigenizing foreign technology” (Yin 1992, 25).

In terms of incentives for technology diffusion, policy and economic factors seem to provide the strongest incentives to firms. For example, new regulations and laws, along with increased market competition in the recipient country, can affect the technology transfer and diffusion process. In one study of the Chinese steel industry, it was found that larger and younger firms were more likely to adopt energy-saving, continuous-casting technologies, and that the availability of investment, higher profit rates, and local ownership also accelerated continuous casting technology diffusion (Fisher-Vanden 2003). There can also be ethical, political, environmental, and diplomatic motivations for technology transfer and diffusion.

7.4.4 The Relationships Among FDI, Technology Transfer, and Economic Development

The promise of foreign direct investment has been considerable. FDI is considered by many to be a strong contributor to economic growth and industrial development because it provides financing for worthy projects and can serve as an

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17 Author’s emphasis.
effective mechanism for technology transfer (OECD 2002). Along with the technology transfer, proponents expect that FDI will cause integration with the world economy, backward and forward linkages to related industries (spillovers), human capital formation, and surges in domestic innovation.\textsuperscript{18} Increasingly, this promise is being challenged by empirical evidence that FDI does not automatically provide these benefits to developing countries. FDI does not always accelerate growth, generate linkages and spillovers, and provoke greater innovation (Saggi 2002). In fact, there is evidence that FDI is correlated negatively with some indicators of innovation: the more FDI, the less industrial innovation on the part of the developing economy (Amsden 2001). Lastly, it has been shown that when conceived as “cumulative learning,” technology transfer does not automatically occur through FDI (Saggi 2002).

There are other potential downsides associated with FDI: it can be associated with greater environmental degradation, labor abuses in the supply chain, increased inequality, deterioration of the balance of payments, increased financial volatility, and the crowding out of domestic companies (OECD 2002). The extent to which FDI produces positive benefits is strongly dependent on the particular context in which the investment is made. If there are good policies, effective institutions, motivated recipient firms, and “enlightened” foreign firms, then FDI is more likely to have a positive effect on the local economy.

\textsuperscript{18} Saggi (2002) notes that there are three potential channels of spillovers: demonstration effects (where firms adopt technologies through imitation or reverse engineering), labor migration (workers move to other firms and carry their knowledge with them), and vertical linkages (otherwise known as backward and forward linkages). Vertical linkages refer to the concept that a foreign investment in one industry can indirectly produce benefits in other related industries. For example, suppliers of automotive parts and components may benefit from having a new source of demand for their product if there is FDI into a manufacturer. This would be an example of a “backward” linkage.
No single international institution governs foreign direct investment by transnational corporations.\textsuperscript{19} During the mid-1990s, the Organization for Economic Cooperation and Development (OECD) initiated a discussion among its members about creating a Multilateral Agreement on Investment (MAI). The initial framework of the MAI was perceived to be strongly tilted toward the interests of the foreign investor rather than the needs and interests of the recipient. Also, the MAI did not have substantive protections for labor and the environment. After much criticism, the MAI was abandoned and replaced in 2000 by an updated set of voluntary guidelines called the OECD Guidelines for Multinational Enterprises. These guidelines provide voluntary principles and standards for “responsible business conduct, in a variety of areas including employment and industrial relations, human rights, environment, information disclosure, competition, taxation, and science and technology” (OECD 2003).\textsuperscript{20} Many developing countries have some rules associated with the inflow of FDI, but they vary widely.

China receives more foreign direct investment than any other developing nation and has consistently done so since the mid-1990s.\textsuperscript{21} Within China, the automobile industry has received a huge proportion of total FDI; for example, GM’s investment represented the largest single foreign investment ever in China. At the beginning of 2001, it was estimated that more than 800 Chinese companies in –related industries had

\textsuperscript{19} The Trade-Related Investment Measures (TRIMS) agreement under the WTO applies only to investment measures related to trade in goods, but not services. Moreover, according to the WTO, “TRIMS is not concerned with the regulation of foreign investment.” (WTO\textsuperscript{b} 2003) The TRIMS agreement does prohibit local content requirements because they are seen as discriminating between imported and domestic products.
\textsuperscript{20} These guidelines were originally established as part of the OECD Declaration on International Investment and Multinational Enterprises, adopted by the OECD governments in 1976 to facilitate direct investment among OECD Members.
\textsuperscript{21} Including Hong Kong (which received US$22 billion alone in 2001), China received US$69.6 billion in 2001, more than twice as much as Mexico, which ranks second as a developing country recipient of FDI at US$24.7 billion in 2001. (UNCT AD 2002) However, China does not receive as much foreign direct investment as some of the most industrialized nations.
received FDI during the past decade with US$12 billion of investment actually registered in China (Zhang 2002). The question to be answered next is whether or not effective technology transfer accompanied this abundance of FDI in China’s auto industry.

7.4.5 Why FDI is Not Helping to Improve Chinese Technological Capabilities

The evidence from this study is that products were transferred to China along with U.S. foreign direct investment in China’s automotive sector, but U.S. FDI did not substantially contribute to improving Chinese automotive technological capabilities because little knowledge was transferred to China along with the products. This study finds that, up until 2002, there are five main reasons why U.S. FDI did not substantially contribute to improving Chinese capabilities (see Fig. 7.8):

- U.S. firms do not see themselves as responsible for “teaching” their partners how to improve basic capabilities;
- U.S. firms view their counterparts in China as manufacturing partners, not potential sources of innovation;
- The joint ventures were not structured to create the incentives for U.S. firms to transfer knowledge along with product; and,
- The Chinese government’s inconsistent automobile industrial policies, weak R&D program, and lack of unambiguous performance standards weakened the Chinese firms capabilities to receive new technologies.
- No binding international rules govern foreign direct investment.

Numerous Chinese business representatives and automotive experts interviewed in China bemoaned the continued laggardness of the Chinese automobile industry’s capabilities. According to the China Automotive Research & Technology Center (CATARC), “Before the reform and opening up to the outside world, the Chinese auto industry was 30 to 40 years behind that of the developed countries, whereas nowadays the level as a whole is 10 to 15 years . . . behind that of the advanced countries”
One Chinese working for GM commented that foreign companies are not good teachers, but the Chinese companies are not good learners either (GM China Chinese Employee A 2002). Another working for Beijing Jeep estimated that Chinese capabilities are at best “one-tenth” the level of U.S. capabilities (Beijing Jeep Chinese Employee 2002). And, an employee at Chang’An said that China has just learned the manufacturing process (Chang’An Employee 2002).

Another finding is that none of the U.S. firms believe they currently have a responsibility to “teach” their partners how to innovate and improve their technological capabilities. The U.S. firms do, however, teach their partners many other skills, such as how to install and operate manufacturing equipment, how to work with parts and components suppliers to maintain the quality of their products, how to run the business profitably, how to train the workers on the assembly line, and, in some cases, how to adapt products for the local market. In the case of Shanghai GM, GM argues that it has also learned some business skills from SAIC, but none of them have to do with technological capabilities. Recalling the typology of technological capabilities described in Chapter 3, U.S. firms have transferred sufficient knowledge to their Chinese counterparts to give them production capabilities, and perhaps some limited project execution capabilities. None of the U.S. firms, however, has tried to cultivate innovation
capabilities in their Chinese partners. All felt that they had no near-term incentives or responsibilities to cultivate these innovative capabilities in their Chinese partners. As Wei-Ming Soh of DaimlerChrysler commented, “We are here to make money, not to do training. If it is worth it, we can do some training while we make money” (Soh 2002). To Soh, there must be a direct financial rationale for training.

GM’s point of view is somewhat different. By investing in applied-research projects in Chinese universities and investing in PATAC, GM is clearly making an effort to cultivate better technological capabilities in China, particularly in the realm of production and project execution.

The availability of low-cost, highly educated and skilled researchers in China is also alluring to Ford. If the Chinese market becomes sizable and if there is a significant cost advantage for Chinese researchers, then it might become worthwhile to Ford to focus on cultivating an innovative research staff in China. Because Ford is locked into an equal ownership structure, it recognizes that it has to invest in the technological capabilities of Chang’An in the long term to be competitive in the Chinese market. Up until 2002, Ford had made relatively modest physical investments in improving those longer-term capabilities inside the joint ventures (other than providing training and know-how). Keith Davey, Director of Business Strategy in the Asia-Pacific and Africa for Ford, said that the investment in Chang’An’s technological capabilities is proceeding on a step-by-step process, building successive capabilities as the scope and complexity of the products...

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22 As discussed in the introduction to Chapter 3, production capabilities include being able to oversee the operation of established facilities, production engineering, repair and maintenance of physical capital, troubleshooting, and adaptation of products and processes as needed. Project execution capabilities include personnel training, pre-project feasibility studies, project management, project engineering, procurement, plant construction, and start-up of operations. Innovation capabilities include the skills necessary to create new processes and products (ranging from basic science to product development). See Dalman, Ross-Larson, and Westphal (1987) and Amsden (2001).
expand. In addition, Ford will continue to support more advanced research at Chinese universities and institutes through Ford China’s R&D fund (Davey 2003).

All of the U.S.-China joint ventures were structured with the primary goals of launching foreign automotive models into production in China to maximize the profits of the joint ventures. In other words, the joint ventures are not structured to spark innovation in new technologies. Yet, the Chinese firms always held out hope that they would somehow acquire innovative capabilities through the joint ventures. Beijing Auto Industry Corp. wished that American Motors Corp. would help them design a new model for the Chinese military, but AMC never had any intention to design one and was under no obligation to do so in the contract. A Chinese worker who was interviewed commented that the top foreign executives only see China as a market to sell cars, not as a place to develop them (Beijing Jeep Chinese Employee 2002). To some in China, this attitude demonstrates that the U.S. firms have a short-term profit motive for China because otherwise, the U.S. firms would be trying to invest in improving capabilities for the long term. As one Chinese engineer at another company said, if their U.S. partner were more open technologically, there would be mutual benefit (Chang'An Employee 2002).

In the case of Shanghai GM, SAIC tried hard to insure that there would be more technology transfer by insisting that (1) the transfer be measured and verified and, (2) by establishing a new technical center to help train Chinese workers and develop Chinese technical capabilities. Although SAIC also chose the first product that GM was to transfer: the Buick Century/Regal, SAIC was very worried about how to verify that GM transferred all the technology it was supposed to send. So, SAIC developed a
classification scheme to characterize the technological quotient of each technology. Not
surprisingly, measuring the technology transfer proved to be difficult. (Murtaugh 2002).
From GM’s point of view, it agreed to put US$25 million into the Pan Asian Automotive
Technical Center (PATAC) because such a center was obviously part of the price of
winning the manufacturing joint venture with SAIC, and also because GM thought it
could become a competitive advantage. GM probably would not have established
PATAC if it had not been a requirement to gain approval for the joint venture, but once
GM made the investment, it was determined to develop PATAC into a good China-
focused vehicle-development center. GM does not believe that PATAC will ever devote
substantial resources to research, but PATAC is expected to substantially contribute to
vehicle development (Murtaugh 2002).

Chang’an asked for a technical center during its negotiations with Ford, but Ford
felt no particular obligation to respond to this request since Ford knew that the WTO
rules prohibited the Chinese government from requiring technology transfer (Davey
2003). Thus, Ford did not establish a separate technology center with Chang’an. To
the extent that the U.S. Big Three lobbied for the above components of the PNTR
agreement, they were in fact bargaining indirectly against further technology transfer
within their own joint ventures.

This study concludes that the Chinese government failed to design and implement
an aggressive, consistent strategy for the acquisition of technological capabilities from
foreigners in the automobile industry. Such a strategy has been shown to be the key to
the Korean automobile industry’s success (Amsden 1989; Lee and Lim 2001). With the
1994 Automobile Industry Law, an attempt was made by the Chinese government to

23 See “Thrust into the Unfettered Market” section in Chapter 3.
articulate such a strategy, but the implementation of this law was haphazard, and then the government effectively reversed its policies through its concessions regarding the auto industry upon entry to the WTO. One Chang’an employee recommended that Chinese government regulations needed to be more stable and constant over time because there had been too much change. Moreover, according to him, there was too much inconsistency between the local and national government policies and that without government support of R&D, China’s automobile industry would just become a manufacturing base (Chang'an Employee 2002).

The weakness and inconsistency of Chinese policy helps explain the variation in the levels of technology transferred over time. The three Sino-U.S. joint ventures were formed in the context of three distinct and differing policy periods. Beijing Jeep was formed before there was a formal industrial policy for the automobile sector. Shanghai GM was formed in the wake of the 1994 Auto Industrial Policy when the government had decided it needed to build up domestic technological capability in this sector. Finally, Chang’an Ford was established in April 2001, seven months after the U.S. Senate had ratified the Permanent Normal Trade Relations (PNTR) bill.

Although technology transfer through FDI does not appear to have substantially contributed to knowledge-creation in China’s automobile industry itself, there is some evidence from this study that the investment generated positive backward linkages to Chinese suppliers. Because foreign firms were required to use a certain percentage of Chinese-made parts before China entered the WTO, the foreigners were forced to work with Chinese suppliers to improve the quality of their products. When product quality of the parts suppliers improved, they were able to expand their businesses and start

24 See discussion of backward linkages in Chapter 2.
exporting their products. Thus, the U.S. firms appear to have helped the Chinese parts and components companies to develop not just product capabilities, but also project execution capabilities.

7.5 **WHAT ARE THE MOST IMPORTANT BARRIERS AND INCENTIVES TO CLEANER TECHNOLOGY TRANSFER?**

Barriers and incentives for technology transfer tend to be fairly specific to a particular circumstance (Reddy 1996). It has proven difficult for analysts to determine which ones are generally most significant, and especially which ones matter the most for “sustainable” or “clean” technology transfer (Metz et al. 2000). There is general agreement that special barriers and incentives for environmental technology transfer do exist, but paradoxically, one of the most recent and comprehensive studies of the transfer of sustainable technology concludes that, “there are no corresponding overarching theories” about environmentally sound technology transfer, only a “number of pathways” (Metz et al. 2000, 17). This Intergovernmental Panel on Climate Change (IPCC) study

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25 The word, “sustainable” is often used in the literature about environmental technology transfer. A “sustainable” process or condition is defined as “one that can be maintained indefinitely without progressive diminution of valued qualities inside or outside the system in which the process operates or the condition prevails” (Holdren, Daily, and Ehrlich 1995). Thus, without radical socio-technical breakthroughs, it is hard to imagine that any automotive technology transferred from the United States to China in the next few decades could ever be deemed “sustainable.” It would be unsustainable because all internal combustion vehicles burn fossil fuels and produce air pollutants as by-products. Automotive technologies such as the hybrid electric exist, however, that could substantially reduce local air pollution damage even if they couldn’t eliminate it. In addition, such fuel-efficient technologies could reduce the rate of automotive emissions of greenhouse gases (especially carbon dioxide) into the atmosphere. Reducing the rate of greenhouse gas emissions would give humans and ecosystems more time to adapt to climatic disruptions because the rate of climate change itself would also decelerate (Watson 2001). Holdren, Daily, and Ehrlich (1995) state that constraining the rates of degradation of monitor-able environmental stocks to not more than 10 percent per century would be prudent practice. There are some automotive technologies on the horizon (such as fuel cells) that could theoretically drastically reduce pollution enough to actually contribute to “sustainable” automobile development if deployed widely. Until they are deployed, however, automobile technologies transferred to China that improve air quality can only be termed, “cleaner,” but not “sustainable.”
concludes that the “pathway” is determined by the role of the key stakeholder. These three main pathways are: government-driven, private sector-driven, and community-driven.

Thus, the incentives and barriers to sustainable technology transfer depend on who is participating in the process (Trindade, Siddiqi, and Martinot 2000). So while there may be no “theory” of sustainable-technology transfer, generalizations have again been formed about how such technology is usually transferred, what barriers exist, and how those barriers could be overcome. Empirical studies are beginning to show on a case-by-case basis which barriers and incentives are the most important in environmentally-related technology transfer (Ohshita and Ortolano 2002).

To focus explicitly on cleaner-energy-technology transfer, Martinot, Sinton, and Haddad (1997) propose a useful framework. They argue there are three useful perspectives for examining the process of energy-technology transfer from industrialized to developing countries:

- technological;
- market/transaction (economic costs and benefits); and
- agent/agenda perspectives

Technological perspectives highlight technology needs, choices, and development. A market/transaction approach highlights the importance of the technology’s price or cost, the evolution of markets, and the types of institutions and transactions that underlie them. The agent/agenda viewpoint highlights the different types of actors who can influence technology transfer (Martinot, Sinton, and Haddad 1997). There are two weaknesses in this framework: key barriers and incentives might be obscured by only delineating three main perspectives, and the relative importance of each factor is not expressed.
In the 2000 IPCC study on Methodological and Technological Issues in Technology Transfer, no fewer than twenty-two barriers were identified for what the authors call “environmentally-sound” technology transfer (see Fig. 7.9). Even so, by just glancing at this list, one can see that many of these barriers are not necessarily unique to environmentally sound technology transfer. Other barriers seem more distinctive such as the lack of full-cost pricing, which would incorporate the costs to society of environmental damage. A similar list could be generated for the incentives for technology transfer, and the IPCC provides one chapter on what it calls “enabling environments.” This chapter generally encourages the development of national systems of innovation, participatory approaches, building institutions (forming codes, standards, and certificates) building human and institutional capacities, and stimulating research and development activities. By examining the cases of technology transfer from the U.S. to China in the automobile industry, the specific barriers that are most inhibitory to cleaner-technology transfer in the

- Lack of full cost pricing
- Poor macroeconomic conditions (i.e. underdeveloped financial sector, high import duties)
- Low private sector involvement because of lack of access to capital
- Lack of financial institutions or systems to ensure initial investments for the utilization and use of transferred technologies
- Low prices (often subsidized) for conventional energy prices resulting in negative incentives to adopt energy saving measures and renewable energy technologies
- Lack of markets for ESTs
- Lack of supporting legal institutions and frameworks including codes and standards for the evaluation and implementation of ESTs
- Lack of understanding of the role of developed and developing countries and international institutions in the failures and successes of past technology cooperation.
- Lack of support for an open and transparent international banking and trading system
- Corruption
- Reluctance to identify and make available ESTs that are in the public domain
- Insufficient human and institutional capabilities
- Inadequate vision about and understanding of local needs and demands
- Inadequate capacity to assess, select, import, develop, and adapt appropriate technologies
- Lack of confidence in unproven technologies
- Lack of data, information, knowledge, and awareness on “emerging” technologies
- Lack of confidence in unproven technology
- Risk aversion and practices that favor large projects in financial institutions including multilateral development banks
- Insufficient R&D
- Inadequate resources for project implementation
- High transaction costs
- Lack of access to relevant, credible, and timely information on potential partners, which could enhance the spread of ESTs
Chinese automobile industry, and the incentives most likely to facilitate cleaner-technology transfer, can be identified.26

There are many other barriers that are commonly cited in the literature for why it is generally difficult to transfer technologies from advanced-industrial countries to developing countries, such as concerns about intellectual property rights, competition, poor communication, lack of supporting infrastructure, unrealistic expectations, cultural differences, and the appropriateness of technologies for the recipient country (Reddy 1996; Guerin 2001). Such analysis is not very helpful because technology transfer is so dependent on the particular context in which it occurs. In a 1990 study of U.S.-China technology transfer, the three most important barriers that were identified were: effective communication, surrounding infrastructure, and decision-making processes in China (Schnepp, von Glinow, and Bhambri 1990). In the three specific cases of Shanghai GM, Chang’An Ford, and Beijing Jeep, U.S. firms dismissed all such barriers as mere business challenges that have been readily overcome with a little effort and creativity. The complexity of the technology-transfer process itself is another barrier that seems compelling, but there was no evidence that any of the joint ventures had trouble with the actual process of transferring technology.

The two most effective incentives identified by this study for the deployment of cleaner automotive technology through technology transfer are: (1) Chinese policies that set performance standards for automobiles; and (2) market competition. These findings support the results of another study that concluded, “whether a country imports

26 The IPCC does not seem to disagree. It advocates taking a country-by-country approach to identifying, analyzing, and prioritizing the particular barriers to technology transfer. They argue that it is “important to tailor action to the specific barriers, interests, and influences of different stakeholders in order to develop policy tools” (Metz et al. 2000, 19).
equipment to lower pollution depends upon the strength of environmental regulations” (Lanjouw and Mody 1996, 566). When the Chinese government issued its first emissions-control policy in 2000, U.S. firms immediately responded by transferring the requisite emissions-control technologies to their joint ventures in China. The increasing market competition during the late 1990s, initially sparked by GM’s introduction of the Buick New Century sedan (and later China’s entry into the WTO), provoked the introduction of many relatively modern automobile technologies (such as the VW Passat, VW Polo, and the Toyota Xiali 2000). As GM China’s CEO remarked, “Shanghai GM had to both improve its product and lower price a little because of increased competition” (Murtaugh 2002).

7.6 LIMITS TO LEAPFROGGING AND HOW TO OVERCOME THEM

The evidence from this study indicates that there may be numerous practical limits to leapfrogging to substantially cleaner vehicles through technology transfer, depending on how leapfrogging is defined. Once these constraints are identified, strategies for how to overcome the limits can be devised. This section will explore the limits to leapfrogging and offer some options for how they could be overcome.

Goldemberg was one of the first analysts to write about the potential of leapfrogging as it pertains to energy and environmental issues. He wrote:

Developing countries have a fundamental choice: they can mimic the industrialized nations, and go through an economic development phase that is dirty, wasteful, and creates an enormous legacy of environmental

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27 In their study, “Importing firms cited environmental regulation as the primary motivating consideration, and exporters said that demand was low in countries that lacked sufficient regulation to require such technology” (Lanjouw and Mody 1996, 566).
pollution; or they can leapfrog over some of the steps originally followed by industrialized countries, and incorporate currently-available modern and efficient technologies into their development process (Goldemberg 1998).

This insight is tremendously attractive because it reasonably assumes that if the advanced, cleaner technologies exist, they can be transferred to, and deployed in, developing countries.

This research shows that China’s ability to “leapfrog” to substantially cleaner automobiles, using a strategy of knowledge acquisition through technology transfer from foreign firms, may actually be quite constrained. This discovery does not mean that the Chinese should not try to leapfrog to cleaner automobiles. Indeed, a primary motivation for this study was to determine how foreign firms could help China deploy the cleaner technologies that they developed in recent years. The caution being offered here, based on the findings of this study, is that leapfrogging through technology transfer from foreign firms could be challenging, but not impossible, for the Chinese auto industry.

First, the term, “leapfrogging,” must be defined in the context of the automobile industry in China. There are two kinds of leapfrogging that are most relevant to this analysis: (1) leapfrogging by skipping over generations of technologies; and, (2) not only skipping over generations, but also leaping further ahead to become the technological leader. An example of the first kind of leapfrogging is the widespread adoption of cellular phones in China because the Chinese essentially skipped over wire-based communications technology to a wireless network. An example of the second kind of leapfrogging is illustrated by the performance of the Korean steel industry, which not

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28 Limits to leapfrogging to cleaner energy technologies have also been identified in East Africa, where the social conditions and economic realities of rural life limit the capacities of rural households to absorb new technologies (Murphy 2001).
only leapfrogged up to, but also eventually surpassed, the former top producers of steel to become one of the technological leaders of this industry.

There are two other kinds of technical change that are not exactly “leapfrogging” but could result in the deployment of substantially cleaner automotive technologies in developing countries: (1) encouraging the use of the cleanest technologies available, even if they do not necessarily require skipping generations of technologies; and/or (2) deliberately choosing not to adopt dirtier technologies. For example, if the Chinese government decided to only encourage the use of highly-efficient, gasoline-fueled cars, and to prohibit the use of large, “gas-guzzling” vehicles such as most sport utility vehicles (SUVs) for passenger car use, substantially cleaner automobiles could be deployed. Another example of cleaner technological change is the Brazilian adoption of ethanol-fueled vehicles and related imposition of disincentives for conventional gasoline-fueled automobiles. This adoption of cleaner technologies resulted in the avoidance of 9.45 million tons of carbon per year, corresponding to 18 percent of all carbon emissions in Brazil (Goldemberg 1998).

Thus, technological change through adoption of incrementally cleaner technologies may be sufficient to achieve the goal of cleaner-vehicle deployment without leapfrogging – especially as a near-term, interim strategy. Just as the combined effect of many incremental innovations is “extremely important in the growth of productivity” (Freeman 1992, 194), incremental technological improvements can also be a major

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29 The Brazilian government purchased a guaranteed amount of ethanol through the state-owned oil company PETROBRAS, provided economic incentives for industries to produce ethanol (such as offering low interest rates and US$20 billion in loans (nominal dollars) to reach current installed capacity, and, most importantly, set the price of gasoline at twice the price of gasoline in the United States to create a strong disincentive for the consumption of gasoline. (Moriera and Goldemberg 1999) Also, it should be noted that Goldemberg considers the ethanol example to be one of leapfrogging.

30 I did not attempt to study whether alcohol derived from sugar-cane would be an effective strategy for China.
source of gains in environmental quality. But to achieve the deployment of unequivocally clean vehicles, a new techno-economic paradigm will likely be required.

In a useful typology of technological innovation, four kinds of technological change are specified (Freeman 1992):

- **incremental innovations** – usually occur virtually continuously as industries try to improve quality, design, performance, and adaptability;
- **radical innovations** – discontinuous inventions that are usually the result of deliberate research and development that lead to a radical departure from previous production practice (such as Schumpeter’s example of stage coaches to railways);
- **changes of technological systems** – far-reaching changes in technology as a result of a cluster of radical innovations that affect several branches of an economy
- **changes of techno-economic paradigm** – those technological systems that affect directly or indirectly every other branch of the entire economy (such as the information and communication technology revolution)

In the clean vehicle context, what kind of technological change is leapfrogging?

The answer to this question depends on the technology. Some, including China’s Ministry of Science & Technology (MOST), believe that the technologies that China should consider adopting are hybrid-electric or fuel-cell vehicles (Christenson 1997; Conte, Iacobazzi, Ronchetti, and Vellone 2001; Burns, McCormick, and Borroni-Bird 2002). Do hybrid-electric and fuel-cell vehicles represent incremental or radical technological changes? Would they require leapfrogging? Commercially-available hybrid-electric vehicles contain both a conventional gasoline engine and a battery-driven electric motor, and the two are used interchangeably when the automobile is in operation. At times, the gasoline engine is used, and at times the electric motor is used. The fuel savings are mostly derived from utilizing clean, more efficient electric motors in stop-and-go urban driving, capturing wasted energy from braking, converting it into electricity, and storing it for later use by the electric drive motor in a battery. Hybrid-
electric vehicles vary in the degree to which they actually utilize the electric motor, but all hybrids take advantage of the main innovation – the combined use of electric and gasoline motors together to power the automobile (even though both kinds of motors have been in use separately for decades). So, hybrid-electric automobiles are based, at least in part, on accumulated and incremental technological development, but the integration of the vehicle system is a radical innovation. Therefore, hybrid-electric vehicles can be considered a new generation of passenger cars.

Fuel-cell vehicles (FCVs) are still in the research and development stage, and are not available commercially yet. This kind of automobile also uses an electric motor, but it abandons the gasoline-fueled engine entirely. Instead, fuel-cell vehicles use hydrogen as a fuel, and the hydrogen passes through a fuel cell to produce electricity, which runs an electric-drive motor. Again, FCVs can be considered, in part, the result of evolutionary or incremental technological change because many key components, such as electric motors and the fuel cells themselves, are not new inventions. Like the hybrid-electric vehicle, the fuel-cell vehicle could be considered a radical innovation, however, because the electric motor and fuel cell are combined as a system for the first time for use in automobiles. Thus, fuel-cell vehicles could also be considered a new generation of passenger cars. Adopting either technology would thus require leapfrogging in the sense of skipping generations of technologies, but not necessarily in the sense of becoming technological leaders. Depending on how the hydrogen is generated, fuel-cell vehicles might require changes to the technological system because new energy generation and distribution networks might be required. It is also conceivable that the clustering of these technological changes could bring about a new techno-economic paradigm if innovations
in the energy supply sector profound affected the entire economy, similar to how the discovery of cheap and plentiful oil enabled the mass production of automobiles and many other products.

7.6.1 Limits to Leapfrogging

This dissertation evaluates the efficacy of past technology transfer from U.S. to Chinese firms in the automobile industry. The question is, which lessons from this analysis can be applied to possible leapfrogging in the Chinese automobile industry? Although all of the automobiles transferred from the United States to China from 1983-2002 contained conventional internal-combustion gasoline engines, the resulting modernization effect can be considered a leapfrog-type change for China. Between 1960, the year of the Sino-Soviet split, and China’s re-opening to the world during the late 1970s, automotive technology did not evolve at all within China. In the United States, however, automotive technology evolved significantly, especially due to the introduction of front-wheel drive and the computerization of many control technologies. Therefore, the foreign auto technology that was transferred to China beginning in 1983 effectively allowed China to skip over about twenty years of automotive technological development to a new generation of automobile technologies.

Therefore, to the extent that China decides to skip to incrementally cleaner generations of technology through technology transfer, the findings from this analysis of China’s past experience should apply. In addition, the findings would apply to decisions to adopt incrementally cleaner conventional technologies and/or avoiding dirty conventional technologies.
With these caveats, one can conclude that it will be difficult for China to skip to cleaner technologies such as hybrid-electric or fuel cell vehicles for a number of reasons. The costs of such automobiles (especially fuel cell vehicles) are still substantially higher than conventional automobiles, and they would initially be prohibitive for the average price-sensitive Chinese consumer until large economies of scale have been reached. Also, it is unlikely that the foreign firms will want to transfer technology that they consider to be at the cutting-edge because of concerns about intellectual property rights, U.S. investment in such technologies has been substantial, and financial bottom-line concerns will always influence corporate decisions to transfer technologies. This study showed that intellectual property rights have not been a big concern for the U.S. firms in China so far, but U.S. firms have not yet been asked to transfer revolutionary technologies. Chinese capabilities are still far enough behind, moreover, that they do not currently threaten foreign firms.

If technological capabilities for innovation are acquired gradually through learning-by-doing, then greater investments need to be made in China to improve the basic capabilities in production, adaptation, engineering, parts and components, and project execution, so that knowledge can be acquired for how to shift to advanced-automobile production. If China tries to skip to the world’s technological frontier without assimilating enough knowledge about the conventional technologies upon which many of the advanced technologies are based, China may fail to effectively leapfrog to clean technologies. As one study notes, “In establishing new production units, there is a

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31 The Ministry of Science & Technology in China is trying to demonstrate the feasibility of battery electric vehicles in its electric-vehicle demonstration project in Shantou, Guangdong Province. The advantage to electric vehicles is that China could avoid importing large quantities of oil for use in motor vehicles if it could power vehicles with coal-generated electricity.
32 But, niche markets could be exploited.
tendency in developing countries to go for the latest technology – presumably to get on an equal footing with developed countries. . . .There is a danger, too, that selecting technology on or very near the frontier (without understanding how or why it works) can lock firms into a situation of continuously receding from that frontier as it advances” (Dahlman, Ross-Larson, and Westphal 1987, 764). Foreign firms need to have compelling incentives to transfer any technologies not demanded by the market. In other words, the Chinese government would have to create a comprehensive system of incentives and penalties to elicit clean automobile technology transfer, and China has not done so yet. As was shown in Chapter 3, without fail, the Chinese government has been highly inconsistent in its policy for the sector and the development of related technological capabilities.

When considering whether China could skip to these advanced technologies without technology transfer from abroad, a number of different challenges come to mind. By many accounts, Chinese automotive technological capabilities still lag far behind the world-level, so it is hard to imagine China being able to catch up in conventional technologies alone, much less imagine them leapfrogging to these more advanced clean automotive technologies without foreign technology transfer. In terms of annual production, the Chinese automobile industry is still decades behind the U.S. auto industry. Current U.S. annual production of passenger cars is more than 12 times greater than current annual Chinese production, and even as early as 1960, annual U.S. production was nearly 8 times greater than current Chinese production (Bureau of Transportation Statistics 2002).\textsuperscript{33} The unusually large number of Chinese automobile

\textsuperscript{33} Includes trucks under 10,000 pounds gross vehicle weight rating (GVWR) such as compact and conventional pick-ups, sport utility vehicles, minivans, vans, trucks and buses over 10,000 pounds GVWR.
firms also indicates that there is a need for more consolidation within the Chinese auto industry to achieve substantial economies of scale. In 1914, there were more than 100 automobile manufacturers producing cars in the United States, just as there are currently more than 100 automobile manufacturers producing cars in China (Womack, Jones, and Roos 1991).  

Another problem is that government, academic, and firm-based R&D programs for vehicles in China are still very small and not well connected to each other, so the general development of technological capabilities in China continues to be slow. Finally, the nature of the technological capabilities that would be required could be a real challenge for Chinese engineers because both hybrid-electric and fuel-cell vehicles require the capacity to integrate all the systems within an automobile, and this is perhaps the hardest type of capability to acquire (Chan 2002; Frosch 2003).

The question of whether China can become the technological leader in these advanced automotive technologies is even more problematic, and it cannot be readily answered based on the findings of this study. One relevant finding, however, is that U.S. auto manufacturers have transferred products, but not much knowledge, to China. Based on this finding, it seems more likely that U.S. firms might help China to skip generations of technology through product transfer rather than knowledge transfer. In other words, there is no evidence so far that U.S. firms will teach their Chinese counterparts how to develop and manufacture advanced, clean automobiles. It would not be surprising if the U.S. firms were reluctant to spawn future competitors in the world market. Moreover, the current high-reliance on foreign direct investment in the Chinese auto industry may

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34 The authors note that by 1924, however, the number of manufacturers had been reduced to about a dozen, of which Ford, GM, and Chrysler accounted for 90 percent of all sales.
reduce China’s incentive to innovate domestically. So long as China can acquire reasonably modern products through its joint ventures with foreign firms, it has little incentive to invest in its own capabilities unless the Chinese government or industry becomes really determined to make China a world leader in automotive technology.

There are also market-related problems influencing leapfrogging that China would have to overcome. First, because the market is not likely to produce the incentive to leapfrog to cleaner vehicles, the Chinese government would have to intervene. When intervening, the government might be tempted to choose the technologies to which it would ask firms to leapfrog, and governments do not always make the right choices in technology, as seen, for example, in the U.S. case of the Synfuels project (PCAST 1997). In another example, the U.S. State of California mandated that a certain percentage of vehicles sold there had to be zero-emission electric vehicles (ZEVs). As automakers tried to comply with this law, it became clear that there were many advantages to hybrid-electric vehicles over electric vehicles, but there was no provision in California’s zero-emission vehicle program for hybrid-electric vehicles.\(^{35}\) This hindered the more rapid development and deployment of hybrid vehicles in the United States. While, hybrid-electric or fuel-cell vehicles may seem like the right technologies to aim for today, it is hard to say for sure. In the case of mobile phones in China, the cost and market incentives were all strong. There was substantial consumer demand, the technology was coveted by the Chinese government, the survival of existing players was not threatened, and the revenues of existing Chinese firms were actually enhanced by leapfrogging to mobile phones (de Meyer 2001).

\(^{35}\) In April 2003, the CARB modified its ZEV regulation to give auto manufacturers partial credit for AT-PZEVS (advanced technology partial ZEVs), including some gasoline-electric hybrid vehicles. (CARB 2003)
If China decides to leapfrog to hydrogen-fueled, fuel-cell vehicles, there is a problem with infrastructure. In the case of China’s adoption of cellular phones, the fact that China could avoid installing a costly wire-based infrastructure was a huge incentive for leapfrogging to a wireless network. The opposite would be true for fuel cell vehicles in China because an entire hydrogen infrastructure would have to be built.

7.6.2 Surmounting the Challenges

There is no single best practice that the Chinese government and firms could employ to enable China to leapfrog to the technological frontier of clean automobiles; a combination of government policies, regulations, and non-governmental initiatives is required. Leapfrogging to the frontier of clean automotive technologies may not be immediately necessary. The main lesson from this study is that it would take a coherent, concerted, consistent, and long-term effort of government, industry, and civil society cooperation to achieve such a goal. China’s failure to “catch up” with the world level in conventional automotive technological capabilities is not a result of some inherent inability to do so. When China tries hard to become a world leader in a given sector, it has shown that it is capable of achieving that goal. Consider that China plans to launch a manned rocket into space in 2003, that China has developed its own domestic nuclear power designs, and that it is about to launch its own nuclear-powered submarine. China’s failure to develop world-class automobiles can only be attributed to the conjecture that the Chinese government did not give the automotive sector the same concerted attention and resources as it gave the military and space sectors.
Turning to the question of whether or not it is necessary for China to “leapfrog” to the most advanced clean automotive technologies available, in the short to medium-term, a case might be made that China should concentrate on providing alternative transportation options and skipping to the most efficient, cost-effective, low-polluting commercially-viable automotive technologies available (including hybrid-electric vehicles). As the oil scenarios developed in Chapter 2 show, in a best-case scenario, total vehicular Chinese oil consumption could be contained to less than one million barrels per day of oil consumption in 2020, with related environmental and fuel-efficiency benefits. There is no reason that China needs to follow the practice of the United States with respect to fuel efficiency, which is essentially to delay the adoption of more stringent fuel efficiency standards in hope that a big technological “breakthrough” will eventually provide a magical solution. Repeatedly, U.S. policies have emphasized the longer-term potential of futuristic energy technologies rather than requiring manufacturers to continuously implement cleaner technologies. Fuel efficiency standards in the U.S. have not been tightened since 1980, but billions of dollars have been spent on public-private partnerships like the Partnership for a New Generation of vehicles or the current FreedomCAR program, with no widespread deployment of cleaner automobiles.36 There

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36 By the time PNGV was cancelled, the U.S. government had spent approximately US$1.25 billion, or US$250 million per year on average according to the U.S. General Accounting Office. DOE had provided half of the funding, NSF and the Dept. of Commerce together provided about 40 percent, and EPA and the Department of Transportation also funded about 10 percent. However, 45 percent of this funding reportedly was only indirectly relevant to its goals or was not coordinated through PNGV. (GAO 2000) Officials at DOE estimate that even though the need was approximately US$600 million per year, the peak annual allocation was only US$166 million, not including NSF money. (Wall and Yoshida 2002) Although only one estimate of industry spending has been made, it appears that industry could have spent much more than the federal government – and a far greater share of total investment than the program had envisioned. In the National Research Council’s sixth peer review of PNGV, they estimated that for FY1999 alone, the three companies together spent US$980 million dollars. Estimates of investments for each of the previous years were comparable. (NRC 2000) However, no detailed accounting of how this money was spent is provided in the NRC report, making it difficult to assess how much of the US$980 million was directly spent on PNGV research or whether some of this spending went to indirectly related projects.
is an idiom in the English language, “Don’t put all your eggs in one basket, but if you do, watch them carefully.” The United States has put all its eggs in one basket – futuristic automotive technologies – and not only has it ineffectually ‘watched this basket,’ but it has neglected the present-day production of automobiles. Meanwhile, the U.S. automobile manufacturers association claims that the fuel-efficiency of automobiles has improved, on average, about two-percent each year. Automakers have not used those fuel savings to improve fuel-efficiency. Instead, they have used the savings to increase vehicle weight, power, and the number of accessories. In contrast, the U.S. government continuously required automakers to reduce tailpipe emissions, and as a result, automobiles currently sold on the U.S. market emit remarkably few criteria air pollutants.

If China decides to go for the full leapfrogging strategy, it must approach the task comprehensively. China would need to improve its education system generally, and specifically the education of its automotive engineers. It would have to send its most promising workers overseas to study, and devise a strategy for luring those experts back to China to work in the industry. The Chinese government would have to promulgate policies to help foster a market demand for cleaner automobiles, such as raising the price of gasoline and implementing performance standards for air pollution and fuel efficiency that are continuously made more stringent over time. The Chinese government would have to force its domestic manufacturers to “learn by doing” increasingly on their own, without relying so heavily on the foreign manufacturers. And, China would probably have to start developing capabilities in clean vehicle components, such as automobile-scale fuel cells, until the Chinese producers acquire good enough system integration
capabilities to fully participate in the innovation process – from invention to deployment – extracting “first mover” profits from their brilliant innovations.

7.7 CONCLUSION

This study has documented that even though cleaner alternatives exist in the United States, relatively dirty automotive technologies have been transferred to China. In order for leapfrogging to significantly cleaner technologies in China to become a reality, either the foreign firms have to be compelled to transfer their cleaner technologies, or the Chinese firms have to develop their own capabilities for clean automobile development and production. There is little evidence that either alternative will happen soon unless policies are formulated and implemented to create the necessary incentives for the foreign and Chinese firms to change their past behavior. The implications for policy are considered next, in Chapter 8.
Chapter 8

IMPLICATIONS FOR POLICY, THEORY, AND FUTURE RESEARCH

The main question this research sought to illuminate is the extent to which technology transfer through foreign direct investment can serve as an effective mechanism for the deployment of cleaner technologies – particularly automotive technologies – in developing countries. This study addressed this question through empirical case studies of international technology transfer from U.S. automobile firms to their Chinese joint-venture partners. Examining this particular industry provides a critical test for successful technology transfer because the development of the automobile industry as an economic development strategy is a high priority for the Chinese government. Furthermore, this sector has the potential to become an important sector of the Chinese economy, to have significant environmental consequences for local and regional air pollution, and to contribute to global climate change. Joint ventures are particularly useful to study as they are the most tightly linked of commercial collaborations, in which technology transfer should have the greatest likelihood of succeeding.

The central finding of this dissertation is that during the time period studied (1982-2002), technology transfer did not help to deploy substantially cleaner automotive technologies in China for multiple reasons. Furthermore, Chinese firms did not acquire advanced innovative capabilities because U.S. firms did not transfer knowledge to their Chinese joint-venture partners along with the automotive products. With properly structured incentives, however, international technology transfer could be an effective tool for the deployment of cleaner automotive technologies in China.
There are three realms of policy where the nature and extent of technology transfer from the United States to China can be affected: U.S. policy, Chinese policy, and international policy. These realms overlap with each other because U.S. and Chinese policies can target domestic affairs, bi-lateral relations, and global governance. Presently, Chinese policy has the most short-term potential to affect technology transfer to China, but, in the longer term, U.S. and international policy could have an equally strong effect. If policy in each of the three realms was coordinated toward achieving the same goals, the effectiveness of technology transfer as a means of deploying cleaner technologies could be significantly enhanced. The United States and China are more likely to coordinate their policies when their interests are aligned. On the imperative to reduce oil consumption and minimize harm to the environment, the fundamental interests of the United States and China are the same. These mutual interests have not been fully explored, however, because short-term economic interests in both countries have thus far dominated policy decisions.

This concluding chapter first explores the implications of the earlier chapters and findings for U.S. policy, Chinese policy, and international policy. Then, the implications of the findings for theory are identified. Finally, recommendations for future research are proposed.

8.0 IMPLICATIONS FOR U.S. POLICY

The U.S. government presently has little influence over investment by U.S. firms in other countries. President Bill Clinton proposed creating environment and labor
standards for international trade and investment in 1994 (Barber 1994), but he failed to accomplish this goal during his administration. There is little current effort to push for such rules. There are three other means through which the U.S. government could promote the transfer of cleaner automotive technology from the United States to China. First, if U.S. clean-vehicle policies and programs provoke innovation and reductions in the costs of clean automotive technologies, they could be transferred to China. Second, the United States could pursue a more concerted strategy of bilateral energy and environmental cooperation with China. Third, the U.S. government could use its power in multilateral fora to support the creation of internationally recognized standards for the conduct of investment and trade-related activities, including establishing protections for human health, environment, and energy conservation. Each of these options will be further elaborated in turn.

China represents a huge potential source of demand for cleaner automotive technologies. Most of the growth in demand for automobiles is expected to come from rapidly growing industrializing countries, such as China. If the Chinese government sets increasingly stringent standards for pollution control and fuel-efficiency, then the demand for cleaner automotive technologies in China will be high. If these advanced technologies are invented in the United States, then U.S. firms are positioned to be the primary suppliers of cleaner technologies in the future. As of 2003, no U.S. firm had commercialized hybrid-electric or fuel cell vehicles (in contrast to Japanese firms). Thus, the U.S. automotive industry is starting to fall behind its competitors in Japan in the innovation of fuel-efficient technologies. On the other hand, U.S. firms are at the cutting-
edge for emission-control technologies. If U.S. firms invent and develop the best clean-vehicle technologies, they will be positioned to transfer the technologies to China – but, this study has shown that they will not necessarily do so without the appropriate incentives. Even though the U.S. Big Three automakers already possess advanced pollution-control technologies and install them into automobiles sold on the U.S. market, the firms have not transferred the best-available technologies to China.

Because China has become the world’s second-largest economy in purchasing-power-parity terms, it is easy to forget that it is still a developing country, home to millions of impoverished people. The U.S. government persists in denying foreign aid to China because it is a communist country. This policy fails to reflect important U.S. interests in China, such as poverty alleviation and environmental protection. The logic of this prohibition is also inconsistent with the extensive economic ties between the two countries. Firms in the United States trade heavily with Chinese firms, invest in China, and profit from business interests in China. As of 2001, China was the United States’ fourth largest trading partner (ITA 2003b). U.S. consumers greatly benefit from the lower prices of Chinese products. In January 2001, the U.S. Trade and Development Agency (TDA) was re-authorized to work in China after an 11-year prohibition. The United States Export-Import Bank also is allowed to work in China. In 1999, a memorandum of understanding was signed between the Ex-Im Bank, U.S. Department of Energy, China Development Bank, and China State Development Planning Commission to establish a program to encourage U.S. firms to speed the deployment of clean energy

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1 Innovation in cleaner technologies for all major multinational automobile firms was initially sparked by California’s strict regulations on pollution control and fuel efficiency (Van Vorst and George 1997). The U.S. federal government tends to lag behind California in terms of vehicular pollution control legislation, but once a regulation has proven to be feasible in California, the U.S. government often adopts the California rule.
technologies in China. This program originally offered China US$50 million in credit for renewable-energy projects, and the financing was later expanded to US$100 million for both renewable-energy and energy-efficiency projects. This program has not been heavily utilized. If the TDA and Ex-Im can be authorized to work in China, foreign aid for the protection of human health and the environment should be allowed too.

As a practical matter, it is in the U.S. national interest to give monetary aid and technical assistance to China for energy- and environment-related causes for two reasons. This study showed in Chapter 2 that it is entirely possible that within two decades, China could import as much oil for transportation consumption as the United States currently imports today. If that were the case, world oil prices would certainly rise in response to this large new source of demand, with likely harm to the U.S. economy. This study has also shown that Chinese passenger cars could also be a major source of greenhouse emissions from motor vehicles within two decades, just as U.S. passenger cars currently are today. There is an opportunity to help China avoid emitting large quantities of greenhouse gases by transferring cleaner, more efficient technologies to China, and this would be in the U.S. interest because global climate change is likely to adversely affect the United States in a number of ways (Watson 2001). At the same time, the United States should also improve its own fuel-efficiency and reduce its own greenhouse-gas emissions (just as it has done with respect to reducing criteria air pollution from automobiles) so that it has more international credibility.

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2 Once carbon dioxide is emitted, it has a half life in the atmosphere of the order of one hundred years, so releases of greenhouse gases cannot be readily reversed. Carbon dioxide can be absorbed in plants and oceans, and this process is known as carbon sequestration. According to the Intergovernmental Panel on Climate Change, it is not clear how much carbon can be absorbed by these sources (Watson 2001). Therefore, it is preferable to prevent emissions of greenhouse gases wherever possible.
Aside from increasing foreign aid, the U.S. could also work more cooperatively with China on a bilateral basis to create the incentives for clean technology transfer. There is a decades-long history of U.S.-China energy cooperation, dating back to 1979 when Deng Xiaoping and Jimmy Carter signed the Agreement on Cooperation in Science and Technology. There are now 30 protocols to this agreement, many of which cover energy and environment-related topics. Two of the most relevant protocols to this research are the Protocol on Cooperation in the Field of Fossil Energy, and the Protocol on Cooperation in the Fields of Energy Efficiency and Renewable Energy Development and Utilization. The latter agreement has many annexes, one of which is devoted to electric and hybrid-electric vehicles. Very little progress has been made on the implementation of this annex, so this is an area ripe for greater attention. For example, the two governments could initiate and support scholarly exchanges, the collection and dissemination of clean vehicle-related data, and the study of mechanisms to facilitate the deployment of cleaner automotive technologies in both countries.

In a different realm of bilateral relations, that of trade and investment policy, the United States government has both facilitated and inhibited technology transfer to China. It facilitated technology transfer by pushing the Chinese government to create the conditions to encourage foreign direct investment, such as better protections for intellectual property rights. On the other hand, as described in Chapter 3, the U.S. government insisted that China not place any performance requirements, such as technology transfer, on foreign investors during the PNTR negotiations.

Finally, the United States could use its power in multilateral economic forums to create incentives for cleaner-technology transfer. It could ratify the Kyoto Protocol on
global climate change to demonstrate a commitment to multilateral solutions for global environmental problems. Even if the United States wants to amend the Kyoto Protocol, ratifying it would demonstrate real commitment to reducing greenhouse-gas emissions around the world, and provide a legitimate way to do so. Also, the United States would show determination to be a leader in finding solutions to the problem of climate change.

The U.S. government could also help devise an international agreement on investment that sets minimum standards for environmental performance, fuel efficiency, and the protection of human health. In trade agreements, the United States could support provisions to allow developing countries to enact domestic laws to protect the environment and human health without fear of retribution from any country or foreign firm. In recent years, the U.S. government has typically not supported such provisions. For example, Chapter 11 of the North American Free Trade Agreement (NAFTA) was written to provide protections for foreign investors from expropriations, but this provision subsequently has been appropriated by industry to subvert environmental regulations. Some companies have filed lawsuits against NAFTA governments over the enactment of environmental laws, arguing that these laws are tantamount to expropriation because the costs of compliance are so high. Naturally, such lawsuits can have a chilling effect on the passage of new environmental laws. As of March 2001, 10 cases had been brought by companies against new environmental and natural resource management laws of the three NAFTA states (IISD & WWF 2001). There have yet to be any rulings on these cases, but the effect has been to chill introduction of new environmental requirements.
8.1 IMPLICATIONS FOR CHINESE POLICY

Chinese government regulations are the most direct incentive for cleaner technology transfer to China. This study showed that when the Chinese government passed the first tailpipe emissions standards for automobiles in China, the U.S. joint-venture partners immediately transferred the requisite pollution-control technologies to bring their products into compliance with Chinese regulations. As noted in Chapter 7, representatives from all three of the U.S. manufacturers said in interviews that if the Chinese government passed a more stringent environmental law, the joint venture would certainly find a way to comply. Current Chinese environmental laws are not providing sufficiently strong incentives to provoke the transfer of the most appropriate, cost-effective, and cleaner automotive technologies. Not only are more aggressive Chinese emission and fuel-efficiency standards needed to elicit cleaner technology transfer, but these standards must also be implemented consistently and enforced vigorously. The lack of a strong inspection and maintenance regime in China appears to permit non-compliance with automotive emission standards. Another reason why performance standards need to be set, maintained, and scheduled into the future, is that they provide a rationale for Chinese firms to ask for cleaner technologies from their foreign partners.

The absence of any Chinese fuel-efficiency policies or standards is causing China’s oil imports for motor vehicle consumption to increase rapidly. Although U.S. manufacturers would probably protest the implementation of new fuel-efficiency standards in China (as they historically have done in the United States), the record clearly shows that when the U.S. government passed fuel-efficiency standards, the manufacturers
found ways to comply. The Chinese government could spur more demand for fuel-efficient automobiles among consumers by increasing the price of gasoline in China (perhaps through a carbon tax, which would have the added benefit of reducing greenhouse-gas emissions), an initiative that the U.S. government has failed to undertake thus far. The Chinese government has approved the imposition of a fuel tax in principle, but it has not yet implemented this tax (People's Daily 2003b). It is almost inconceivable that U.S. firms would flout such regulations because it would be embarrassing for the U.S. companies to fail to meet Chinese laws. Such regulations would create clear incentives to transfer cleaner automotive technologies to China.

A second method for creating incentives for cleaner technology transfer is through the Chinese government’s education policies and government-sponsored R&D programs. It has been confirmed that, comprehensive educational systems play major roles in the assimilation of industrial knowledge (Rosenberg and Frischtak 1985; Sharif 1989). Innovative, capable workers need to be fostered through the education system generally, and then specialized workers need to be given the opportunity to learn-by-doing. The most promising automotive engineers need to be sent overseas for training, and then lured back to China to work in the industry. In the case of Korea, for example, it was the government’s large investments in human resource development that facilitated Korea’s ability to acquire technological capabilities rapidly (Kim and Dahlman 1992). As one analyst notes, “Without adequate human capital or investments in R&D, spillovers from FDI may simply be infeasible” (Saggi 2002, 229). Such public

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3 Revenues from such a tax could be used to enforce the environment and health-related standards and regulations, for additional research and development on cleaner technologies, and for developing additional technological capacity for clean deployment.
investments would not only strengthen Chinese capabilities, but would also increase the bargaining power of Chinese firms at the negotiating table with their foreign partners.

If Chinese automotive engineers are innovative and capable of automotive design, the need of the Chinese automobile firms for their foreign partners will slacken. The Chinese Ministry of Science & Technology (MOST) has demonstrated great vision and determination to develop and deploy cleaner vehicles in China with its “863” high-tech research program on electric, hybrid-electric, and fuel cell vehicles. Enhancing the resources of this program, and continually working to improve it, will only fortify Chinese capabilities for cleaner automotive production in the future. Along with government-sponsored R&D, the Chinese government could also create incentives for the Chinese firms to become less reliant on foreign technology, and more innovative in their own right.

So far, market competition is proving to be a “double-edged sword” for China in the automobile sector. In many respects, the Chinese government’s decision to lower trade barriers and foster increased competition in the domestic market should be credited with helping to modernize the industry. As demand for better automobiles soared in the 1990s, certain foreign manufacturers such as General Motors began to introduce newer, more attractive, models into China, and this provoked the other foreign manufacturers to do the same. None of the newer models, however, came with the best-available, advanced, pollution-control technology for the reasons discussed in this study. Purely domestic Chinese manufacturers have been severely challenged by this competition. Some, like SAIC-Chery, have responded to the competitive challenge, and are beginning to produce automobiles that are competitive within the Chinese market (but are not yet
export-quality). Other Chinese firms are failing, and when they fail, jobs are lost, with all the related social repercussions.

Aside from issuing better performance standards for emissions control and fuel efficiency, the Chinese government should also assess its industrial policy for the auto sector. Because of China’s many concessions to gain entry to the WTO, it is now prohibited from using many of its former tools for industrial development. During the 1980s, the lack of a well-defined policy for the automotive sector caused continued Chinese reliance on foreign technology. Once the Chinese government articulated an industrial policy in 1994, much more progress was made in acquiring better technological capabilities. Now that China has become a member of the WTO, it must consider which policy tools remain at its disposal for the cultivation of knowledge-based assets that will contribute to the future development of the industry. Such assets – the skills necessary to create new products or processes (Amsden 2001) – are essential for the further development of China’s automobile industry.

8.2 IMPLICATIONS FOR INTERNATIONAL POLICY

The evidence from this study indicates that in the absence of any international rules, Chinese domestic policies will most strongly affect the nature and extent of international technology transfer through foreign direct investment. On the other hand, if international rules were established, they could accomplish the same goal of provoking technology transfer for cleaner vehicles if the rules harmonized performance standards globally.
Presently, there are very few international rules or policies that govern foreign direct investment. The Trade-Related Investment Measures (TRIMS) agreement of the WTO only governs investment as it pertains to non-discriminatory trade. For example, TRIMS prohibits local content requirements because they are viewed by the WTO as discriminating against products that do not contain local products. The one significant and historic attempt to create an international accord on investment was the OECD effort to devise a Multilateral Agreement on Investment (MAI). Because the draft MAI was tilted so strongly to serve the interests of the investors (not the recipients of the investment), it was widely criticized and eventually abandoned. The OECD has since created the more sensitive Voluntary Guidelines for Multinational Enterprises that better take into account the interests of the recipient country, but these guidelines are not binding. In September 2003, the WTO is scheduled to begin discussing whether to launch negotiations within the institution of the WTO regarding foreign investment. Until 2003, WTO members limited themselves to organizing a working group in 1996 to study the relationship between trade and investment. Any new trade and investment agreements would need to allow developing countries, including China, to have some degree of latitude to create incentives for technology transfer. As one noted development economist argues, “Poor countries need the space to follow developmental policies that richer countries no longer require” (Rodrik 2001, 29).\footnote{Rodrik does not specifically endorse any specific policies, such as policies to provoke technology transfer, at this point in his article. He simply writes, “For example, poor countries might be allowed to subsidize industrial activities (and indirectly their exports) when this is part of a broadly supported development strategy aimed at stimulating technological capabilities” (Rodrik 2001, 31).}

Weaker environmental standards theoretically can give a country comparative advantage if the costs of compliance to meet the standards are high. There is no
evidence, however, that U.S. or other foreign firms decided to invest in China’s automobile industry because of China’s relatively weaker environmental standards. Even so, U.S. firms have not transferred pollution-control technology to China that is nearly as clean as the technology that they install in cars sold in the United States. The Chinese government has not imposed special rules on the foreign-invested joint ventures, even though those firms could easily transfer cleaner automotive technologies to their counterparts in China. If foreign investors were subject to international rules about environmental performance, then they might be more inclined to transfer cleaner automotive technology to China.

A number of analysts have supported the notion of establishing minimum standards for foreign investment for environmental performance (French 1998; Zarsky 1999a). According to Zarsky, these rules should cover both micro-level investor responsibilities, and also macro-level sustainability objectives. The establishment of minimum standards for environmental performance is an attractive idea because it would provide clear environmental rules for all investors, eliminate the potential comparative advantage that would derive from having lower standards, and reduce the potential for pollution havens in developing countries. Of course, individual countries should be allowed to set tighter standards if they wish to suit their particular needs and circumstances. Subsequent to the creation of minimum standards, however, countries might relax their own more stringent standards to the minimum level required internationally, which might cause an increase in pollution. Another concern is that individual countries might get “trapped in the mainstream,” unable or unwilling to go beyond the international standard for political or economic reasons, even if there was a
local need for more stringent standards. Some of the environmental challenges facing
the world today require bold and courageous policy solutions, which minimum
performance standards might not achieve. Yet, if standards were designed to achieve a
social (i.e. environmental or human health) goal, and they were regularly reviewed and
revised upward, they could be effective. For example, if a performance standard for
carbon dioxide was set, but emissions of carbon dioxide from motor vehicles continued to
rise unabated, the standard might have to be tightened. The European Union has devised
a set of pollution standards that roll forward as the most polluting sources are dropped,
and the average performance continuously improves. Zarsky argues that such rules
should govern all investment, not just foreign investment, so that there is no
discrimination against foreign investment.

Global rules for trade and investment should be formulated on a multilateral basis
in an open, inclusive, consensus-based process. International rules will only work if there
is widespread support for them. Otherwise, countries can just flout the rules without fear
of retribution.

Clearly, it is hard to measure and understand the effects of foreign direct
investment on environmental quality without good information or data. In China, for
example, no systematic and independent data are collected on the fuel efficiency of
automobiles, the emissions of different pollutants from automobiles, and the amount of
air pollution that is attributable to motor vehicles. Thus, it is very difficult to measure the
effects of foreign direct investment in China. International institutions can help to
standardize and collect this valuable information. Related to the need for better data
collection and dissemination, there is also a need for some basic corporate accountability
mechanisms for foreign investors (Zarsky 1999a). There is ample evidence that if local communities have access to information about the companies operating in their cities and towns, they can make better informed decisions about whether the firm is causing a problem that need to be remedied or not.

Of course, another way to affect business practices internationally is through multilateral environmental agreements. The most relevant one for this research is the Kyoto Protocol, as previously mentioned. China has already signed and ratified the Kyoto Protocol, but the United States has not. If the United States joins this regime, there are a number of mechanisms in the protocol to help both countries reduce their greenhouse gas emissions individually and cooperatively, such as the Clean Development Mechanism, Joint Implementation program, emissions trading, and common but coordinated policies and measures. An international carbon tax might be the most simple and economically-efficient method to reduce greenhouse gases (Schmidheiny 1992), although there are potential impediments to this policy.

8.3 IMPLICATIONS FOR THEORY

As discussed at length in Chapter 7, the findings of this study have several implications for theory. These implications are summarized here:

(1) There is little evidence in the case of U.S. technology transfer to the Chinese automobile industry for many of the leading hypotheses about the relationships between environmental policy, international trade, and foreign direct investment (including the pollution-haven, pollution-halo, race-to-the-bottom, and stuck-in-the-mud hypotheses).
(2) There appear to be some practical ‘limits to leapfrogging’ to substantially cleaner vehicle technologies through technology transfer from foreign firms in joint-venture arrangements. These barriers can be overcome through international investment rules, U.S. and Chinese policy, and the goodwill of foreign firms, but probably most effectively by Chinese regulations.

(3) If technology is defined to include knowledge, foreign direct investment is not automatically an effective mechanism for technology transfer. Although many discrete technologies were transferred, Chinese firms acquired little “how-to” tacit knowledge from their U.S. joint-venture partners. If Chinese firms are not acquiring more advanced technological capabilities through their partnerships with foreign firms, they are not accumulating knowledge-based assets, which are considered to be fundamental for strong economic development.

(4) Foreign direct investment is not automatically an effective mechanism for transferring cleaner technologies to developing countries. Proponents of FDI argue that along with the actual investment, FDI brings modern technologies, and cleaner products and practices. The evidence in the case of the Chinese auto industry is that U.S. FDI did not bring substantially cleaner automotive technologies to China until they were required by Chinese pollution-control regulations. As of 2003, none of the U.S. firms had transferred pollution-control technology to China comparable to what they produce in the United States.

(5) Although U.S. firms transferred slightly cleaner technologies to China, the huge growth in the number of automobiles on the road vastly outweighs the potential technological benefit of these cleaner technologies. This means that the “scale” effect of deploying so many more cars outweighs the “technique” effect of transferring slightly cleaner technologies.

(6) The role of the state in technology transfer for industrial development appears to be very important. Chinese policy (or at times, its lack thereof) strongly affected the nature and extent of technology transferred to China from U.S. firms.

(7) The most important incentives for cleaner automotive technology transfer in these cases were market competition and Chinese government regulations. The most inhibitory barriers to cleaner automotive technology transfer were the lack of Chinese pollution-control and fuel-efficiency regulations, poor fuel quality, weak bargaining from Chinese firms, a vicious circle related to domestic competitiveness (or a marriage of convenience between the Chinese government and foreign auto companies), and a politically-powerless environmental movement.
This dissertation provides the first study of firm-level technology transfer from the United States to China in the automobile industry. There are two obvious comparative studies that would complement this research. First, it would be interesting to compare U.S. automotive technology transfer to China with U.S. automotive technology transfer to other developing countries with relatively large automobile markets, such as India, Mexico, and Brazil. This comparative analysis would allow the barriers and incentives to cleaner automobile technology transfer that were identified by this study to be tested in other developing country contexts. Alternatively, U.S. automotive technology transfer to China could be compared with Japanese and European automotive technology transfer to China to test whether other foreign firms have transferred cleaner technologies to China than the U.S. firms, and why (or why not).

Although not a big focus in this dissertation, the apparent success of the Chinese automotive parts and components industry is intriguing because these Chinese supplier firms appear to have acquired more advanced capabilities than total-manufacturers in China. Why have the parts and components firms become more innovative than the big auto firms? My hypothesis is that Chinese government local content policies caused foreign firms to work with Chinese suppliers to bring their products up to specification, and so the foreign firms were forced to teach these suppliers. If this hypothesis is true, then the implications for Chinese policy are significant because the Chinese government just agreed to eliminate its local content policies in order to enter the WTO.
Another tantalizing question that arose during the course of this research was why U.S. firms were more interested in funding R&D activities at the Chinese universities rather than within their own joint ventures in China. Are the universities more innovative than firms in China? Does this practice indicate that U.S. firms trust university researchers more than they trust their manufacturing partners? What are the connections between Chinese universities and firms for technological innovation, and how could they be improved?

Finally, this dissertation provides a preliminary analysis about the barriers and incentives for China to leapfrog to cleaner technologies, such as hybrid-electric or fuel cell vehicles using a strategy of acquiring these technologies from foreign firms through technology transfer. A more detailed and comprehensive analysis of this topic is still warranted, especially to support the creation of policies that will facilitate this leapfrogging.
APPENDIX A: ACRONYMS

AMC  American Motor Corporation
BAIC  Beijing Automobile Industry Corporation
BJC  Beijing Jeep Corporation
CKD  complete knock-down kit
CATARC  China Automotive Research & Technology Center
Chang’An  Chang’An Automobile Group
CNG  compressed natural gas
CO₂  carbon dioxide
DMC  Dongfeng Motor Company (Dongfeng)
EIA  U.S. Energy Information Administration, U.S. Department of Energy
EURO I-IV  European air pollution emission standards, phases I-IV
FAW  First Auto Works
FCH  First Auto Works Hainan Motor Company
FDI  foreign direct investment
GM  General Motors
HC  hydrocarbons
IPCC  Intergovernmental Panel on Climate Change
LPG  liquefied petroleum gas
MAI  Multilateral Agreement on Investment
MFN  most-favored nation (trading status)
MOFTEC  China Ministry of Foreign Trade and Economic Cooperation
MOST  China Ministry of Science & Technology
NOₓ  Nitrogen oxides
OBD  on-board diagnostic system (for emissions)
OECD  Organization for Economic Cooperation and Development
OPEC  Organization of the Petroleum Exporting Countries
PATAc  Pan Asian Technology Center, joint venture between GM and SAIC
PNTR  Permanent Normal Trading Relations (between the U.S. and China)
R&D  research and development
RMB  Renmenbi (Chinese currency)
SGM  Shanghai GM
SAIC  Shanghai Automobile Industry Corporation (Shanghai)
SAW  Second Auto Works (now DMC)
SDPC  China State Development Planning Commission
SEPA  China State Environmental Protection Administration
SETC  China State Economic and Trade Commission
SO₂  Sulfur dioxide
SUV  Sport utility (all-terrain)
SVW  Shanghai VW
TAIC  Tianjin Automobile Industry Corporation (Tianjin)
TRIMS  Trade-Related Investment Measures, WTO agreement
VW  Volkswagen
WTO  World Trade Organization

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APPENDIX B: CHRONOLOGY OF EVENTS

1913

- Model T Fords are exported to China

1920’s

- GM Buicks begin to be exported to China
- Sun Yat-Sen writes to Henry Ford, asking him to help build an automotive industry in China
- Ford sets up a sales and service branch in Shanghai (1928)

1930’s

- One out of every six automobiles on the road are Buicks
- Japan invades China, beginning of Japanese-Chinese War (1937)

1947

- China becomes a founding member of the General Agreement on Tariffs and Trade (GATT)

1949

- People’s Republic of China founded

1949-1950

- Mao negotiates with Stalin for Sino-Soviet treaty of Friendship, Alliance and Mutual Assistance

1950

- First Taiwan Straits crisis
- Nationalists in China withdraw from the GATT; Communists contest the withdrawal
- Korean War begins
- U.S. imposes trade embargo on China once Korean War starts

1953

- China forms the first government oversight agency, the Automotive Industry Administrative Bureau, under the First Ministry of Machine Building.
• First Auto Works (FAW) established in Changchun
• Soviets transfer ZIS 150 light truck model to FAW, which became known as the Jiefang (liberation)

1958

• Great Leap Forward begins.
• Second Taiwan Straits crisis
• FAW produces its first passenger car, the Hongqi (Red Flag) black sedan, based on Daimler Benz’s 200 model
• Shanghai Automotive Assembly Plant (now Shanghai Automotive Industry Corporation -- SAIC) produces its first passenger car
• Chang’An Machine-Building Plant produces first all-terrain, using technology imported from the U.S.S.R.

1960

• Soviet withdraws all economic assistance
• Major famine in China through 1961

1963

• China produces a grand total of eleven cars

1964

• Third Front campaign launched, spurring establishment of many rural automobile factories, most notably the Shiyan Number Two Automobile Factory (known as Second Auto Works), now called Dongfeng Automobile Company (DAC)
• October 16, 1964, China explodes its first atom bomb

1965

• China National Automotive Industrial Corporation (CNAIC) is formed to oversee auto companies and coordinate planning for the industry.

1966

• Cultural Revolution launched
• Passenger car production ceases
• CNAIC is eliminated

1969
• China opens back up to the world
• U.S. National Security Advisor Henry Kissinger secretly flies to China to open up communication channels between the United States and China

1971

• Premier Zhou Enlai invites U.S. national ping pong team to Beijing to play against Chinese team
• United Nations admits the People’s Republic of China to its General Assembly after 22 years

1972

• President Richard Nixon flies to China to meet Chairman Mao Zedong, and they write the Shanghai Communiqué

1976

• Mao Zedong dies
• Cultural Revolution officially ends
• Downfall of Gang of Four

1978

• Law on Joint Ventures is promulgated in China, creating the initial framework for Foreign Direct Investment (FDI) in China.

1979

• Formal normalization of relations with the United States
• Jimmy Carter and Deng Xiaoping sign “Agreement on Cooperation in Science & Technology”

1980

• China applies for observer status at the GATT
• Chinese government imposes tight import restrictions on passenger cars

1982

• China is granted observer status at the GATT
• State Council re-instates the China National Automotive Industry Corporation (CNAIC)

1983
- Beijing Jeep joint venture established between American Motors Corporation (AMC) and Beijing Auto Works (BAW)

1984

- China officially permits the private ownership of s
- Shanghai VW joint venture established between Shanghai Automotive Industry Corp. and Volkswagen.
- Import restrictions are temporarily relaxed

1986

- Licensing agreement between Tianjin Automobile Xiali Company (TAIC) and Daihatsu for acquisition of Xiali car model (used as taxis in Beijing and other northern cities).
- China applies for full membership at the GATT
- State Council releases Provisions for the Encouragement of Foreign Investment (October 11)

1987

- CNAIC is designated an “association” and loses significant power

1988

- Top Chinese political leaders announce “Big Three, Little Three” industrial plan to consolidate the dozens of auto companies into six major firms.

1989

- Tiananmen Square massacre (June)
- Formal normalization between Russia and China negotiated by Deng Xiaoping and Mikhail Gorbachev
- Chinese government again imposes tight import restrictions

1990

- FAW-VW joint venture between First Auto Works and Volkswagen established
- Dongfeng Citroen joint venture between Dongfeng Auto Company (formerly Second Auto Works) and Citroen established
- CNAIC is re-instated as a “corporation” but its governmental authority is unclear

1991

- Eighth Five-Year Plan is published, designating the auto industry as a “pillar industry” (along with electronics, machine-building, and petrochemicals)
1992

- Guangzhou Peugeot joint venture established between Guangzhou Automotive Manufacturing Corp. and Peugeot
- Ford opens a representative office
- Jinbei GM joint venture established between FAW Jinbei Automotive Company and General Motors to produce light trucks
- Dongfeng Auto Co. and French company, Citroen, form US$800 million joint venture

1993

- Chang’An Suzuki joint venture established between Chang’An Auto Group and Suzuki Motor Corporation
- China becomes a net oil importer

1994

- New Automotive Industry Policy announced by State Planning Commission (February)
- GM China office opens in Beijing

1995

- Negotiations for Shanghai GM joint venture begin
- Ford establishes Ford Motor China Ltd.
- Jinbei GM closes down for four years

1997

- Shanghai GM joint venture between Shanghai Automotive Industry Corp. and General Motors established. Separately, the Pan Asia Technical Center is established between the same two firms
- Guangzhou Honda is established with Honda taking over the ownership of the foreign share in the joint venture with Guangzhou Automotive Manufacturing Corp., formerly held by Peugeot SA

1998

- Dongfeng Yueda-Kia established between Dongfeng Auto Company, Jiangsu Yueda Group, and Kia Motor of Korea

1999
• Regular production of Shanghai GM Buick New Century sedan begins (April)
• Negotiations on Permanent Normal Trading Relations (PNTR) status between the U.S. and China conclude (November)
• Jinbei GM re-established
• Jiangsu Nanya Auto Company, a joint venture between Yuejin Motor Corp. and Fiat Auto S.p.A is established in Nanjing
• China launches Clean Action program to deploy alternative-fueled vehicles
• China Ministry of Science & Technology (MOST) launches research program to develop electric vehicles in China and creates an electric demonstration project in City of Shantou.

2000

• General Motors donates five electric vehicles to MOST (September)
• U.S. Senate passes PNTR bill (September), paving the way for China to join the World Trade Organization. The PNTR agreement enters into force in October. PNTR specifies many changes for foreign direct investment in China and for policies governing the automotive sector in particular, including:
  • Phasing down tariffs on all vehicles to 25% by 2006
  • Phasing down tariffs on auto parts to 9.5% by 2006
  • Eliminating quotas by 2005
  • Opening auto financing market fully to foreign investors
  • Elimination of any export performance, trade, foreign exchange balancing, and prior experience requirements as criteria for trading rights
  • Elimination of conditions on investment including performance requirements, local content, export performance, technology transfer, offsets, foreign exchange balancing, or R&D
  • Abiding by the Trade-Related Investment Measures (TRIMS) agreement of the WTO
  • Elimination of all subsidies that are prohibited under WTO rules
• First Buick Sail is produced (December)
• Fengshen (Aeolus) Automotive Co. (also known as Guangzhou Nissan) is established as a joint venture between Dongfeng Auto Company, Jing’An Yunbao Motor Co. and Yulon Motor Company (a Taiwanese firm 25 percent owned by Nissan) to produce the Aeolus Bluebird
• China requires that all new cars produced in China must have a catalytic converter and meet EURO I emission standards. New cars in Beijing, Shanghai, and Chongqing have to meet EURO II standards.
• Leaded fuel is banned

2001

• Chang’An Ford joint venture is established between Chang’An Automotive Company and Ford Motor Co. in Chongqing (April)
- Chevy Blazer begins production at Jinbei GM (May)
- Buick Sail (compact car) begins regular production at Shanghai GM (June)
- First Auto Works and Mazda agree to start production at FAW Hainan Motor Co
- China becomes 143rd member of the World Trade Organization
- China’s Ministry of Science & Technology launches major R&D initiative in its “863” (High Tech) Program for the development and deployment of electric, hybrid-electric, and fuel-cell vehicles during the 10th Five Year Plan (2001-2005) period.

10th Five Year Plan for auto industry is released, setting the following goals for the industry by 2005:
- Total output of passenger cars shall reach 1.1 million
- Added value of entire motor vehicle industry (including trucks & motorcycles) shall reach US$15.72 billion (1% of GNP)
- Passenger cars will comprise 35 percent of total vehicle fleet mix
- Independent development capabilities will be strengthened
- Carburetor cars will be banned as well as those using CFC-12 air conditioners
- Formulate energy-efficiency rules for vehicles and issue stricter emission controls
- Formation of state-level R&D centers at major automotive enterprises that will receive preferential treatment
- Encourage further development of the auto parts and components industry

2002

- First Auto Works takes over Tianjin Automotive Xiali Co. and they sign a joint venture with Toyota
- Dongfeng and Nissan sign memorandum of understanding to form a new joint venture
- SAIC-Wuling-GM announce new joint venture to produce minibuses
- Beijing Hyundai joint venture established between Beijing Auto Industry Holding Company and Hyundai Motor Corp.
- SAIC invests in Daewoo with GM (first example of foreign direct investment by a Chinese automobile company) (October)
- China produces a million passenger cars for the first time in one year
- China permits two purely domestic firms to begin producing passenger cars – Geely Group in Zhejiang Province, and Brilliance Automotive in Shanghai

2003

- Shanghai GM buys new factory in Yantai, Shandong Province in order to double its capacity
## APPENDIX C: Sino-Foreign Joint Ventures in the Chinese Automobile Industry

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<tbody>
<tr>
<td>First Auto Works (FAW)</td>
<td>FAW-Volkswagen (Changchun, Jilin)</td>
<td>Volkswagen (1990-present)</td>
<td>$40 million, 40% VW, 60% FAW</td>
<td>Jetta (1996-) Bora (1.6L-1.8L) (2002-) Audi A6 (1.8L-2.8L) (1999-)</td>
<td>106,210</td>
<td>52,444</td>
<td>94,147</td>
</tr>
<tr>
<td>Shanghai Automotive Industry Corp. (SAIC)</td>
<td>Shanghai GM (Pudong,Shanghai)</td>
<td>General Motors (1997-present)</td>
<td>$1.2 billion with 50% SIAC, 50% GM</td>
<td>Buick Regal Sedan GLX, GL (1998-) Buick Sail and Sail RV (2001-)</td>
<td>36,894</td>
<td>17,801</td>
<td>58,328</td>
</tr>
<tr>
<td>Guangzhou Automotive Manufacturing</td>
<td>Guangzhou Honda (Guangzhou, Guangdong)</td>
<td>Honda (1997-present)*</td>
<td>n/a</td>
<td>Accord HGT7230 (2.0-3.0L) (1999-) Odyssey (2002-)</td>
<td>45,075</td>
<td>13,949</td>
<td>51,058</td>
</tr>
<tr>
<td>Chang’An Auto Group</td>
<td>Chang’an Suzuki (Chongqing)</td>
<td>Suzuki Motor Corp. (1993-present)</td>
<td>51% Chang’An, 35% Suzuki, 14% Nissho Iwai (Japan)</td>
<td>Gazelle (1.0L-1.3L) Alto (SC7080A and SC7101)</td>
<td>17,699</td>
<td>43,111</td>
<td>53,956</td>
</tr>
<tr>
<td>Dongfeng Auto Co. (DMC) and Jing’An Yunbao Motor Co. Corporation</td>
<td>Jiangsu Nanya Auto Co., Ltd. (Jing’an, Jiangsu)</td>
<td>Fiat Auto S.p.A. (1999-present)</td>
<td>50% Fiat, 50% Yuejin</td>
<td>Palio (2002-) Unico (2002-) Encore (2003-) Siena</td>
<td>13,914</td>
<td>9,175</td>
<td>9,175</td>
</tr>
<tr>
<td>FAW Jinbei Automotive</td>
<td>Jinbei GM (Shenyang, Liaoning)</td>
<td>General Motors (1992-1995, 1999-present)</td>
<td>50% FAW Jinbei, 50% GM</td>
<td>Chevy Blazer (2001-)</td>
<td>&lt;10,000</td>
<td>n/a</td>
<td>0</td>
</tr>
<tr>
<td>First Auto Works Car Co.</td>
<td>FAW Hainan Motor Co.</td>
<td>Mazda (Ford owns 33.4% of Mazda) (2001-present)</td>
<td>17.5% Mazda, 82.5% FAW</td>
<td>Familia (2002-) Premacy Minivan (2001-) Mazda 6 (2003-)</td>
<td>n/a</td>
<td>n/a</td>
<td>32,228</td>
</tr>
<tr>
<td>Jiangsu Yueda Group</td>
<td>Dongfeng Yueda-KIA (Jiangsu)</td>
<td>Kia Motor (1998-)</td>
<td>30% Jiangsu Yueda, 50% Kia, 20% Dongfeng (as of 2000)</td>
<td>Pride (2001-) Accent (2003-)</td>
<td>n/a</td>
<td>n/a</td>
<td>0</td>
</tr>
<tr>
<td>Beijing Automotive Industry Holding Corporation (BAIHC)</td>
<td>Beijing Hyundai Motor Co.</td>
<td>Hyundai Motors (2002-)</td>
<td>n/a</td>
<td>Sonata (2003-)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>First Auto Works (FAW) and Tianjin Auto Xiali Co.</td>
<td>FAW-Tianjin-Toyota (Changchun and Tianjin)</td>
<td>Toyota (2002-)</td>
<td>n/a</td>
<td>Starting 2003-2004</td>
<td>n/a</td>
<td>n/a</td>
<td>0</td>
</tr>
<tr>
<td>Chang’An Automobile Group</td>
<td>Changan Ford (Chongqing)</td>
<td>Ford Motor Co. (2001-present)</td>
<td>$98 million with 50% Chang’An, 50% Ford</td>
<td>Fiesta (2003-) Mondeo (2003-) Maverick SUV (anticipated 2003)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dongfeng Motor Co.</td>
<td>Dongfeng Nissan (Hubei)</td>
<td>Nissan (2003)</td>
<td>n/a</td>
<td>Nissan Sunny (2003-)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Compiled by Kelly Sims Gallagher, 2003
Data Source: China Automotive Research & Technology Center (various reports).
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