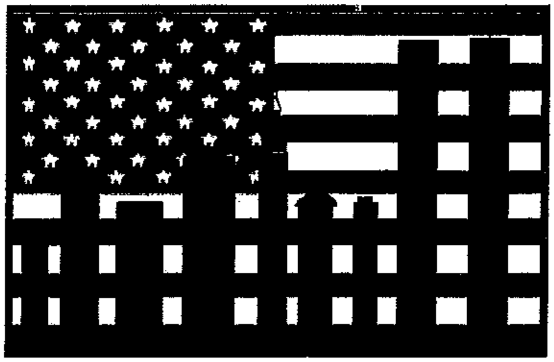

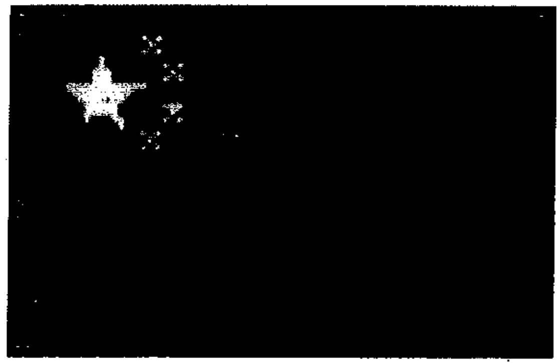

U.S. COMMERCIAL TECHNOLOGY TRANSFERS TO THE PEOPLE'S REPUBLIC OF CHINA

Office of Strategic Industries and Economic Security
Bureau of Export Administration

and

DFI International

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U.S. Commercial Technology Transfers to The People's Republic of China

A Report

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US COMMERCIAL TECHNOLOGY TRANSFERS TO THE PEOPLE'S REPUBLIC OF CHINA

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Acronyms

AEA	American Electronics Association
AECMA	European Association of Aerospace Industries
ATM	Automatic Teller Machine (Banking); Asynchronous Transfer Mode (Telecommunications)
AVIC	Aviation Industry of China
CAAC	Civil Administration of Aviation in China
CAS	Chinese Academy of Sciences
CDMA	Code Division Multiple Access
CICIR	China Institute for Contemporary International Relations
COCOM	Coordinating Committee for Multilateral Export Controls
COSTIND	Commission on Science, Technology, and Industry for National Defense
DOD	Department of Defense
EU	European Union
FDI	Foreign Direct Investment
GSD	General Services Department (PLA)
GSM	Global System for Mobile Communications
HTS	Harmonized Tariff Schedule
IC	Integrated Circuit
IPR	Intellectual Property Rights
ITI	Information Technology Industry Council
JV	Joint Venture
MEI	Ministry of Electronics Industry
MII	Ministry of Information Industry
MIPS	Million Instructions Per Second
MNC	Multinational Corporation
MOU	Memorandum of Understanding
MPT	Ministry of Posts & Telecommunications
MSS	Ministry of State Security
MTOPS	Millions of Theoretical Operations Per Second
NDU	National Defense University
NERC	National Engineering Research Center
NORINCO	China North Industries Co.
NSF	National Science Foundation
OTP	Office of Technology Policy
PC	Personal Computer
PLA	People's Liberation Army
PRC	People's Republic of China
PRCG	People's Republic of China Government
R&D	Research and Development
RMA	Revolution in Military Affairs
S&T	Science and Technology
SACI	State Administration of Import and Export Commodity Inspection
SEC	State Education Commission
SIA	Semiconductor Industry Association
SOE	State Owned Enterprise
SSTC	State Science and Technology Commission
UL	Underwriters Laboratories
UN	United Nations
US	United States
USG	United States Government
USTR	United States Trade Representative
VAT	Value Added Tax
WFOE	Wholly Foreign Owned Enterprise
WTEC	World Technology and Evaluation Council
WTO	World Trade Organization

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Foreword

The Bureau of Export Administration, through authorities delegated under the Defense Production Act and other statutes, has a mandate to study the US defense industrial and technology base and to develop and administer programs to ensure the continued economic health and competitiveness of industries that support US national security. BXA has from time to time heard allegations that US firms in high technology sectors are being "forced" to transfer technology as a condition of accessing the China market. However, the information that is available on this issue is limited and largely anecdotal.

This study is intended to expand the existing body of knowledge on the extent to which US firms are being pressured to transfer commercial technology as a condition of doing business in China. In addition, it examines the overall business and regulatory environment facing US high technology firms in China. The report does not, nor was it intended to, make any specific policy recommendations. It was also not our objective to uncover any illegal or illicit transfers or diversions of US technology to or within China. This report focuses largely on unlicenced or uncontrolled commercial technologies transferred as part of normal business interactions.

This report was prepared by DFI International for the Bureau of Export Administration under Contract No. FAR 16.207-1. DFI International is a consulting firm specializing in research, analysis, and advising senior executives in industry and government on issues of strategy, technology, and innovation. Bureau of Export Administration staff provided overall guidance and informational input throughout the course of the study, and participated in many of the Washington, DC area meetings.

The project was conducted between June 1997 and December 1997, with minor modifications, amendments, and updates performed in late 1998 to allow for publication. Except for a few key statistics or name changes, we did not attempt to update all of the information contained in the report.[1] *The report is based on numerous telephone interviews with industry and corporate representatives with experience or knowledge about US business practices in China. In addition, information was gathered through discussions with academic and government experts on China and international trade. Public sources, including press releases, media reports, and current academic literature on China's economic, industrial, and military modernization policies were used, as were trade statistics available from the US Census Bureau and the United Nations.*

The authors would like to thank Barry Blechman, Jay Korman, and Kevin O'Prey of DFI International and Brad Botwin, Margaret Cahill, Frank Carvalho, Will Fisher, Anne Kawachika, Ron Rolfe, Dan Seals and the entire Office of Strategic Industries and Economic Security of the Bureau of Export Administration for their invaluable assistance in this effort. Special thanks also to the Office of Technology Policy, Technology Administration, US Department of Commerce for their generosity and support. Thanks also to the International Trade Administration of the US Department of Commerce.

Portions of this report are expected to be included in a forthcoming report on China's science, technology, and innovation policies published by the Technology Administration's Office of Technology Policy.

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[1] References made to several of China's ministries have not been updated to their new designations following the National People's Congress of March 1998. For instance, China's State Science and Technology Commission (SSTC) is now the Ministry of Science and Technology (MST). Similarly, this report does not reference the new Ministry of Information Industry (MII), but uses the former names of the ministries – the Ministry of Posts and Telecommunications (MPT) and the Ministry of Electronics Industry (MEI) – that were merged as the new MII.

Executive Summary

The phenomenal economic growth witnessed in China since Deng Xiaoping first declared China's "Open Door" policy in 1978 has led many to predict China's certain emergence as an economic superpower in the early 21st Century. Indeed, China has followed a structured path toward gradual market reform of its still largely state-owned industrial sector, which has been transfused with increasing amounts of foreign capital and technology.

There have been numerous reports over the last several years, however, of US companies being "forced" to transfer technology to China in exchange for access to this enormous market. The purpose of this study is to assess the extent to which US commercial technology is being, in effect, "coerced" from US companies engaged in normal business practices and joint ventures in China in exchange for access to China's market. The cumulative effect these transfers may have on China's efforts to modernize its economy as well as its industrial and military base is also examined. Finally, this study addresses the impact of US technology transfers to China on the issues of long-term US global competitiveness and broad economic and national security interests.

PART 1: TECHNOLOGY TRANSFER - CHINESE POLICIES AND PROCESSES

The first section of this study addresses China's foreign investment and trade policies, regulations, and practices, which largely explain how and why US technology is being transferred to China. The answer lies in the underlying and stated objectives of China's foreign investment and trade policies, the goals of which are modernization and self-sufficiency of China's industrial and military sectors. The transfer of US and other Western technology plays an important role in these efforts. This section, therefore, describes China's policies regarding reform of its scientific and research and development institutions; China's ability to absorb, assimilate, and innovate transferred technology; as well as the emerging role of US high-tech firms in China's science, technology, and research efforts.

Key findings:

Science and Technology

- China's large-scale science and technology development plans and projects are dependent upon indigenous research and technological advances as well as foreign investment, research, and technology. Comparative analysis of China's rules and regulations regarding domestic and foreign investment in these and other state-run programs reveals discriminatory provisions regarding the rights and obligations of foreign partners. As a result, US companies currently engaged in collaborative research under the aegis of these state plans risk losing the monetary and technological gains from their investments.

Research and Development

- By 1993, more than half of China's large state-owned enterprises (SOEs) had established technical development centers, founded for the purpose of improving production efficiency as well as increased product quality and marketability. China's policies for industrial and commercial reforms continue to emphasize the need for cooperation among China's industrial, commercial, and research enterprises in an effort to bolster the revenues of China's state-owned enterprises and to modernize China's economy as a whole. This effort has achieved mixed results to date.

- In an effort to spur domestic technological innovation and to diffuse applied technologies across government, industry, scientific, and academic communities, China has established numerous National Engineering Research Centers (NERCs) across the country. These centers play a key role in China's strategy to reform its science and technology research system and are likely to become more prominent over time. The highly regarded Chinese Academy of Sciences (CAS) has also established over 500 commercial enterprises in the high-tech sector

as part of a government program to develop "technical enterprises" as subsidiaries of existing research institutes.

China's Ability to Absorb and Apply Technology

- China has no shortage of well-trained scientists, engineers, mathematicians, or other technical experts, unlike the United States. Chinese scholars educated abroad over the last decade reportedly make up more than half of the top scientific researchers now working on key research projects and receiving priority in conducting this research. As China's economic reforms continue and older researchers retire before the turn of the century, there will be more opportunities for China's younger, Western-educated, science and technology-minded researchers and engineers. As a result, high-tech firms in the United States and the government of the PRC are competing in some cases today for the services of these same talented individuals.

- China is increasingly attractive for highly skilled, Western-trained Chinese workers given the increased opportunities to work with US and other high-tech firms in China. This fact plus the benefits that accrue to the US firm as a result, make it likely that the trend toward US high-tech firms establishing joint ventures accompanied by R&D and training centers in China will continue for the foreseeable future.

Foreign Direct Investment

- China's investment policies are explicit in the type of foreign investment that is "prohibited," "permitted," or "encouraged," with the latter category focusing on advanced technologies. Foreign investors in high-tech industries enjoy preferential treatment, such as tax rebates and lower tariff rates as incentive to transfer technology, but are at the same time subject to regulations not imposed on domestic competitors.

- China's investment policies are geared toward shifting foreign investment into the central and Western parts of China. As this trend takes hold, US companies will have to carefully determine the end use or end-user of US high-tech, potentially dual-use goods. China's national laboratories and the majority of China's military/defense industrial enterprises are located in this region, some of which are involved in foreign joint ventures.

- The amount of FDI coming into China reached a peak of $111,436 million and 83,437 new contracts in 1993. The greatest growth has been in the number and value of joint venture contracts, although the number of overall contracts has decreased since 1993. China's investment and industrial policies frequently include explicit provisions for technology transfers in the form of local content requirements, production export quotas, and/or collaboration in production, research or training.

- China receives more foreign direct investment than any other developing nation and currently ranks second only the United States. In 1996, the US contribution to China's FDI inflow was almost $3 billion, much of which was invested in manufacturing enterprises. The US is among the top FDI contributors to China.

- The rate of Chinese utilization of FDI (contracts or investments that are actually implemented or used) amounted in 1996 to over 50 percent, for the first time since 1990. This indicates that Chinese officials and enterprises are making better use of, and can better absorb, foreign capital and the technology that typically accompanies it.

- Exports outnumber imports in China's top trading, coastal zones (except in the cities of Beijing, Shanghai, and Tianjin, where imports exceeded exports in 1996). According to Chinese statistics, the share of Chinese exports produced in foreign-invested plants (either joint ventures or wholly foreign owned enterprises) has grown significantly over the last decade, accounting for *nearly half* of all exports in 1996.

Import Policies

- In the effort to develop indigenous high-tech industries, China's foreign import and investment policies have become increasingly

selective and restrictive in the type of imports and investments that are allowed or officially encouraged. In particular, there has been an increased emphasis on industry-specific investment and high-technology imports.

- The Chinese leadership has identified several industrial sectors as "pillar" industries, namely machinery, electronics, petrochemicals, automobiles and construction materials. The central government will provide more than $60 billion through the year 2000 to promote domestic capabilities in these industries. These pillar industries will be developed with preferential state support as the primary engines of continued economic growth in China.

Defense Conversion

- China's economic and industrial development strategies and defense conversion programs are also intended to assist China's military development.

- China's military capabilities are considered by Western and US analysts to be far behind in terms of Western models of military technology as well as in command, control, and force structure. However, the extent to which the commercial activities of China's civilian defense industrial complex are tied to the uniformed military departments (PLA) is not well understood in the West. More research is needed on this issue.

The Role of US Technology

- One of the more common approaches to establishing a presence as well as goodwill in China is by donating equipment or funds for training or education in China. Numerous US high-tech firms have done so, often in connection with one of China's leading universities or research centers.

- The most significant commercial offset and/or initiative put forward by US high-tech companies in seeking approval for joint venture manufacturing partnerships or facilities in China is the establishment of an institution, center, or lab devoted to joint research and development. This is a relatively recent trend and involves many US firms in several high-tech sectors in China. Compared to donations of equipment and scholarships as well as training for Chinese workers, the new R&D initiatives would appear to involve more technology transfer to China. The extent of collaboration and product development, however, is as yet unclear.

PART 2: US PERSPECTIVES ON TECHNOLOGY TRANSFERS TO CHINA

This section examines US investments in three key industry sectors in China: automotive, aerospace, electronics (including telecommunications). Each case study assesses the relationship between investment by high-tech US firms and provisions in China's investment or industrial policies, competition with China's state-owned or non-state sector enterprises, the effect of China's infrastructure on investment, and the current state of the industry in China. Also addressed are technological or potential military advances that could result from US commercial technology transfers. Trade statistics are included as a means of assessing the effect(s) of US high-tech investment in these areas. Finally, a brief examination is made with regard to the approaches to technology transfers taken by the European Union nations and Japan, and contrasting these to the prevailing US view.

Key findings:

- The dynamism of China's relatively rapid economic liberalization since 1978 has overshadowed in large part China's industrial goals and policies that are explicitly designed to restrict and manage foreign investment in order to protect and bolster China's domestic industries through acquisition of high-technology imports.

- While numerous complaints have been registered by US companies with the US Government (formally and informally) with regard to unfair trade practices in China, many companies are hesitant, if not unwilling, to complain publicly or even privately about the numerous difficulties inherent in doing business in China. Nevertheless, the majority of industry representatives interviewed for this study clearly stated that technology transfers are required to do business in China,

although most also were optimistic about their future business prospects in China. They also did not think the "price" had yet become too high in terms of the level or type of technology transferred as a result.

- China's is a buyer's market. As such, the leverage of such an enormous potential market allows Chinese officials to frequently play foreign competitors against one another in their bids for joint venture contracts and large-scale, government-funded infrastructure projects in China. The typical result is usually more technology being transferred as competitors bid up the level or type of technology that they are willing to offer. There are also recent cases, however, of foreign companies joining forces with domestic or foreign companies in the same industry in order to enhance their own leverage. Microsoft, DEC, and Oracle, for instance, have joined forces in selling software in China and Exxon, Raytheon, Dupont, and Union Carbide have teamed up with Japanese companies in China. Although cooperation may not be possible across all industries, where such an arrangement is possible, there will likely be less technology being transferred or coerced from foreign firms.

- The answer given most often in interviews and in press reports as to why, despite demands made for commercial technology transfers and other unfair trade practices in China, US industry continues to invest heavily in China is that one cannot *not* be in China lest a competitor get a foothold. US high-tech firms seem willing to pay the price — technology transfers — in exchange for limited market access.

- US high-tech firms in China enjoy large market shares in the aerospace and electronics industries, although not in the automotive sector. Despite several years of high-level investment in China, however, survey data and press reports indicate that relatively few US companies are realizing profits or even a return on their investments in China.

- China's electronics sector, more than the other industry sectors studied, has emerged rapidly and achieved some technological successes. This is because of the sheer size of China's market, the learning curve in the electronics industry (the potential for "fast followers" based on the success of other Asian nations in this sector), and the potential for "leapfrogging" to the most advanced technologies (which China's comparatively immature electronics market and infrastructure makes more likely). China's capacity and increasing sophistication in the electronics sector could, if current trends continue, easily make China a leading producer (by volume) of electronics in the next decade or two. However, China's electronics industry remains highly dependent on foreign inputs for design, marketing, and R&D.

- While the EU has fully and officially embraced technology transfers to China, Japan has been in the past more conservative in investing or sharing its advanced technologies, while the United States' approach has been somewhere in the middle.

Conclusion: US Commercial Technology Transfers to China

This section addresses the potential short- and long-term economic and security implications of US technology transfers to the People's Republic of China. The conclusion addresses the basic questions that this study is designed to answer: "Is the transfer of US technology the price of entry into China's market?," and "Are US commercial technology transfers forced?" The following are key findings resulting from this study:

Key Findings:

- According to experts and executives interviewed for this study, the transfer of advanced US technology is the price of market access in China for US high-tech companies.

- Most US and other foreign investors in China thus far seem willing to pay the price of technology transfers — even "state-of-the-art" technologies — in order to "gain a

foothold" or to "establish a beachhead" in China with the expectation that the country's enormous market potential eventually will be realized. A primary motivation for investing in China at this time and despite the difficulties and risks involved, is in order to beat foreign and domestic competitors to the China market.

- Numerous US high-tech firms have agreed to commercial offset or technology transfer agreements in exchange for joint ventures and limited market access in China. An increasingly frequent type of commercial offset is the establishment of a training or R&D center, institute, or lab, typically with one of China's premier universities or research institutes located in Beijing or Shanghai.

- Technology transfer is both mandated in Chinese regulations or industrial policies (with which US companies wishing to invest in China must comply) *and* used as a deal-maker or sweetener by US firms seeking joint venture contracts in China.

- Unless significant changes are made to China's current investment regulations and import/export policies, US commercial technology transfers to China are likely to continue, potentially enhancing Chinese competitiveness in high-technology industry sectors such as aerospace and electronics. The US-China trade imbalance may continue to worsen in the short term as commercial offset demands and foreign-invested enterprise exports increase and in the long term as China's plans to develop indigenous capabilities in both basic and advanced technology industries are implemented.

- In the industry sectors studied, it is apparent that what technological advances and increased exports exist are disproportionately due to foreign investment capital and technology rather than to indigenous technological advances.

- The US export control review process is not designed to evaluate continuing US commercial technology transfers to China that are demanded or offered in exchange for market access.

- Although it is not possible to make a clear determination of the US national security implications of commercial US technology transfers to China, the continuation of the trends identified in this study could pose long-term challenges to US national security interests. This study does not identify any specific Chinese military advances made as a result of US commercial technology transfers, but does suggest that continued pressures on foreign high-tech firms to transfer advanced commercial technologies, if successful, could indirectly benefit China's efforts to modernize its military.

Introduction

What constitutes technology transfer is difficult to either define or measure as the term or concept can potentially encompass very wide or very narrow criteria. The following is a description of the concepts and the criteria utilized throughout this study.

What is Technology Transfer?

Technology transfer can be defined in terms of both process and purpose. That is, there are several methods by which technologies, expertise, or know-how can be transferred from one party or state to another, and this is done for various reasons or objectives.[1] This study will address the processes by which advanced commercial technologies are being transferred from the United States to China, the reasons or motivations behind these transfers from both the US and Chinese perspectives, and the implications commercial technology transfers may have for Chinese and US competitiveness, industrial base development, and national security concerns.

Why is Technology Transfer Important?

Technology is a key factor in maintaining US competitiveness in the global economy. Technology transfers are not necessarily detrimental to US business, the US economy, or to national security interests. However, where technology transfers are unduly required in exchange for access to a foreign market or where foreign investment policies mandate the transfer of technology, there exists an artificial incentive to transfer more advanced technologies than would likely prevail under free-market conditions. The potential effects of this on the US economy include loss of jobs (which in the high-technology sector are typically high-wage positions), loss of capital or revenue that could be reinvested in the United States, decline in or loss of basic industries critical to the US defense industrial base, and the potential for creating or enhancing foreign competitors where they might not otherwise exist.

How is Technology Transferred?

There are several means by which technology is transferred from one state to another, including normal trade in goods (importing technology); licensing of technology; sharing of designs, patents, formulae, management style and accounting procedures in high-tech joint ventures; training of foreign employees; collaboration in basic and/or innovative research and development; and donated technologies, machinery, or equipment. Illicit or illegal means of technology transfer can include regulations explicitly mandating technology transfers in exchange for market access, diversion of technology from authorized end-users, theft or infringement of intellectual property, and espionage.

Why is Technology Transferred?

The primary motivation for transferring technology is economic gain, whether this is achieved in the short- or long-term. For the recipient of high-technology transfers, the motivation is typically to 1) obtain needed advanced technological equipment or parts not available from domestic suppliers; or 2) develop domestic capabilities in a particular industry or sector through reproduction, re-engineering, or innovation of transferred technology. The party transferring technology is typically motivated to do so in order to 1) provide needed advanced technological equipment, parts, or know-how where local supply and content is unavailable or of poor quality; 2) provide greater incentive and leverage for approval of joint venture contracts over other foreign competitors; and 3) fulfill (*de facto* or *de jure*) provisions requiring technology transfers found in government regulations or industrial policies.

What are Commercial Offsets?

For the purposes of this study, offsets are defined as industrial compensation practices mandated by many foreign governments (by law or by practice) as a condition of purchase of imported products or of approval of an investment. Offsets can be "direct" or "indirect." Direct offsets refer to compensation "directly" related to the product being imported or to the investment, such as licensed production of the product in the purchasing country, or subcontracting in the country of parts and components for the product. "Indirect" offsets – compensation unrelated to the imported item or joint venture – can include establishment of a research facility, donation of equipment or machinery, or countertrade in unrelated items. Countries, including China, require offsets for a variety of reasons: to ease (or "offset") the burden of large purchases on their economy; to increase or preserve domestic employment; to obtain desired technology; and to promote targeted industrial sectors.

Part 1
TECHNOLOGY TRANSFER: POLICIES, PROCESS, AND DECISION MAKING IN CHINA

It is difficult to comprehend the reasons behind US and foreign technology transfers to China without a basic understanding of China's policies and goals with regard to science and technology development, trade, and foreign investment. The following section outlines the evolution of Chinese policies in these areas, including reforms made in China's research and development system, the increased emphasis on high technology in China's economic, industrial, and military modernization efforts, and the role of US high-tech firms in China's plans to develop a modern economy and military.

DEVELOPMENT OF SCIENCE & TECHNOLOGY IN CHINA: 1949-1978

Development of science and technology has long been a priority in Chinese policy planning. Between the formation of the People's Republic of China in 1949 and the beginning of the reform era under Deng Xiaoping, China's policies for development of science and technology consisted of grand, long-term plans for achievement of "major tasks" in the industrial and military sectors. Chief among the accomplishments during this period were China's successful missile and nuclear weapons programs. These accomplishments, however, were atypical in terms of the amount of resources, funding, and labor devoted to achieving these major tasks. There was very little progress made in terms of research with industrial or commercial value. Furthermore, the source of most of the technology transfers into China at this time was the Soviet Union, a relationship that has had lasting implications for the structure of China's scientific, research, and industrial sectors. Although some successes were achieved under state plans during this period, what progress was made ended with the onset of the decade-long upheaval of the Cultural Revolution (1966-1976).

DEVELOPMENT OF SCIENCE & TECHNOLOGY IN CONTEMPORARY CHINA: 1978-Present

The announcement in 1978 of China's "Four Modernizations" program marked the beginning of China's era of economic reforms and remarkable growth.[2] Domestic science and technology development has been a key factor and priority in this modernization effort and in China's impressive 9-10 percent average annual GDP growth rates over the last two decades.[3] The early period of reform in China's science and technology sector was characterized by increased central government planning and promotion of science and technology-related programs that were compulsory, government funded, and conducted primarily in medium- to large-size state-owned enterprises (SOEs). These policies proved to be largely ineffective and unsustainable. During the latter phase of the reform era (roughly 1985 to the present), central government mandates and funding for science and technology projects have diminished to be increasingly replaced by central government "guidance" or incentive programs that encourage competition among SOEs for limited government funds in selected sectors.

Applied Science & Technology: "Anchor at one end and let the other end be free"

Beginning in the mid-1980s, China's state planners began to develop more specific policies targeted at commercializing and applying the new technologies being developed primarily by China's state-owned research organizations and defense industrial institutions. Unlike the earlier plans, however, these new plans provided more incentives for state enterprises to collaborate in developing and modernizing particular sectors of the economy (agriculture, infrastructure, and industry). In order to promote greater cooperation between China's research and industrial sectors, government funding for research and development projects was made competitive and decisions on funding became based on the applicability of new technology to industrial or commercial purposes. Accordingly, it was at this time that China established a National Science Foundation (NSF) modeled on the US counterpart and instituting for the first time a peer-review system throughout China's research community.[4]

Over time, these research projects were (and are) expected to become self-financing (through bank loans or sales revenue) as the new technology developed with government funding is applied in business ventures. The guiding philosophy of these various plans would come to be known as "Anchor at one end and let the other end be free" (*wenzhu yitou, fangkai yipian*). In other words, the state ("the anchor") would provide at least partial funding and basic research for projects or enterprises employing this research and technology in China's industrial and commercial sectors. Reiterating the need for increased support for and application of science and technology in the industrial/commercial sector, China's State Council in May 1995 announced a "Decision on Accelerating Scientific and Technological Development."[5]

Among the more important plans or incentive programs devised at this time was the so-called "863" project aimed at promoting basic research in advanced industrial technologies. In addition, the "Spark" Program (for developing and applying new technology in the agricultural sector) and the "Torch" Program (projects designed to apply technologies derived from the 863 plan) were established at this time and continue to be funded primarily by the central government.[6] Similarly, an extremely ambitious series of plans —the so-called "Golden Projects— was established in the mid-1990s to improve and advance China's limited government and commercial communications infrastructures." The number and type of "Golden Projects" have expanded to comprise the establishment of fiber-optic communication networks in sectors such as banking, customs and tax collection, telecommunications infrastructure, medical and health information, and academic or scientific networks. The main objective that all of these post-1985 "programs" share is the application of research, science, and technology developed or administered by the state sector (the "anchor") to the industrial and commercial ("free") sectors of China's economy as a means of advancing economic growth in China.

THE ROLE OF US TECHNOLOGY IN CHINA'S SCIENCE & TECHNOLOGY DEVELOPMENT PLANS

These large-scale science and technology development plans and projects are dependent upon indigenous research and technological advances as well as foreign investment, research, and technology. Thus, these projects have provided domestic and foreign investors alike with attractive business opportunities. Some collaboration between US and other foreign enterprises with Chinese organizations has occurred under these various state-sponsored programs in the form of investment and joint research.[7] For instance, Intel is participating in the "Golden Card Project" to establish a bank/credit card system in Shanghai, and US computer and telecommunications companies such as Motorola, Bell South, IBM, Cisco, Sun Microsystems, and Hughes are assisting China's Ministry of Posts and Telecommunications (MPT) and its provincial offices (PPTs) in establishing the various "Golden Projects" networks.

TABLE 1
Trends in China's Science & Technology, Research & Development: 1949-1997

1949-1978	1978-1997 (Reform Era)
Centrally planned economy and development plans	Market-oriented economic reform and more local government input
Compulsory programs managed by the central government	Mix of mandated policies and "guidance" or incentive plans*
Full government funding for research	Limited government funding supplemented by preferential loans, non-state enterprise revenues*
R&D conducted solely by state-run or military institutions	R&D increasingly conducted by non-state sector organizations, universities, and joint ventures*
R&D results/product utilized solely by government or military sector	R&D results/product increasingly used in commercial ventures*
Limited incentives for innovative scientists, engineers, or technicians	Increasing incentives, benefits, and rewards for scientists, engineers, and entrepreneurs*
Scientists, technicians, engineers typically educated in Moscow or education hampered by Cultural Revolution decade (1966-76)	New generation of scientists, engineers, technicians educated in China or in the West, primarily the United States

* Trends emerging in the late 1980s-early 1990s.

Sources: State Science and Technology Commission (SSTC), "China's S&T Policy: A View from Within," in Science and Education for a Prosperous China; Wendy Frieman, "The Understated Revolution in Chinese Science & Technology: Implications for the PLA in the 21st Century," draft paper prepared for AEI 1997 Conference on the People's Liberation Army (American Enterprise Institute, September 1997 conference); and Sally Stewart, "Technology Transfer and the People's Republic of China," in Technology Transfer in the Developing Countries, Manas Chatterji, ed. (New York: St. Martin's Press, 1990).

Comparative analysis of China's rules and regulations regarding domestic and foreign investment in these and other state-run programs, however, reveals discriminatory provisions regarding the rights and obligations of foreign partners that are not included in regulations governing domestic investors (this is discussed in detail below). Furthermore, the legal terms of ownership regarding research resulting from any such collaboration remain unclear. In fact, research that results from technology development projects funded or administered by the PRC government (PRCG) is considered government property and must be reported by Chinese parties to central authorities (although Chinese research institutions are now reportedly demanding payment for their research work, which has previously been provided to the central government gratis). This issue will clearly need to be addressed in order to assure mutual benefit from any technological innovations that may result from future collaboration. Without sufficient legal protection, US companies currently engaged in collaborative research under the aegis of these state plans risk losing the monetary and technological gains from their investments.[8]

RESEARCH & DEVELOPMENT

The major beneficiaries of the state-sponsored science and technology development programs throughout the planning process have been China's large state-owned enterprises, which have been designated by the central government as engines of economic and industrial growth as well as vehicles for experimental reform measures.[9] One result of these programs is that by 1993 more than half of China's large state-owned enterprises had established technical development centers, founded for the purpose of improving production efficiency as well as increased product quality and marketability.[10] China's policies for industrial and commercial reforms continue to emphasize the need for cooperation among China's industrial, commercial, and research enterprises in an effort to bolster the revenues of China's state-owned enterprises and to modernize China's economy as a whole.

TABLE 2
Technical Development Centers in Large State-owned Enterprises

Year	No. of Large- or Medium-Sized Chinese Enterprises with Technical Development Centers	Percent of all Large- or Medium-Sized Chinese Enterprises	Expenditure by Large- or Medium-Sized Chinese Enterprises on Technical Development Centers
1985	1,913	24%	5.3 billion yuan
1993	9,503	50.7%	24.86 billion yuan

Source: Jiang Xiaojuan, "Chinese Government Policy Towards Science and Technology and Its Influence on the Technical Development of Industrial Enterprises," Chinese Technology Transfer in the 1990s, p. 144.

Although China's indigenous R&D programs have resulted in some notable past achievements in the military sector (e.g., nuclear weapons and space launch vehicles), overall they seem to have only marginally benefitted China's industrial sector. For example, approximately five percent of about 30,000 Chinese patents annually prior to 1995 were actually developed into products.[11] These shortcomings are due to several systemic problems in China's state sector, which Chinese officials have identified as the following:

- A limited amount of R&D conducted in small- to medium-sized state-owned enterprises;
- Poor communication across bureaucracies and industrial, commercial, and research communities in terms of infrastructure needs and standard practices;
- A "focus on quick profit from imported technology" by Chinese enterprises (instead of assimilation or absorption of imported technologies);
- Import of advanced technologies that are inappropriate for the China market;
- A shortage of highly educated and technically skilled workers, primarily trained scientists, engineers, and technicians;
- A military culture of secrecy and difficulties in spinning off military technologies to the civilian industrial sector; and
- Periodic domestic political upheavals.[12]

"Wherever conditions permit, research institutes and institutions of higher learning should combine production, teaching and research by entering into association or cooperation with enterprises in various ways so as to solve the problems of segmentation and dispersal of strength in the management systems of science, technology and education. Innovation, competition and cooperation should be encouraged."

Jiang Zemin's report delivered at the 15th National Congress of the Communist Party of China (CPC) on September 12, 1997, entitled "Hold High the Great Banner of Deng Xiaoping Theory for an All-round Advancement of the Cause of Building Socialism with Chinese Characteristics to the 21st Century."

Chinese leaders have identified these problems, several of which persist. Although the

latter three areas have become arguably less worrisome at present, the remainder require significant improvement. Furthermore, despite the incentives provided in the new state science and technology plans, there seems to be little communication or collaboration occurring among China's large-scale SOEs, industry, and academic or research sectors. Figures for 1992, for instance, indicate that less than two percent of large- and medium-sized SOEs that had established technical developments centers had collaborated on projects with outside institutions or experts.[13] Thus, the planned integration of state-funded R&D with Chinese industry, commercial, and academic sectors has not yet been fully realized.

It is, instead, China's smaller SOEs and non-state sector enterprises that have contributed most to China's modernization efforts.[14] These enterprises have not been able to (or perhaps have had no real need or desire to) take advantage of the large-scale, government-sponsored programs for science and technology development. Nevertheless, due to their ability to, and the necessity for, these small or non-state enterprises to absorb, adapt, innovate and diffuse new technologies, they have been more profitable and productive than the large state-owned enterprises. As a result, despite the advantages and incentives provided to China's large- and medium-sized SOEs, most of China's high-technology productivity results from small, local (state and non-state sector) enterprises or joint-venture partnerships. This is most likely due to the large number of joint research projects (approximately 4,000) between domestic state or non-state sector enterprises and China's numerous state-run research institutes (discussed in further detail below).

In addition to the above described central government plans or "guidance" policies, the state has also encouraged its national research institutes to become more involved in commercial activities, applied research programs and, in some cases, joint research projects with foreign firms. As is discussed below, there has been a significant increase in the number of exchanges and cooperative or collaborative programs between Chinese research institutes and US high-tech firms.

National Engineering Research Centers (NERCs)

In an effort to spur domestic technological innovation and to diffuse applied technologies across government, industry, scientific, and academic communities, China has established numerous National Engineering Research Centers (NERCs) across the country. These centers play a key role in China's strategy to reform its science and technology research system and are likely to become more prominent over time.

The NERCs are bureaucratically subordinate to China's State Science and Technology Commission (SSTC), equal in status to China's civilian industry-related ministries or "corporations," and senior to China's other research institutes and universities. There are currently 56 official centers devoted to conducting research in applied technologies for China's "pillar industries," and basic, high-tech, and "new technological industries." (See Appendix A for a list.) These areas include research in agriculture, electronics, telecommunications, manufacturing, metallurgy, light industry and textiles, natural resources and raw materials, environmental processes, as well as medicine and health, among other areas. As conceived and outlined in the Eighth Five-Year Plan (1991-1995), 144 more centers are planned for a total of 200 NERCs by the year 2000 and employing between 30,0000-40,000 engineers nationwide. These centers will also serve to establish technological standards for Chinese industry.[15]

TABLE 3 Chinese National Spending on Research & Development in 1995	
Enterprise Expenditures	32%
Government-sponsored R&D:	
Research Institutions	44%
Universities	14%
Other	10%

Source: Innovation and Technology Policy in the People's Republic of China, Office of Technology Policy, US Department of Commerce (draft paper, 1997), p. 3.

The NERC system is administratively controlled by the central government but designed to encourage and make use of research already being conducted by a variety of government-, industry-, and university-based research institutes. Provincial or local government departments or research institutes can apply to the SSTC to establish a NERC. Once having been approved and established as NERCs, however, non-performing centers (those not meeting NERC standards for two consecutive years) can be disassociated from the NERC system. As with other research efforts underway in China today, the NERCs are expected to become financially independent of government funding by means of competitive research that meets the demands of China's industries and emerging market economy. Technology transfers are included as an integral part of this strategy.

The World Bank also funds a number of NERCs in China. Although the application and establishment process appears to be quite similar, NERCs sponsored by the World Bank receive funds and administrative direction via the Gold China Corporation (GCC) in addition to following SSTC guidelines.

Among the main tasks assigned to the NERCs is to "actively import, digest and absorb foreign technologies so as to support enterprises in their technological progress and structural readjustment."[16] It is unclear, however, to what extent foreign technologies have contributed to NERC efforts to date.

SOEs continue to be a serious burden to China's economic planners. According to the World Bank, over 40 percent of the SOEs are in the red. Chinese President Jiang Zemin has appointed his top economic expert, Premier Zhu Rongji, to fix the SOE problem.

The current plan is to pick 1,000 of the more than 100,000 SOEs to become the "core" of China's state industrial structure. The remaining SOEs will gradually be sold, leased, or merged into existing (profit-making) enterprises, or be declared bankrupt and dissolved. Such a massive re-organization will surely cause numerous political, economic, and social domestic pressures, which is why the PRCG has for so long avoided doing anything about the problem.

The plan to reform the SOE sector was announced by Chinese President Jiang Zemin at the 15th National People's Congress in September 1997.

See "Country Brief: China," The World Bank Group, September 1997; and Dexter Roberts and Mark L. Clifford, "Overhauling China Inc.? Beijing's New Catchword: Privatization," Business Week, no. 3522, April 14, 1997, p. 58.

Chinese Academy of Sciences (CAS)

China's premier scientific institution, the highly regarded Chinese Academy of Sciences (CAS), is also involved in China's drive to spread technological know-how throughout the country and across government

and business communities. The CAS has over one hundred research institutes throughout the country employing more than 50,000 technicians and scientists. The Academy's "Industry-Academic Research Plan" calls for industry and university cooperation on 100 designated projects involving 100 key state-owned enterprises on 10 major science projects over the next five years in an effort to further the commercialization of technology. These particular enterprises are to be turned into state-run "corporations," which will both permit and necessitate more foreign trade and investment as a means of revenue. In addition, the CAS has established over 500 commercial enterprises in the high-tech sector as part of a government program to develop "technical enterprises" as subsidiaries of existing research institutes.[17]

University-Based Research

Since the implementation of the post-1985 plans, China's premier universities have become virtual hotbeds of scientific research and development.[18] This has not always been the case, however, and represents a significant change in status. Whether this dynamic increase and improvement in university-based R&D — in terms of the breadth of research being conducted, scientific achievements, and the financial resources available — is more the result of economic liberalization or government policy is debatable. But it is reasonable to conclude that the market mentality emerging in China was probably the key factor leading to a more productive scientific apparatus, at least in the university environment. After all, scientific progress has long been a goal of Chinese domestic policy, though the stated goals have rarely been fully realized in the past due to the reliance on mostly closed and secretive government-run research institutes of old. Chinese domestic policies on science and technology have aided progress by requiring (or cutting loose) China's academic community to pursue wide-ranging, profit-making, industry-relevant research projects, and they have quickly taken to the task.[19]

Conclusion

The establishment of NERCs, the ambitious CAS plans, and numerous other government-sponsored technology transformation projects demonstrate China's commitment to a highly coordinated but more market-driven research and development system with an emphasis on high technology products and innovation. In commenting on the SSTC's own assessment of the current status of science and technology in China, a US Embassy representative states that "It is plenty evident that China is attempting to muscle technology out of joint ventures with foreign companies to achieve this purpose. In addition, China has consistently rejected digestible technology that is offered which is appropriate to the Chinese market in favor of technology that China cannot absorb and support."[20]

The most interesting trend in terms of this study is the growing collaboration between US high-tech firms and China's leading R&D centers, especially university-based centers. The extent to which these programs have been successful or that foreign technology has contributed to these efforts is unclear.[21]

TABLE 4 Key Indicators of Technological Advancement		
Type	**Time Period**	**Level**
R&D Expenditure	1990	(64.2% Testing & Development 28.5% Applied Research 7.3% Basic Research)
	1995	Approximately 0.5% of GDP (54.1% Technology Development 39.8% Applied Research 6.1% Basic Research)
	2000 goal	1.5% of GDP (requires 30% growth in R&D spending per year)
Patents	1992	Approx. 30,000 issued
	1995	45,064 registered (54% of patent applications; 8% foreign registrants)
Licensing	1992	$39m
	1993	$62m (93.5% in industrial
	1994	$36m process technology)
	1995	$36m
Scientists & Engineers in R&D	1995	Over 400,000 out of about 1.4million total Research institutions (30%); Enterprises (29%); Academic institutions (21%); Other (20%)
International S&T Agreements/Exchanges	Presently	Government-government agreements with 83 foreign countries
High-Tech Exports (as percentage of total exports)	1997	5.9%
	2000 goal	15%
	2010 goal	25%

Sources: Innovation and Technology Policy in the People's Republic of China, Office of Technology Policy, US Department of Commerce (draft paper, 1997), pp. 28-30 (citing Science and Technology Statistics Databook, 1995, compiled by the State Science and Technology Commission); and State Science and Technology Commission (SSTC), "China's S&T Policy: A View from Within," in Science and Education for a Prosperous China.

As US Government officials and scholars have found, "In China it is very difficult to obtain information which cuts across the compartments and analyzes the impact of China's science and technology programs on national economic competitiveness and development of indigenous technological capabilities." This is because "governmental reports prepared on each technology program tend to use quantitative output as the primary indicator of effectiveness."[22] Nevertheless, the Chinese government estimates that about six percent of China's export growth can be attributed to advances in domestic science and technology.[23] As a result of the various state policies promoting science, technology, and research described above, China has a relatively large S&T system. Furthermore, according to the State Science and Technology Commission, the state continues to provide "half of all Chinese R&D."[24] However, the almost completely top-down dynamic still apparent in these policies and institutions continues to limit technology innovation and development of the technologies needed most by rapidly growing high-tech industries in China.

Lastly, there is clear evidence that collaboration with foreign joint ventures on research and development of high-tech products is being pursued as a parallel effort to China's domestic high-tech research and is an increasingly frequent method of technology transfers to China (examples of which are detailed below).[25] Although it is unclear exactly what type and level of research is actually being conducted in these joint research projects and foreign-sponsored research centers, labs, and institutes, it can be stated with some degree of confidence that it is more than simply training and recruiting of Chinese workers. While most of the joint R&D being conducted at these centers appears to be "localization" of existing products and technologies rather than "innovation" (e.g., new Chinese-language software programming based on existing applications versus creating new software), at least some R&D projects involve more advanced or basic research. In either case, a significant amount of technology know-how is being transferred. However, much more research into this particular area is necessary before a definitive determination can be made as to the contributions made by foreign enterprises to China's overall R&D capabilities and advances.

CHINA'S ABILITY TO ABSORB AND APPLY FOREIGN TECHNOLOGY

Even if China is successful in importing high techology and/or gaining access to new technologies via foreign joint ventures, this technology may not necessarily prove to be useful unless China has the ability to absorb these new concepts, processes, and equipment. The key to utilizing acquired technology in an efficient manner is a highly skilled workforce and exposure to international experts in high-tech fields.

Scientists & Researchers

China now has a sizable pool of well-trained scientists, technicians, and engineers (although not on a per capita basis), and this group is becoming increasingly sophisticated and international. More Chinese academics, engineers, and scientists are participating in international scholarly fora, meetings, and workshops that provide exposure to global standards and practices. China is currently engaged in cooperation on science and technology-related projects with at least 83 foreign countries.[26]

These scholars are also benefitting from global interconnectedness and the communications revolution, which allows them to regularly keep in touch with colleagues around the world.[27] In order to keep China's scientists from staying abroad, preferential hiring policies and specially designated institutes such as the newly established Qinghua University Higher Research Center in Beijing are being established to lure them back. Chinese scientists and researchers abroad are also being enticed by pledges of large numbers of jobs set aside for them, and research grants available to them, if they return to China. The freeing-up of China's research regime from state control has also allowed these technically savy, young people to find jobs in dynamic, for-profit, non-state sector enterprises. A parallel trend is also emerging with China's leading electronics companies beginning to establish research and development centers in the United States.[28]

According to a recent, informal survey of American scientists familiar with visiting Chinese fellows over the last two decades or so, regarding the relative capabilities of PRC students, scientists and technicians, the younger generation of Chinese scholars coming to the United States is considered to be "extremely impressive" as compared to students of previous decades. Their contribution to China's modernization efforts will be critical if China is to make significant progress in closing the technological and scientific gap with the West. Despite the technological gap that exists between China and other industrialized countries, one expert concludes that "it does appear that whatever scientific progress was made in China during the past 15 years should be attributed to the return of smart and dedicated people rather than to the purchase of expensive scientific instrumentation."[29]

Despite these positive trends, however, there still exists in China a bureaucracy filled with relatively aged scientists and researchers, though many (42 percent of professors and 50 percent of senior engineers) are scheduled to retire by the year 2000.[30] These scientists and engineers have in the past been "concentrated in specialized research institutes, in heavy industry, and in the state's military research and military industrial facilities, which had the highest standards and the best-trained people. A very small proportion of scientists and engineers worked in light industry, consumer industry, small-scale collective

enterprises, and small towns and rural areas."[31] This likely accounts for much of the ineffectiveness of central government plans to revitalize and promote collaboration between state-sector research institutes and Chinese large-scale industrial enterprises.

Chinese Students

Students from the PRC continue to flock to the United States in large numbers as the United States is, by far, the most popular choice for PRC students studying abroad. The number of students from the PRC in the United States in 1996 was estimated at more than 100,000.[32] Between 1978 and 1996, an estimated total of 250-270,000 students came to American universities from China, the vast majority arriving during the last decade.[33] These figures include many of the children of China's current leadership, who for the most part received their own higher education in Moscow. Former President Deng Xiaoping, the current Chinese President Jiang Zemin, and Vice Premier Qian Qichen are among China's elites who have sent their offspring to be educated in America (the obvious exception to this trend is Premier Li Peng).[34] The opportunity to study abroad is reserved for China's best and brightest as even getting a college education in China remains a privilege for the most elite and brightest students. Recent figures show that China currently has the smallest percentage of college-educated young people in Asia[35]

For many years, especially the post-Tiananmen era, PRC students in the United States were reluctant to return to China, thereby creating a "brain drain" to the United States. This has had two major consequences. First, many of these students were able to find employment in American high-technology firms (many in Silicon Valley) and remain reluctant to return to China at least in the near term due to greater opportunities and the higher living standard available in the United States.[36] Second, given the dearth of highly skilled American graduates in technical, scientific, or the mathematics fields (about which US firms have recently complained), high-tech firms in the United States have become dependent upon foreign (including Chinese) workers with training in these fields.

Most of the Chinese students in the United States pursue science or math-related fields. As a result, Chinese scholars educated abroad over the last decade reportedly make up more then half of the top scientific researchers now working on key research projects and receiving priority in conducting this research. Therefore, high-tech firms in the United States and the government of the PRC are today competing for these same talented individuals. This trend is reflected at least to some degree in the number of "deemed" export licenses issued in the United States for Chinese employees of high-tech firms, which have increased significantly over the last few years such that the figure for 1997 is greater than the sum of the five previous years. More than half of all the "deemed" export license applications received by DOC/BXA are for Chinese nationals. Although it is possible that these figures simply reflect the recent effort by DOC/BXA to make American high-technology firms more aware of their licensing requirement, it is also true that US high-tech firms are hiring more foreign high-tech workers. As compliance becomes more regular and wide-spread, these figures will provide a better measure of the degree to which "deemed" exports to China are increasing.

The brain drain from China resulting from the Tiananmen aftermath seems to have abated, and may even be reversing, with more Chinese students returning to China following completion of undergraduate or graduate-level course work. The Chinese government is also providing incentives (such as preferential hiring of returning students for jobs in a new high-tech industrial park in Beijing) and disincentives (such as an increase in the amount needed to be left as bond or deposit to study abroad) in order to entice students back to China.[37] In fact, there are hints that a new trend may be emerging of Chinese students choosing to stay in the United States in order to be entrepreneurial and to start their own (often high-tech) business. These

According to a California recruiter of Asian-American workers, "Lots of people are coming in asking for opportunities that will send them back to China. Those people aren't ABCs (American-born Chinese); they're the people from mainland China who came here to get their degrees and are working for Silicon Valley companies. Now they want to go back to China. They want to work for US companies, but they want to work in China...they want to work for American companies but still do something for their countries."

Mark Hull, "Translating Immigrant Dreams Into Jobs," San Jose Mercury News, October 1, 1997.

plans seem also to include a return to China after a period of years working in the United States, primarily in high-tech firms.

TABLE 5 "Deemed" Export Licenses for Employment of Chinese Nationals						
Fiscal Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
No. of approved licenses	1	3	3	15	89	211

Source: ECASS Database, DOC/BXA

Foreign Experts

Most foreign experts in China work in foreign-invested ventures or enterprises. In 1988 there were only approximately 20,000 foreign experts in China.[38] Since that time, however, China has come to rely on the services and know-how provided by foreign experts, and they will play an increasingly important role in China's efforts to modernize its economy. "In the next two years, China plans to recruit about 170,000 overseas experts and send 90,000 people to attend overseas training programs."[39] Shanghai has its own plan to recruit a large number of foreign experts — up to 300,000 through 2010 (or about 23,000 each year) — in areas such as finance, communications, transport and telecommunications as well as autos, power station or telecommunications equipment and other "new high technology" fields. Although there is no figure available for the total number of American experts from US industry residing in China in support of US joint ventures, training of Chinese workers is a growing (and arguably necessary) means of technology transfer in many high-tech ventures. This cooperation is enhanced by US- and Western-funded research and development centers established in China as part of many high-tech joint venture agreements.

Technology Leakage

Although almost half of all foreign intellectual property rights (IPR) infringement cases occur in Great Britain, Canada, or Germany, China ranks among the top five nationalities known to be involved in intellectual property theft targeting US companies both at home and abroad, according to a 1996 report published by the American Society for Industrial Security (ASIS).[40] The US Government has identified joint ventures, cooperative research, and exchange agreements as easy targets for technology theft, which has apparently become a "fact of life" for many foreign businesses in China.[41]

A growing problem is that of keeping workers who may have access to technical or proprietary knowledge from going to competitors or creating their own competing enterprises. The price for keeping workers happy is steadily increasing in China, as foreign-invested enterprises are finding it necessary to provide more of the "iron-rice-bowl" benefits that had in the past been the responsibility of the state (such as providing housing for workers). Although this dilemma (how much to pay for a skilled worker not to leave) is a problem for both foreign and domestic firms in China, the risk of technology transfer in this manner is arguably higher for a US/Western high-tech firm than for many others. Even in wholly foreign-owned enterprises, it is not possible to completely protect against unintentional technology transfers in that the work is still done mostly by Chinese nationals, who gain knowledge by doing.

Furthermore, as with several post-Cold War intelligence agencies, China's intelligence gathering is increasingly focused on economic, industrial, commercial, and technological information. This is not surprising in the post-Cold War world, but a fact that US joint venture partners may not be fully aware of or wary about. There also have been numerous alarming reports recently of Chinese companies in the United States that are connected either to China's military or its (civilian) defense industrial sector, through which American technologies have allegedly been transferred back to China.[42] If this is occurring, it should not be allowed to continue if existing laws are capably enforced.

As US commercial and political engagement with China expands, so too will the opportunities for corporate espionage and illicit or unintentional commercial technology transfers. However, it can be hoped that improved US-China relations and better enforcement of existing bilateral and multilateral agreements regarding intellectual and technological know-how will offset much of the potential for serious damage to national security and US global competitiveness from these irregular transfers.

Conclusion

China has no shortage of well-trained scientists, engineers, mathematicians, or other technical experts, unlike the United States. As China's older researchers retire before the turn of the Century, there will be more opportunities for China's younger, Western-educated, science and technology-minded researchers. As this occurs, China's ability to absorb, assimilate, and innovate new technologies can be expected to grow, perhaps rapidly.

Furthermore, the dynamic of the last decade or so has been a growing influx of Chinese students to the United States for education and training. With continued economic growth and liberalization in China, it is not surprising that many of these talented people are thinking of returning to China to work in China's emerging high-technology industry sectors and development zones. The Chinese Government would like these people to return to China and is enticing them with jobs, funding, and other preferential treatment if they return. Many of these young people have found jobs in the technology centers of America (e.g., Silicon Valley or the Route 128 area of Boston), which has afforded them with comparatively high standards of living and well-paying jobs as well as high-tech skills. These same people are increasingly able to find work with foreign high-technology ventures in China. In fact, having a joint venture manager with some knowledge of the ways of doing business in China is an obvious advantage for a US company.

Thus, due to the attraction China is increasingly providing for highly skilled Chinese nationals, the opportunities to work with US high-tech firms in China, and the benefits that might accrue to the US firm as a result, it is likely that the trend toward US high-tech firms establishing joint ventures, many of which are accompanied by R&D and training centers in China, is likely to continue for the foreseeable future. According to one Chinese researcher who conducted a survey of foreign firms in 1994, "transnational corporate invested joint venture enterprises including foreign solely invested enterprises have become the cradle of China's modern industrial, managerial, and technical workers."[43]

FOREIGN INVESTMENT AND THE EVOLUTION OF CHINA'S TECHNOLOGY IMPORT STRATEGY

China's development strategies for advancing its domestic science and technology capabilities have been largely dependent on foreign investment and technology imports. After decades of largely self-imposed isolation, Deng Xiaoping in 1978 opened the flood gates of foreign investment into China. The early years of market reform progressed beyond and despite restrictive, "go-slow" central government reform policies. Deng's famous 1992 tour of the southern coastal areas marked the official "go-ahead" signal for the rest of China to proceed with market reforms and foreign investment incentive programs.

This cautionary approach, however, has had serious consequences for China's economic and technological development. The initial concentration of market reforms and foreign investment along China's coastal areas has resulted in unbalanced growth — a booming, modern, increasingly technology-driven economy in the East while China's central or Western regions remain comparatively closed, underdeveloped, and poor.[44] China's technology import policies have evolved in a similar manner, with more industrial sectors open to foreign investment but with increasingly restrictive and specific terms controlling the level and type of foreign technology sought and allowed into China. The consequences of China's gradual, measured approaches toward foreign investment and technology imports are reflected in China's trade policies, which have resulted in large trade imbalances and continued international criticism of persistent barriers to market access.

Foreign Direct Investment (FDI)

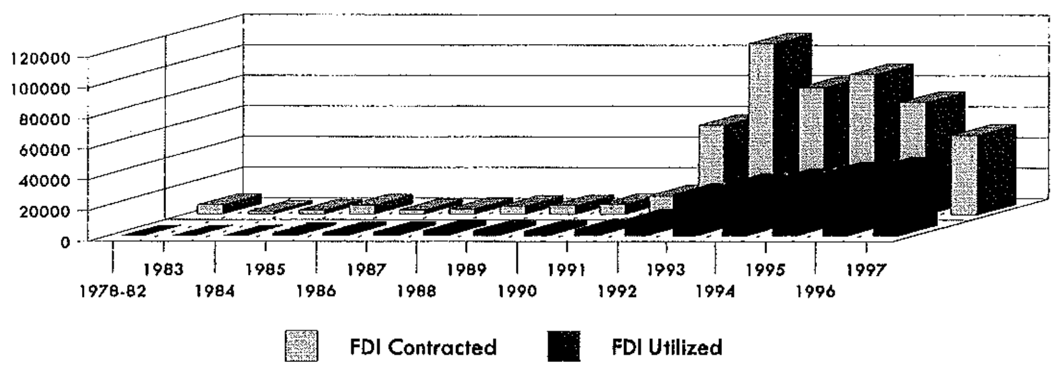
With the opening of China's economy in the late 1970s came new sources of foreign investment and technology transfers, including the United States, Japan, and Eastern and Western Europe, followed by "Greater China" (including Hong Kong and Taiwan), and Southeast Asian states. This new infusion of capital and technology is reflected in China's immense inflow of foreign direct investment, which currently ranks second only to FDI in the United States. In 1995, the US contribution to China's FDI inflow was $2 billion, a more than 20 percent increase over the year before and "concentrated largely in the manufacturing and petroleum sectors."[45] US direct investment in China in 1996 rose to $2.9 billion, representing another 36

percent increase over the previous year and ranking the United States as the second-largest investor in China, after Hong Kong.[46]

The amount of FDI coming into China has risen steadily until recently, reaching a peak $111,436 million and 83,437 new contracts in 1993 (see chart). The greatest growth has been in the number and value of joint venture contracts, although the number of overall contracts has decreased since 1993.[47] China receives more foreign direct investment than any other developing nation. However, the total amount of FDI in China is expected to continue to decline somewhat over the next few years due to uncertainties regarding China's accession to the World Trade Organization (WTO), China's treatment of Hong Kong over the long term, and a "wait-and-see"attitude currently being adopted by many foreign investors with regard to the return on their initial investments in China as well as concern over the current Asian financial crisis.[48] More important to note, however, is the rising rate of Chinese utilization of FDI (in terms of contracts or investments that are actually implemented or used) over the last several years. In 1996, China's FDI utilization rate was over 50 percent for the first time since 1990. This may be due also to the fact that much of the early foreign investment in China was directed toward more speculative investments such as real estate, a trend that seems to have abated.[49] The increase in utilized FDI indicates that Chinese officials and enterprises are making better use of, and can better absorb, foreign capital and the technology that typically accompanies it.

In accordance with central government plans, foreign investment in China has been funneled into specific regions and toward certain industrial and, increasingly, high-tech sectors. The evolution over time from restrictive "special economic zones" far away from the central government to specifically "high-tech development zones" in Beijing and throughout China demonstrates the change in thinking on the part of Chinese leaders with regard to China's "Open Door" policy toward attracting foreign investment in advanced technologies.

CHART 1
Foreign Direct Investment in China
(US$Million)



Sources: Adapted from figures provided by The China Business Review; and "China: Capital Flows and Foreign Debt," EIU Country Profile 1996-97 (London: The Economist Intelligence Unit Ltd., 1996), p. 53. FDI figures include joint ventures, cooperative development projects and investments related to wholly foreign-owned enterprises.

There are five distinct types of foreign investment "zones" in China, each with specific incentive structures, administrative authority and governing regulations, as well as preferred industry sectors (see Appendix B for a map of China). Following is a brief description of each of these zones.[50]

TABLE 6 Foreign Investment Zones in China	
Type of Investment Zone	**Year(s) Officially Established**
Special Economic Zones (SEZs)	1979-80
Economic and Trade Development Zones (ETDZs) [a.k.a. Open Port Cities]	1984-85
Free-Trade Zones (FTZs)	1992
High-Technology Development Zones (HTDZs)	1995
Special Administrative Region (SAR): Hong Kong	1997

Special Economic Zones (SEZs) [Established 1979/80]

China's cautious market reforms at first were allowed only in the so-called "Special Economic Zones" (SEZs) located in China's southeastern coastal provinces (Fujian and Guangdong) and usually comprising only a section of a particular urban area.[51] The SEZs function as special customs areas that provide preferential treatment for foreign-invested enterprises in terms of customs duties (up to 50 percent reduction), corporate income tax, and certain duty-free imports. The result of these policies has been remarkable growth (though this is also due largely to the distance of these cities and their people from the leaders in Beijing). In 1996, for instance Guangdong Province topped the list for Chinese exports, due to exports from the SEZ city of Shenzhen plus those of the capital Guangzhou. As it became more and more clear to the Chinese leadership that these zones were attracting large amounts of foreign investment, interest, and opportunities, other parts of China were gradually opened up to foreign investment as well.

TABLE 7 Special Economic Zones: Trade			
1996 Figures ($billion)	**Guangdong Province**	***Shenzhen***	***Guangzhou***
Exports	$59.34	$21.21	$7.08
Imports	$50.57	$17.85	$5.69
Balance	$8.77	$3.36	$1.39

Source: "Top 12 Trading Provinces and Cities, 1996," Business China, April 28, 1997, p. 7.

The SEZs, however, were not considered initially to be a complete success story in the eyes of Chinese leaders, who had been disappointed with the type of foreign investment attracted to the SEZs.[52] The unexpectedly greatest draw to the SEZs had not been in the high-technology industries but, rather, mostly in light industry and low-tech sectors.[53] Although the economic progress witnessed in the SEZs was welcome by Chinese leaders, it was decided that an emphasis on foreign investment in high-technology industry was needed in the future in order to promote technology acquisition and diffusion.

Open Port Cities (OPCs) and Economic and Trade Development Zones (ETDZs) [Established 1984/85]

In order to address the initial investment and technology shortcomings of the SEZs, Chinese leaders decided to open additional, select areas to foreign investment. Originally designed as "open port cities" due to their special import or investment policies and location along China's eastern coastline, the initial OPCs were by 1985 officially turned into Economic and Trade Development Zones (ETDZs). Although the central government recognizes and administers only 12 such zones, there may be as many as 200 ETDZs functioning in China with or without central government approval and each with separate investment incentives and regulations.[54] The ETDZs are reported to be more successful than were the original SEZs in terms of high-technology foreign investment with consumer electronics and computer-related businesses thriving, especially in the southern capital of Guangdong Province, Guangzhou (formerly known as Canton).

Free-Trade Zones (FTZs) [Established 1992]

These are specially designated urban areas selected by the central government for special treatment, incentive programs, and trade privileges. Shanghai's Pudong District — the Waigaoqiao area of Pudong in particular — is probably the most well-known of these zones. The other areas designated as Free-Trade Zones are Tianjin Harbor in the city of Tianjin (a city about 70 miles outside of Beijing that has been designated as an official ETDZ), Futian (an area of Shenzhen, which is itself a SEZ), Dalian (also an ETDZ), and the city of Haikou on Hainan Island.[55] The investment incentives provided in the FTZs are extremely attractive as they allow imports and exports free of any taxes or tariffs as long as foreign imports are not re-sold within China. Items imported into China through the FTZs but intended for sale in China are subject to normal tax and tariff rates, which remain excessively high in China.

High-Technology Development Zones (HTDZs) [Established 1995]

The success of investment strategies employed in the SEZs and other zones has led to the establishment of additional experimental zones in China specifically designed to attract foreign investment in high-technology industries. There are currently 53 "High-Technology Development Zones" (HTDZs), that can be found in all but three of China's inner-most provinces (Qinghai Province and the Tibet and Ningxia Autonomous Regions).[56] Each zone includes a number of "industrial parks" or "science and technology parks," which are open to both domestic and foreign high-tech investors.[57] As with ETDZs, there are numerous "unofficial" HTDZs established by local authorities without central government (State Council) approval. Some ETDZs have also been turned into HTDZs. These "zones" are a product of the "Torch Program" to promote industrial applications of technology and are located in proximity to existing or planned research institutions or technical, research and development centers.

The HTDZs comprise whole provinces, cities, or certain sections of urban areas where high-technology research and industry are concentrated (Beijing's well-known "Haidian" District, for example).[58] An important characteristic shared by all HTDZs is the use of a cooperative "three in one development system," which requires each HTDZ to include a university-based research center, an innovation center to provide applied technology for product development, and partnership with a commercial enterprise(s) to provide product manufacturing and marketing.[59] The HTDZs are expected to contribute significantly to China's export volume and to advances in Chinese high-technology and innovation capabilities. Finally, foreign investors are also offered preferential treatment as incentive to establish high-technology joint ventures within these zones. (See Appendix C for a list of HTDZs and the industrial or technology "parks" therein).

Special Administrative Region: Hong Kong [Established 1997]

China's renewed sovereignty over Hong Kong in July 1997 presented Chinese leaders with the problem of maintaining Hong Kong's world-renowned economic and financial strength and independence while also integrating Hong Kong into Mainland China. The decision was made to make Hong Kong into its own unique type of foreign investment zone that, per agreement with Great Britain, is to remain autonomous in terms of its economy for at least the next 50 years. In October 1997, Hong Kong's new governor, Tung Chee-hwai, announced a five-year plan for Hong Kong that included a provision for promoting development of Hong Kong's high-technology sector.[60]

Conclusion

Since these various zones were established, the growth experienced in China's coastal areas has far outpaced that of the rest of China, leading policy planners to shift attention to development of China's central and Western areas, which have until recently been closed to foreign investment. As a result, the Chinese leadership announced that under the Ninth Five-Year Plan (1996-2000) preferential treatment of foreign investment would be gradually phased out in the SEZs and elsewhere but increased in the inner regions where foreign investment is currently being sought. However, by late 1997 it had become apparent that foreign investment, especially in high-technology sectors, was declining substantially as a result of the phase-out plan announced in 1996 as part of China's efforts to establish "national treatment" for investment. In order to stem the decline, China's top economic expert, Premier Zhu Rongji, announced that tariff exemptions would be reinstated, but only for high-tech investments or those in excess of $30 million and conforming to China's industrial policies.[61]

As outlined above, China's foreign investment policies have expanded in terms of both regional distribution and types of investment. China's strategy of gradually opening up certain regions to foreign investment has led to impressive amounts of foreign direct investment, especially over the past several years. Exports outnumber imports in many of China's top trading, coastal zones (except in the cities of Beijing, Shanghai, and Tianjin). According to Chinese statistics, the share of Chinese exports produced in foreign-invested plants (either joint ventures or wholly foreign-owned enterprises) has grown significantly over the last decade, accounting for *nearly half* of all exports in 1996.[62]

Although China's efforts to establish "national treatment" of foreign and domestic investments will be a welcome reform that has been suggested by the US and other governments, it would be unwelcome if the SEZs gradually are stripped of their preferential foreign investment policies simply as part of a plan to attract more foreign investment into China's central and Western regions, essentially shifting the special development zones inland.[63] This shift would be cause for concern in the future if the various trade barriers now existing are also moved inland along with the foreign investment incentives.[64]

TABLE 8 Percentage of Total Chinese Exports Produced in Foreign-Invested Enterprises	
1985	2%
1990	12%
1996	48%

This Westward shift has already occurred to some degree (for example, with the establishment of HTDZs in almost every province) and is likely to continue. Preferential tax treatment and other incentives are increasingly being put forward to attract foreign investment in these relatively remote and underdeveloped areas. As US companies invest in these more remote areas, they will need to give even greater scrutiny to cooperative venture partners and end-users given the fact that most of China's military industrial complex is located in these central provinces, a legacy of the Cold War and China's relationship with the Soviet Union.[65] All of China's nuclear weapons labs and most of its defense-related research institutions are located in China's interior region, or "Third Front," which will serve to provide foreign investors with a ready pool of skilled, technical workers.[66]

CHINESE LAWS GOVERNING FOREIGN TECHNOLOGY IMPORTS

In the effort to develop indigenous high-tech industries, China's foreign import and investment policies have become increasingly selective and restrictive in the types of investment that are allowed or officially encouraged. In particular, there has been an increased emphasis on industry-specific investment and high-technology imports.

There are primarily three legal documents that govern the terms under which foreign enterprises transfer technologies to China:

- *Detailed Rules for Implementation of Regulations on Administration of Technology Import Contracts* (January 1988)
- *Provisional Regulations on Guiding the Direction of Foreign Investment* (Issued June 1995; Implemented October 1996)
- *Catalogue for Guiding Foreign Investment in Industries* (Issued with *Provisional Regulations* June 1995; Implemented October 1996)

> ***We should import, with our priorities in mind and on a selective basis, advanced technologies from abroad with a view to enhancing our own abilities of independent creation. As a developing country, China should attach greater importance to the application of the latest technological achievements and bring about a leap in its technological development.*** - Jiang Zemin's report to the 15th National Congress of the Communist Party of China, September 12, 1997.

These regulations were issued by China's State Council and are implemented and enforced by the Ministry of Foreign Trade and Economic Cooperation (MOFTEC). Although intended to provide better guidance and transparency with regard to China's regulations on technology imports and investments, these regulations have resulted instead in a good deal of confusion and controversy among foreign investors.

The "Detailed Rules" lay out the terms under which foreign firms may enter into a joint venture agreement with a Chinese partner(s). These "rules" were an attempt by the PRCG to make the foreign investment process more transparent for prospective investors. However, the publication of the "rules" have made it apparent that there are several ways in which foreign investors are treated differently compared to domestic Chinese investors.

Furthermore, the *Provisional Regulations* clearly denote for the first time in which sectors foreign investment will be allowed (i.e., agriculture, energy, telecommunications, raw materials, and advanced technology). Technology transfers from foreign enterprises are an explicit requirement for market access. According to the *China Country Commercial Guide, 1996-97*, "The government's stated intention in promulgating the new guidelines is to better channel foreign investment into infrastructure building and basic industries, especially, in the case of the latter, those involving advanced technologies and high value-added export-oriented products."

The most controversial aspect of the *Provisional Regulations* is the *Catalogue for Guiding Foreign Investment in Industries*, which specifies the industries in which foreign investment is officially "encouraged," "permitted," or "prohibited." Chinese leaders are unabashed about their intention: "These policy guidelines were designed to encourage foreign investors to move away from labour-intensive projects in manufacturing and real estate and towards joint ventures in infrastructure construction, involving advanced technology and high value-added goods."[67]

TABLE 9
Domestic and Foreign Technology Transfers Under Chinese Law

	Detailed Rules[68] **Governing Foreign Entities**	*Technology Contract Law*[69] **Governing Domestic Entities**
Ownership Rights	Sole ownership of newly developed technology is given to Chinese enterprise; foreign party is required to pay fee for technology not directly developed by foreign licensor.	Ownership of technology is the prerogative of the parties involved with "full utilization" of technological developments by all other parties.
Utilization Rights	Includes a list of nine "unreasonable restrictions" that foreign parties are prohibited from imposing on technology transfer contracts with Chinese parties.[70]	No restrictions listed.
Performance Guarantees & Feasibility Studies	Performance guarantees are required by foreign licensor (despite often difficult conditions); feasibility studies are essential for contract approval.	No technical performance guarantee or feasibility study necessary, the latter being discretionary.
Protection of Trade Secrets	"During the process of negotiation and contract approval, the intended licensee has no obligation to keep the foreign technology confidential or refrain from using it unless a separate confidentiality agreement is signed." Work units, but not employees, are potentially liable for misappropriation of proprietary information. Technology licenses usually expire after 5-10 years or at end of contract, allowing Chinese partner free and unrestricted use of technology.	Provides two forms of intellectual property protection: confidentiality throughout negotiations and contract approval process (regardless of outcome); and confidentiality of proprietary information acquired by either employees or work units, both of whom are liable.

Source: Erin Sullivan, Esq., "Chinese Laws and Policy Concerning Science and Technology Exchange," Official Memorandum, US Department of Commerce, Technology Administration, Office of Technology Policy, July 12, 1995.

TABLE 10
The Provisional Regulations for Guiding the Direction of Foreign Investment, June 1995

	"Encouraged"	"Restricted"	"Prohibited"	"Permitted"
General Description	Foreign investment is "encouraged" in areas in which China is seeking new technologies, higher quality products, assistance in building infrastructure, and more efficient use of domestic resources and raw materials, especially in Western/central China.	Foreign investment is "restricted" in areas in which China has developed a degree of domestic capability and capacity (usually via previously imported technology), and areas in which China is experimenting with investment liberalization or attempting to control foreign investment.	Foreign investment is "prohibited" in areas where a domestic Chinese industry or state monopoly exists or foreign investment would be potentially disruptive or threatening in some manner.	*None specified*
Industry Areas	**Transportation** (rural railway, urban subway, and lightrail trains; highway construction, civilian airport construction and operation, auto parts*) **Energy** (nuclear, hydroelectric and alternative energy power plants; ethylene, gas, and oil pipeline construction **Electronics*** (microelectronics, information technologies, ATM exchange equipment, 900 MHz digital cellular mobile communications, optical fibers, precision instrument repairs and after-sales service, software development and production) **Aerospace*** (civilian satellite manufacturing, civilian aircraft and engine production, air traffic control equipment) **Agriculture/Environment** (land reclamation, water quality, biotechnologies, chemical fertilizers, pesticides)	**Transportation** (air transport, general-purpose aviation; auto sedans*, light vans, motorcycles, auto engines, trunk railroads, waterway transport, and cross-border motor vehicle transport) **Energy** (thermal & nuclear power equipment) **Electronics*** (color televisions, tubes, and glass shells, video cameras, VCRs, program-controlled switchboard equipment; production, publication or sale of audio-visual products) **Retail & Wholesale** (material supply, marketing) **Financial Services** (foreign trade rights for certain joint venture enterprises, banking, securities, insurance, auditing, accounting legal counseling) **Raw Materials** (mining, dressing, smelting, & processing of metallic and non-metallic minerals	**Public utilities,** particularly post & telecommunications*; **Media** (television, radio, movie theaters, journalism); **Military weaponry;** **Air traffic control;** **Financial / futures trade;** **Traditional Chinese medicines and handicrafts;** **Wildlife resources;** **Certain mining projects;** and **Any other areas that would "endanger state security or harm the public interest"**	*Generally all areas not specifically listed in the following categories*
Treatment	Foreign-invested projects will receive unspecified preferential treatment (e.g., tax breaks)	Foreign investment is permitted only in areas specifically approved under China's industrial policies or state investment plans; other restrictions may also apply (i.e., limited monetary contribution by Chinese partner in venture, fixed term investment, longer or higher-level approval process etc.)	No joint ventures or wholly foreign owned enterprises are permitted.	*Foreign-invested projects are allowed*

Sources: The Economist Intelligence Unit Limited, February 1996, pp. 10, 17; and Ministry of Science & Technology, China Science & Technology Newsletter (various issues 1997 and 1998). * Industry sectors addressed in detail in Part 2 of this study.

TABLE 11
Industry Areas in Which WFOEs Are Prohibited or PRC Partner(s) Must Have Controlling Interest

- **Transportation:** import/export of motor vehicles; construction/operation of local railways and bridges, tunnels or ferry/water transportation;
- **Raw materials:** high-purity magnesium; mining, extraction or processing of copper, lead, zinc, aluminum, coking coal, wood from endangered trees, precious metals, non-ferrous metals, rare earths, diamonds and other non-metallic precious gems;
- **Financial:** foreign trade, retail or wholesale commercial ventures, tourist industry services, accounting, auditing, legal, or securities consulting firms; educational or translation services; publishing or printing.

Conclusion

China's investment policies are explicit in the type of foreign investment that is "prohibited," "permitted," or "encouraged," with the latter category focusing on advanced technologies. Foreign investors in high-tech industries enjoy preferential treatment, such as tax rebates and lower tariff rates as incentive to transfer technology, but are at the same time subject to regulations not imposed on domestic competitors. Furthermore, according to the Office of the US Trade Representative, "high-technology items whose purchase is incorporated into state or sector plans, for instance, have been imported at tariff rates significantly lower than the published MFN rate."[71] Although China has made some progress in eliminating barriers to trade and investment in accordance with the 1992 Sino-US Memorandum of Understanding (MOU) on Market Access, barriers remain in the form of restrictions on investment, local content requirements, product export quotas, and other non-tariff barriers. These issues and how they pertain to US industry in China are addressed in greater detail in Part 2 of this study.

THE ROLE OF TECHNOLOGY IN CHINA'S ECONOMIC, INDUSTRIAL, AND DEFENSE SECTORS

China views high technology as the key factor driving its modern economic, industrial, and military development. The following section outlines China's plans for developing these sectors.

High Technology in the Chinese Economy

China's economy remains the world's fastest growing economy, with an average annual Gross Domestic Product (GDP) growth rate of 9.3 percent as of 1997.[72] As a result of China's "Open Door" policies since 1978, China's economy has become increasingly interdependent with the global economy, including in high-technology industries. A large percentage of foreign direct investment coming into China is in high-tech ventures. This has had several positive and negative consequences:

Positive:

- An increase in Chinese exports, including some high-tech products such as electronics and telecommunications equipment;
- A rising standard of living, especially along the coastal and urban areas; and

- The emergence of a "Greater China" arising from the dynamic economic interdependencies among China, Taiwan, and Hong Kong (and increasingly Japan, Korea, and Southeast Asian states as well).

Negative:

- Unbalanced trade with several countries, particularly the United States. The US trade deficit with China is second only the US trade deficit with Japan (this is according to US figures, though not per PRCG statistics due to inclusion/exclusion of Hong Kong transhipments);[73]
- Unbalanced growth: economic progress in the coastal region at the expense of the hinterland;
- An emerging anxiety among Chinese consumers regarding the influx of foreign brand names and products (a particularly delicate subject given China's past experience with foreign imperialism);[74] and
- Greater domestic demand for high-tech items, which typically results in greater demand for energy.

China's current trade and development policies are designed to enhance the positive aspects of trade but not necessarily to alleviate all the negative consequences. Thus, it will be a difficult challenge for Chinese leaders to maintain economic growth while also dealing with the negative side of foreign trade and investment in China. If recent reports are any indication, this balance will continue to be a hotly debated topic in China.[75]

TABLE 12
Technology Policies in Developing Nations

Phase I: ***Development of Infrastructure Base for Foreign Multinationals***	Solicitation of Foreign Direct Investment
	Creation of Attractive Investment Regimes: Tax, Labor, and Regulatory Incentives
	Public Expenditures on Infrastructure: Information Technologies, Energy, and Transportation
Phase II: ***Building National Domestic Economy through Foreign Technology Acquisition***	Offset Policies for Market Access
	Technology Transfer and Technology Acquisition Strategies
	Expanded Tax Incentives
	Incentives for Use of Domestic Subcontractors and Suppliers
Phase III: ***Development of Indigenous R&D and Commercialization Capability***	Government Funding of R&D
	Investment in Technology Commercialization
	Investment in Higher Education and Human Resource Development
	Funding of R&D in Specific High-Technology Sectors

Source: Taken from Figure 11 in Graham R. Mitchell, "The Global Context for US Technology Policy," US Department of Commerce, Office of Technology Policy.

China's policy for economic and technological growth is not unlike those of other developing countries. The typical development strategy and policies followed by developing nations consists of three distinct stages, as depicted in the table below. What makes the case of China interesting, however, is the fact that all of these phases are occurring simultaneously and have been for at least a decade.

China's Ninth Five-Year Plan (1996-2000)

China's blueprint for economic growth through the end of this century is set out by China's Ninth Five-Year Plan. As with other five-year state plans, this version includes lofty and ambitious goals to be achieved over the next few years (see figure below). More important, perhaps, are the methods that are planned to reach these goals, which include advances in science and technology as well as the use of high technology as a means of increasing product efficiency plus higher value-added goods and, therefore, exports as well.

This plan also calls for, among other things, a shift of foreign investment toward the central and Western regions of China, which will be enticed with low tax and other preferential investment policies. From Chinese statements and documents it seems clear, however, that as "national treatment" is implemented for foreign and domestic enterprises in the coastal areas, to the extent that any preferential investment policies remain in the latter regions, they will be geared toward high-technology industries.

TABLE 13
The Ninth Five-Year Plan (1996-2000)

Goals for 2000-2010:

- Quadruple 1980 level per-capita GNP by the year 2000;
- Double GNP by 2010;
- Maintain an annual growth rate of at least eight percent through the year 2010; and
- Attract more foreign investment in the "pillar" industries.

Methods of Attaining Goals:

- Promoting sustainable growth rate and higher-quality products;
- Further developing the market economy by shifting economic priorities "from relying on building more production facilities to relying mainly on improved management and advances in science and technology";
- Promoting greater efficiency in producing high value-added goods using new, high technologies; and
- Implementing "National Treatment" of foreign-invested enterprises (ending preferential tax exemptions in coastal areas/SEZs compensated by greater access to the domestic market for foreign investments in China's rural, central and Western regions).

Sources: "China," EIU Country Report, 2nd Quarter 1997 (London: The Economist Intelligence Unit Ltd., 1997), p. 28; "China: Economic Performance," EIU Country Profile 1996-97 (London: The Economist Intelligence Unit Ltd., 1996), p. 29.

"Pillar" Industries

The Chinese leadership has identified several industrial sectors as "pillar" industries, namely machinery, electronics, petrochemicals, automobiles and construction materials. The central government will provide more than $60 billion through the year 2000 to promote domestic capabilities in these industries.[76] These pillar industries will be developed with state support as the primary engines of continued economic growth in China. The central government has also identified 1,000 SOEs and the general areas of agriculture, basic industries, infrastructure,

energy resources and conservation, as well as high-technology as sectors to receive major support and funding, including foreign investment.[77]

China's Ninth Five-Year Plan (1996-2000) assumes a prominent role of foreign technology in developing these pillar industries:

> *"In developing pillar industries, the initial technology must be relatively advanced. While importing advanced technologies, we should boost our own technological development and renovation capabilities, build up the scale of economies and pay attention to economic returns"* - Premier Li Peng, Report on the Outline of the Ninth Five-Year Plan, 1996.[78]

Furthermore, China's State Development Planning Commission (SDPC) has introduced "industrial policies" designed to develop and protect domestic markets in some of these pillar industries. China's "industrial policies" for designated sectors (such as automotive and electronics) typically require increasing percentages of local content over time, mandated exports based on increased levels of production, and indirect distribution of production through PRC companies.

High Technology in Chinese Industry

China's industrial strategy has evolved through several very different and difficult stages. An enduring legacy of China's alliance with the Soviet Union in the 1950s is that much of China's heavy industrial sector is located in central or Western China, far away from the booming coastal economies. Furthermore, the technology, machinery, and bureaucracy inherited from the Soviet Union still dominate most of China's industrial sector. This is due to the decades lost to China's internal, ideological upheaval during much of the 1950s (the Great Leap Forward) and the 1960s-70s (Cultural Revolution). China's leaders are well aware of the opportunities lost to their nation's development during these years and are intent on catching up to the technological standards of their neighbors and of the Western powers.

Chinese leaders have also come to realize the complexities and difficulties inherent in technology absorption and assimilation — that technology imports alone do not necessarily constitute technological know-how or capabilities in the long-run. China's past industrial policies focused mainly on acquiring whole production lines, facilities, systems, and basic equipment; licensing of foreign technology; and preferences for the most advanced technological products. While continuing this general technology acquisition philosophy, the current Chinese policy on technology imports is increasingly geared toward acquiring "soft" and "process" technology (the "how-to" type of knowledge) in order to enhance the quality and sophistication of China's technology base and products as well as to better absorb the inflow of technology from foreign investment and trade.

The result of this new thinking, ironically, seems to be *increased* state planning, involvement, and control over decisions regarding approvals of foreign joint venture agreements. Despite what may appear to be more relaxed licensing and contract approval procedures in China, Chinese government officials are scrutinizing foreign technology transfers to China more closely.[79] Rather than ease government controls and allow technology imports to be more responsive to market demand, the Chinese government seems to have decided to try to manage technology imports by formulating more specific technology import and investment policies to assist domestic Chinese industry. As a result, the USTR notes that, "Based upon experiences of US firms, [Chinese] government approval, at some level, is required for most government projects in China for which imports are required."[80] This would also seem to contradict the simultaneous Chinese government effort to move more of China's science and technology and research and development programs

toward market-based incentive schemes in collaboration with Chinese universities or enterprises (the philosophy of: "Anchor at one end and let the other end be free").

Nevertheless, China's new technology import policies clearly reflect the lessons of many years of acquiring high technologies that were inappropriate for China's economy and therefore could not be properly absorbed. According to a recent Chinese government report on this persistent problem, the preference given to "the very latest and best technology over less advanced technologies" in past Chinese technology import policies led to "severe losses" and an inability to absorb or use these technologies in an effective or efficient manner. For instance, although many of China's labs are reportedly equipped with sophisticated, late 1980s-era technology, much of this equipment seems to have gone unused.[81]

Chinese policy statements on technology imports frequently cite the need for technology that is advanced, but now also require a plan for effective utilization of the technology by Chinese industry. Accordingly, Chinese importers and joint venture partners are directed to deal only in technologies that will assist the effort to build specific areas of Chinese industry. An emphasis is also now put on acquiring and mastering the basic materials, components or parts, and standards that are used in high-technology products in order to provide the capability to develop a domestic industry in various high-tech sectors.

Over the last few years, China has also endeavored to make its investment and trade policies more transparent. Although Chinese leaders had for a long time drawn up internal trade and investment policies that were then implemented by Chinese ministries and officials, the exact terms and language of these policies were often not available to foreign businessmen. Furthermore, Chinese officials would largely base their decisions regarding approval of foreign invested enterprise contracts on "industrial policies" set by the state and outlining the priorities and preferences to be given to certain industry sectors, but which were also not publicly available. This made the prospect of doing business in China a very complex, opaque, and legally hazardous venture. This situation still persists to some extent. As a result, publication of Chinese policies was included as one of the provisions of a 1992 Sino-US Memorandum of Understanding (MOU) on Market Access. In 1994, China announced and published its new "Auto Industry Industrial Policy" (AIIP). This was the first, and thus far only, "industrial policy" to be published, and it was surprisingly blunt in its stated goals.[82] Moreover, many of the provisions included in the AIIP appear aimed at limiting foreign access to China's auto market.

Although other "industrial policies" have yet to be made public (probably due to the harsh international criticism received following publication of the AIIP), it is clear that Chinese officials are *implementing* similar "industrial policies" in the electronics and telecommunications sectors for instance. "Guidelines" on foreign investment in these and other sectors are expected to be made public eventually and may serve to illuminate the reasons behind the policies and regulations currently being implemented.[83]

"We should attach great importance to strengthening the army through technology, enhance research in defence-related science and technology, base the development of arms and other military equipment on our own strength, give priority to developing arms and equipment needed for defence operations under high-tech conditions and lay stress on developing new types of weapons and equipment" - Premier Li Peng, "Report on the Outline of the Ninth Five-Year Plan for National Economic and Social Development and the Long-Range Objectives to the Year 2010" (Delivered at the Fourth Session of the Eighth National People's Congress on March 5, 1996).

High Technology in China's Military Sector

China's high-tech development strategy has a military component. Chinese leaders have been attempting for more than a decade to convert ("spin-off") much of the country's defense

industrial production into commercially viable enterprises. This effort has been successful in many cases, but has also had a number of unexpected consequences that are described below. The extent to which this strategy also includes "spin-ons" (commercial to military applications) is uncertain.

Shortly after having opened its borders to foreign investment, China's leadership embarked on a defense conversion effort (complementing China's industrial, science and technology reform programs). The defense conversion plan has been accompanied more recently by an effort at high-technology acquisition intended to serve both China's civilian and military modernization efforts.

TABLE 14

Defense Conversion Efforts (1982-present)
Defense industrial technology adapted to civilian/commercial applications (spin-offs)

Characteristics: emphasis on quantity over quality ("copy production" doctrine); vertical hierarchy with highly redundant mass production system; emphasis on self-reliance; scarcity of communication and know-how; political versus technical goals and quotas; and lack of incentive toward innovation or "cross-fertilization" of technology.

High Technology Acquisition (1990s-present)
Civilian high-technology converted to military applications (spin-ons)

Characteristics: modern industrial base modeled on Western/US system; increasingly located in urban/coastal areas and abroad; emphasis on R&D, quality over quantity; cross-fertilization of know-how across military industry; emphasis on self-reliance but with occasional purchases of foreign equipment to fill gaps; increased communication of technological know-how; more realistic technological goals stated; profit-making incentives expected to spur technological innovation

Current strategy: *a mix of conversion-reversion, or "swords to plowshares...and better swords"*

Source: Bates Gill, "China and the Revolution in Military Affairs: Assessing Economic and Socio-cultural Factors," Strategic Studies Institute, Conference Series, National Defense University Press, May 1996.

Defense Conversion

The Chinese concept of defense conversion is based on the so-called "16-Character Policy" set by Deng Xiaoping in the late 1970s to guide science and technology development in the defense realm toward production of more commercially viable products (spin-offs). This policy remains the guiding principle governing defense conversion efforts in China today. It is translated as: "integrate the military with the civilian; integrate war with peace; give priority to weaponry; make goods for civilian use and use the profits thus generated to maintain the military" [*junmin jiehe, pingzhan jiehe, junpin youxian, yimin yangjun*].[84] It is important to note that this definition is interpreted by Chinese officials to mean both defense conversion and reversion capabilities, as needed.[85]

Although China's defense industrial complex is separate from the uniformed military forces (the PLA) with the former under civilian authority (China's State Council) and the latter under the leadership of the Central Military Commission, this dual-use philosophy of defense conversion is evident in China's current bureaucratic structure as well (see Appendix D for a chart of China's military industrial complex). In 1982, the Commission on Science, Technology and Industry for National Defense (COSTIND) was formed for the express purpose of coordinating but also separating policies and resources related to military and civilian enterprises. A 1995 US Government document described COSTIND as "a key organization that links the two [civilian and military] hierarchies by coordinating and overseeing defense-related development, production, technology transfer, and marketing.[86] In March 1998, the National People's Congress announced that COSTIND would be moved solely under the State Council's civilian authority to deal with defense-related research and procurement issues. COSTIND's former military responsibilities (including weapons testing and development) have been assigned to the General Armaments Division (GAD), a newly established bureau under the Central Military Commission.

China's development strategy for modernizing its military and industrial sectors has not changed and is primarily based on advances in science, research, and technology. In 1995, the Communist Party of China's Central Committee (CPCCC) and State Council "decided to accelerate the development of national defense science and technology" in order to assist these efforts.[87] Although figures on China's defense spending are not made public, a general consensus seems to be that China's defense-related R&D is in the $1-$5 billion range per year, or no more than ten percent of the overall defense budget.[88]

Domestic military or defense-related R&D will, therefore, necessarily be accompanied by acquisition of foreign technologies as part of the defense conversion and modernization efforts. Accordingly, China's defense industry "has cooperated extensively with foreign partners in developing products for civilian use. By 1994, over 300 Sino-foreign joint ventures had been established" with Chinese defense industrial institutions or corporations.[89]

High Technology Acquisition

The renewed effort to improve and expand military research and development is due in large part to lessons gleaned from the 1991 Gulf War, which has been the subject of numerous articles, discussions, and debates in China.[90] There is new evidence suggesting China's military is thinking about (and possibly developing strategies and weapons to counter) the technologies stressed in the most modern defense systems, which are increasingly based on information technologies and the Revolution in Military Affairs (RMA) concept, as demonstrated during the Gulf War.[91] Thus, as a US expert on China's military modernization points out, "China's emerging power projection requirements have resulted in increased attention being paid to the acquisition of modern combat aircraft, new surface combatants and submarines, improved C^3I systems, and new tactical missile systems and missile defenses. At the same time, China's acquisition plans not only reflect its shift away from a land-based territorial defense, but also the lessons it drew from the Gulf War regarding the growing impact of advanced technologies (e.g., electronics and information technologies) on modern warfare."[92] China currently lags far behind the West and the United States, however, in terms of its capabilities in many of these areas.

Despite a few "pockets of excellence," China's current military capabilities are considered by Western/US analysts to be very limited due to aged technologies and platforms, organizational inefficiencies, increasing corruption, and numerous bureaucratic obstacles. As a result, the PLA has been repeatedly reduced in terms of manpower over the last several years in an effort to save money and to make China's military forces more efficient as well as more self-sufficient financially.[93] In the meantime, however, Chinese military and civilian planners have begun to focus their efforts on developing "comprehensive national power," by which they mean combined economic, scientific, technological, and military power.

Deng Xiaoping laid out in 1978 China's "Four Modernizations" of industry, agriculture, science and technology, and lastly, national defense/military modernization to make clear the priorities and direction for China's future modernization and development. Thus far, it seems that Chinese President Jiang Zemin is following Deng's lead in terms of both policy and national priorities, which means that China's defense-industrial sector will likely continue to serve the commercial/industrial side of China's economy in the near- to mid-term future.

Overall, China's defense conversion plans have met with mixed results. On the one hand, the charge from central leaders for China's military and defense-related industries to become financially independent and to turn manufacturing to commercially valuable items has allowed more flexibility and competition in the defense industrial sector, but also increased disorganization, redundancy in production lines, and a decline in interest and prestige in military production. On the other hand, the percentage of civilian products made by defense industrial enterprises today is

between 80 and 90 percent of output as compared to 73 percent in 1992 and only eight percent when the defense conversion program first began.[94]

The automotive industry is a good example of the effects of China's defense conversion program. The results of government incentive programs for converting production in former defense industrial plants to civilian products has been a large increase in the number of auto and motorcycle facilities in China, significantly increased production, but also capacity far beyond what current production levels warrant due to redundant facilities.[95] Thus, conversion itself may not be a problem, but the successful, profitable, and useful conversion of China's defense industrial sector has yet to be fully realized.

Conclusion

By 1995, it had become apparent to Chinese leaders that something more was needed to stimulate China's industrial reform and defense conversion programs. The resulting 'acceleration' policies of that year for both sectors were intended to further progress by means of increased resources devoted to science and technology. Acquisition of foreign technologies is also a significant part of China's plans to develop its economy, industries, and military.

China's military capabilities are considered by Western/US standards to be far behind in terms of Western models of military technologies as well as in command, control, and force structure. However, the extent to which the commercial activities of China's civilian defense industrial complex are tied to the uniformed military departments (PLA) is not well understood in the West.[96] Much more research is needed on this issue, which is sure to become more pressing as foreign investment in China is gradually moved Westward and adjacent to the Chinese "Third Front" military institutes.

THE ROLE OF US TECHNOLOGY

China's current modernization and technology import strategies call for diverse international sources of technology.[97] For instance, China's "Golden Projects" (to establish national fiber-optic communications networks), which have been compared to the 19th Century American railroad system development program, have reportedly involved over 250 foreign firms, all of whom are providing their Chinese partners (that are in this case mandatory) with modern technology.[98] As a result, the rush to get a foothold in the China market, and in particular this project, has resulted in competition among companies of different nations for market access based largely on comparative technological advantage and the technology giveaways that serve to demonstrate a company's commitment to China.

One of the more common approaches to establishing a presence as well as goodwill in China is by donating equipment or funds for training or education in China (see chart below). Numerous US high-tech firms have done so, often in connection with one of China's leading universities or research centers. US firms benefit in this way also in terms of identifying prospective employees to work in their joint ventures and in improving the skills of all employees and China's labor force in general. Technology primarily in the form of know-how is, therefore, likely being transferred quite frequently to China's elite academic and technical communities. What overall or long-term effect(s) this may be having in China, however, is not yet clear.

The most significant commercial offset and/or initiative put forward by US companies and others in seeking approval for joint venture manufacturing partnerships or facilities in China is the establishment of an institution, center, or lab devoted to joint research and development (see chart below for examples). This is a relatively recent trend and involves many high-tech US firms in China. Compared to donations of equipment and scholarships as well as training for Chinese workers (all of which have been offered by high-tech US firms in China such as IBM, Intel, and

Wang over the last decade or more), the new R&D initiatives would appear to involve more technology transfer.

Furthermore, joint research agreements typically involve a partnership with one or more of China's leading universities (e.g., Qinghua, Beijing, or Fudan Universities) or state ministries involved in scientific and technological development (such as the Chinese Academy of Sciences). Whereas in the 1980s there was very little research being conducted in China's universities and less so in commercial enterprises, today this is officially encouraged and happening frequently .[99]

Examples of US Corporate Donations, Scholarships, and Training Programs in China

Benefits to US companies include the following: identification of prospective employees, training and improvement in employee skills; promotion of positive view of US companies; facilitates guanxi (connections) with local officials, etc.

Donated Equipment

- **Boeing** - has contributed two multi-million dollar simulators to the Civil Aviation Flying College (CAFC) in training assistance effort;
- **Hewlett-Packard** - donation of $200,000 worth of "advanced instruments" to Qinghua University (in conjunction with joint venture electronics research lab);[100]
- **IBM** - semiconductor fabrication tools donated in November 1996 to the Institute of Microelectronics of Tsinghua University (METU)[101]; $32 million worth of computer servers to four Chinese universities in 1997; $25 million worth of computers, research funding, and support donated as part of 1995 agreement with State Education Commission to establish Information Technology Centers in 23 Chinese universities located in 16 separate cities.[102] In 1985, IBM had donated 100 (model 5550) machines to Beijing University, Tsinghua, Fudan and Jiaotong Universities;[103]
- **Intel** - donated Pentium processor-based computers to Beijing and Tsinghua Universities in Beijing as well as more than 60 Pentium computers to Fudan and Jiaotong Universities in Shanghai; donation of Pentium-based servers to Nanjing University; and donation of Pentium-based workstations to the University of Electronics Science & Technology in Chengdu;
- **Lattice Semiconductor Co.** - donated educational and research computer software to Fudan University's Shanghai Communications Institute;
- **Microsoft** - software donated;
- **Motorola** - electronics kits and technical manuals donated to 30 Chinese universities; and
- **Texas Instruments** - $1 million donation of "latest components, software and development tools" as well as personal computers for new Technology Center established in September 1996 at Qinghua University.

Scholarships/Training

- **Altera** - establishment of "a programmable logic training center for design professionals...will be equipped with software, hardware, and components from Altera" at Qinghua University; enrollment of both students and engineering professionals;[104]
- **Ameritech International** - $135 million grant;
- **AT&T** - establishment of technical support center in Guangzhou to assist senior managers and engineers of an AT&T partner, the Guangdong Posts & Telecommunications (GPT): "AT&T Scholarship for Telecommunications and Technology," established for the purpose of supporting "Chinese undergraduate and graduate students who aspire to careers in telecommunications;" and AT&T donation of computer hardware to link Hope Foundation headquarters in Beijing with regional offices;
- **GE Aircraft** (with CFM International) - Aircraft Engine Maintenance Training Center adjacent to the CAAC's Civil Aviation Flying College in Guanghan, Sichuan Province, "the first such world-class training facility outside the US and France," with curriculum identical to that in the United States;
- **IBM** - $25 million in 1995 for university-based research and education in information technology, including "advanced training courses for teachers in these universities in order to train them in new technologies as well as appropriate teaching skills"[105]; IBM Technology Centers to be established in 23 Chinese universities per agreement with State Education Commission in 1995;
- **Intel** - at least 20 academic scholarships at Fudan and Jiaotong Universities in Shanghai;
- **McDonnell Douglas** - pilot training center, Liaoning Province;
- **Motorola** - Motorola University: established to "train employees, customers, suppliers, and government officials in a range of management, technical and other areas," with branches established in Beijing (1993) and in Tianjin (1995); Chinese Accelerated Management Program (CAMP): established in 1994 for Motorola University "as an intensive management training program for high-potential Chinese employees." The 14-month program "includes classroom and, on-the-job training, as well as a two-month overseas rotation"; College Scholarships: 2,000 estimated scholarships provided since 1992 "for Chinese students; and Project Hope: (Chinese government project to improve and expand rural elementary education) donations by Motorola of $820,000 in 1996, making Motorola the largest donor;
- **Novell** - "training centers throughout the country"[106];
- **Rockwell** -Three training centers established with Harbin Institute of Technology, Zhejiang University, and Guangdong University of Technology. Rockwell has "provided the latest state-of-the-art automation equipment and software to these universities and training to the lecturers... to train a large number of students in this technology and establish more training centers with other universities in major cities of China";

- **Silicon Graphics** - Training Center established with Shanghai Automobile Industry Technology Center for employee use of SGI workstations;
- **Sun Microsystems** - Building 10 Java training centers at major universities; plus five Java "competency centers" and manufacturing training center at Jiaotong University in Shanghai, and a finance application lab at Fudan University;
- **Texas Instruments** - China University Program begun in 1993 to establish "technical libraries and laboratories in key universities, and provide technical documentation, samples and development tools." The first such program was founded in September 1996, the TI-Tsinghua Technology Centre, at Tsinghua University in Beijing; a similar center is planned for Shanghai. In addition, in 1995 TI established Digital Signal Processing Elite Laboratories at Qinghua University in Beijing as well as at Fudan and Jiaotong Universities in Shanghai.[107]

Sources: Department of Commerce, Office of Technology Policy, US-China Business Council, Company press releases/websites, press reports.

There are also numerous examples of Sino-foreign joint venture agreements that seem increasingly to depend on a side agreement to also collaborate on research with Chinese universities, state-run research institutions, or government ministries or organizations. This includes many with US multinational, high-tech corporations. According to Chinese statistics, approximately 400 joint research projects (about ten percent of the total number of joint enterprise-research institute projects) had been established with foreign joint venture partners in China by mid-1995.[108] Table 15 shows one US high-tech company's path to joint venture or other similar agreements and the connection with R&D and other technology-related offset agreements.[109]

US Sponsored R&D / Technology Centers In China

Examples: (not an exhaustive list)

- **Bell Labs** (R&D arm of Lucent Technologies) - Two R&D facilities, one each in Beijing and Shanghai for $4 million to "focus on optical, wireless, multimedia communications, digital signal processing, network planning and design, and software technology. The facilities will transfer technology to China and bring technology research into products for the Chinese market";[110]
- **Computer Associates International, Inc. (CA)** - Fudan CA-Unicenter Technical Support Center to provide Fudan with CA-Unicenter software and technical support;
- **Ford Motor Co.** - Two R&D centers: one with Qinghua University in Beijing (China's equivalent of MIT) and one with Jiling University in Xian; Two "Labs": one with Jiaotong University (involving the latest software for advanced computer-aided design and training of PRC employees) and a recent agreement with Fudan University's Institute of Electronics in Shanghai to establish a "Joint Research Institute of Automotive Electronics";
- **General Motors** - GM has set up three R&D centers in China to date (several more are expected): The "GM in China Technology Institute" at Qinghua University for R&D, post-graduate education and training in auto-making (1995); The "Powertrain Technology Institute" with Jiaotong University (1995); and a new, $4 million center for R&D with its Shanghai auto joint venture partner;
- **Hewlett Packard** - R&D center with SSTC's High-technology Research & Development Center (renewable two-year agreement) in Beijing and an electronics research lab with Qinghua University;[111]
- **IBM** - China Research Laboratory; established in 1995 in Beijing "to develop software products for sale in China and around the world" including speech recognition software, Chinese language word processing, and network applications; Software Development Center, "one of seven IBM labs worldwide and the only one in a developing country" and involving "hypertext links for digitized video footage, and software that can archive photographic images and search for them by attributes such as color, texture or shape";[112]
- **Intel** - Intel Architecture Development Lab, established in September 1994 "to assist local Chinese software developers produce Chinese software applications on the Intel architecture"; May 1998 announcement of a new applied research center —the Intel China Research Center— to be established in Beijing;
- **Microtec Research Inc.** - Center of Embedded Software Designing;
- **Motorola** - R&D for advanced communications & computers (Beijing); Asia Manufacturing Research Center (AMRC) established in Beijing (12/95) as first Motorola manufacturing research lab outside the US; AMRC established (earlier 1995) joint venture manufacturing research agreement with the Computer Integrated Manufacturing System-Engineering Center at Qinghua University in Beijing; Software Centers in Beijing and Tianjin, plus "Labs" established with Chinese universities (three are for microprocessors/microcontrollers; five are communications labs); expansion to 20 different universities in China expected by 2000; Product

Development Laboratory established with SSTC's Intelligent Computer Research and Development Center; Joint Development Laboratory (JDL) for Advanced Computer and Communication Technologies;[113]

- **Rockwell** - MOU with Chinese Ministry of Electronics Industry to establish "industry design centers" to initially focus on development of modem and wireless communications;
- **Silicon Graphics** - Beijing Technology Centre, "a facility for technology exchange and support for the development of supercomputing and visualization applications in China." The establishment of the center coincided with Silicon Graphics first WFOE subsidiary in China in November 1995;
- **Sun Microsystems** - Beijing software development center; and
- **Texas Instruments** - Design/technology Center.

Sources: Office of Technology Policy, US-China Business Council, Company press releases/website, press reports.

TABLE 15 Case Study: Intel

YEAR/MONTH		AGREEMENT TERMS	TYPE OF AGREEMENT
1985	*December*	Representative office established in Beijing's Haidian District.	**Representative Office**
1988	*October*	Joint venture established "to manufacture 16- and 32-bit microcomputers for industrial control applications."	**Manufacturing Joint Venture**
1994	*March*	"Technology Cooperation Memorandum of Understanding (MOU)" signed with China Electronics Corp. (CEC) subsidiary, Huajing Electronics Group, "to test and assemble Intel Microcontrollers delivered in wafer form by Intel."	*MOU on Technology Cooperation*
	March	"Pentium processor high performance computers [donated] to Tsinghua and Beijing Universities for the establishment of educational labs."	*Donation of Computer Equipment*
	April	"Established nation-wide Intel Advanced Network Reseller (iANR) program to provide training, technical assistance and marketing services support for Intel Branded networking products."	*Training Program*
	September	"Established Intel Architecture Development Co., Ltd. in Shanghai, a wholly-owned foreign entity of Intel."	**WFOE**
	October	MOU signed with Jitong Communications Co., Ltd. "to begin joint cooperation on a wide variety of personal computer industry related projects," including establishing exhibition center in Beijing and "promotion of Intel ProShare Personal Conferencing products in China."	*MOU on Computer Industry Cooperation*
	December	Establishment of Intel Architecture Development Lab support center "to offer software developer support and information exchange with the PRC," including seminar series for Chinese software developers.	*Lab Support Center Established*
1995	*March*	Sale of first Intel Paragon (Scaleable) Supercomputer in China to Daqing Petroleum for seismic data processing.	Supercomputer Sale
	May	• "Signed an agreement with Founder group to promote Pentium processor-based color desktop publishing (DTP) technology" • Establishment of "color DTP centers" in several cities. • Licensing of "the ingredients of Pentium processor-based Native Signal Processing (NSP) technology to Chinese developers for free."	**Contract Agreement** *DTP Centers* *Technology Licensing (free)*
	June	• Donation of Pentium processor-based workstation labs and scholarships to Jiaotong and Fudan Universities in Shanghai. • MOU signed with Shanghai officials to "preferentially recommend Intel Pentium processors" • IADL co-sponsored "first Chinese PC Application Software Design Contest in Beijing...Intel will assist the Chinese software developers in the development of localized applications."	*Donation of Equipment and Scholarships* **MOU** *Software Design Contest*
	September	"Microcontrollers tested and assembled by the Huajing Electronics Group qualified for the Intel world-class standard and quality guarantee."	Intel Quality Assurance Tests
	October	"Donated Pentium processor-based servers to Nanjing University."	*Donation of Computer Equipment*
	November	"Pentium Pro Processor launched; first ever to introduce a new generation of product in China around the same time as US and Europe."	New Product Introduction in China
1996	*May*	MOU with MEI "on accelerating growth of PC computing in hardware and software development in China"; Beijing presentation of Intel program "The Connected PC."	**MOU** *Intel Presentation*
	June	"Donated Pentium processor-based workstations labs to the University of Electronics Science & Technology in Chengdu."	*Donation of Computer Equipment*
	July	"Co-sponsored the Second nationwide Chinese PC Application Software Design Contest in Beijing with Chinese Software Industry Association."	*Second Software Design Application Contest*
	*November**	Construction begun on Intel WFOE facility for testing and assembly in Waigoaqiao Free Trade Zone in the Pudong District of Shanghai.	**Construction of WFOE**
1997	*May*	Intel presentation on "Connected PC in Business" in Hong Kong.	Intel Presentation

Source: *Adapted from list of Intel's "Major Milestones" in "Intel China: Since 1985."* [See also http://www.intel.com/pressroom/archive/BACKGRND/AW050598.HTM]. * The October 1996 arrival in Beijing of Intel China's new president was also listed as a milestone.

Conclusion

As the above tables show, contracts for many joint ventures or even wholly foreign-owned enterprises are often accompanied by (or contingent upon) side agreements for additional technology transfers or know-how, whether in the form of training, education, or joint research. As cited in the *1997 National Trade Estimate Report on Trade Barriers*, the "Chinese Government routinely seeks to obtain offsets from foreign bidders in the form of local content requirements, technology transfers, investment requirements, counter-trade or other concessions, not required of Chinese firms. In fact, bidding documents, including those for internationally funded procurements, often express a 'preference' for offsets."

It should be noted, however, that rather than viewing these donations or collaborations as an unreasonable or unfair "price of doing business" in China, some (though certainly not all) US companies view these offsets as means toward improving their current labor force in China through training, education, and recruitment. Finding and retaining skilled workers in China is difficult and becoming more expensive, though not as expensive as employing a large number of expatriots in China.[114] Similarly, it is commonly thought that the donated equipment and scholarships will serve the company's interest in the long-run by providing company recognition and a good reputation as well as a better-educated pool of young workers in China, where these manufacturing facilities are located. Given the necessity of long-term planning for most foreign ventures in China, it will probably be less costly and more productive in the long-run to be able to hire local, skilled workers than it would be to continue to use expatriots, who are often unhappy being away from home for extended periods and who are not always adept at conducting business in China.

Through these collaborations, US firms are also contributing to China's ability to absorb and assimilate new technologies, which will be key to ensuring China's sustained growth and innovative capabilities in the future. Thus, US high-tech firms are playing an increasingly important role in aiding China's modernization efforts. It is not yet clear what cumulative effect(s) this collaboration has had or is having on China's ability to compete in these industries in the near term. However, it is likely that as these collaborative efforts grow, Chinese researchers, academics, and technicians will increasingly be involved in developing high-tech, competitive products. One recent example of this is the global collaborative effort organized by IBM to accelerate development of JAVA-based software applications. IBM is tasking programmers at Qinghua University in China and elsewhere (Belarus, India, and Latvia) to work on this 24-hour-a-day effort to produce new software packages.[115] Thus, at least some of the exchanges described above are resulting in new product development with these high-tech products sometimes debuting in China at the same time or soon after their appearance in the US market.

Endnotes - Part I:

1. The working definition of technology transfer is derived from that found in Otto Schnepp, Mary Ann Von Glinow, and Arvind Bhambri, *United States-China Technology Transfer* (New Jersey: Prentice Hall, 1990), p. 3. For a review of changes in perceptions toward international technology transfers, see, Paul David, "Rethinking Technology Transfers: Incentives, Institutions and Knowledge-Based Industrial Development," in *Chinese Technology Transfers in the 1990s* (Cheltenham, UK: Edward Elgar Publishing Ltd., 1997), pp. 13-37.

2. Deng's "Four Modernizations" were, in order of priority, as follows: 1) industry; 2) agriculture; 3) science and technology; and 4) national defense/military.

3. According to World Bank statistics, China's annual GDP from 1976 to 1986 was 9.3 percent and from 1987 to 1997 was 10.1 percent. See "China at a Glance," The World Bank, August 28, 1998.

4. China's NSF has authority to provide grant money on a competitive basis. Wendy Frieman, "The Understated Revolution in Chinese Science & Technology: Implications for the PLA in the 21st Century," draft paper prepared for AEI 1997 Conference on the People's Liberation Army (American Enterprise Institute, September 1997 conference), p. 18. China's civilian and military research institutions have also had to begin competing for research funds provided by the state.

5. "PRC State Council 'Decision on Accelerating S&T Development'," A Report from US Embassy Beijing, November 1996 (a summary of the SSTC report on "Science and Education for a Prosperous China"). At around the same time, a similar decision was made regarding acceleration of S&T in China's defense conversion program.

6. The projects selected to receive funding under these programs have recently been reduced in number to allow a concentration of resources on key technologies such as high-performance computers, Wendy Frieman, "The Understated Revolution in Chinese Science & Technology: Implications for the PLA in the 21st Century," draft paper prepared for AEI 1997 Conference on the People's Liberation Army (American Enterprise Institute, September 1997 conference), p. 20.

7. The trend toward US companies establishing R&D centers in China is addressed in detail later in this study. See also Douglas C. Market and Randy Peerenboom, "The Technology Transfer Tango," *The China Business Review* (Washington, DC: The US-China Business Council, January-February 1997), pp. 25-29.

8. US Government figures on US research and development spending in China in 1995 totaled $13 million (compared to $7 million in 1994). These numbers are relatively small in comparison to other US-sponsored research projects around the world. For instance, US R&D spending in 1995 in Hong Kong was $79 million (up from $68 million in 1994). Interview with Donald Dalton, US Department of Commerce, Bureau of Economic Analysis, December 1997. For data on US global R&D expenditures, see "US Direct Investment Abroad," annual publication. See also Donald Dalton and Manuel G. Serapio, Jr., *Globalizing Industrial Research and Development*, US Department of Commerce, Office of Technology Policy, Asia-Pacific Technology Program, October 1995. Much of this analysis has been assisted by the work done by Ms. Sullivan and her colleagues on this issue.

9. The terms generally used in Chinese documents to refer to the effort to reform and modernize Chinese industry are "technology transformation" (referring to the process of improving domestic technological development and acquisition of foreign technologies) or "technology renovation" (meaning the upgrading of a facility and increasing its efficiency). These processes are particularly relevant to China's large state-owned industrial enterprises, which remain largely dependent on equipment acquired from the former Soviet Union and therefore based on 1950-60s-era technology. According to China's State Science and Technology Commission (SSTC), "only ten percent [of China's industrial base] dates from the 1970s or 1980s; about one-third is so old and inefficient it should be junked as soon as possible." State Science and Technology Commission (SSTC), "China's S&T Policy: A View from Within," in *Science and Education for a Prosperous China* (text available on US embassy China website).

10. There were an estimated 10,000 research institutes in 1985. These centers functioned in a manner similar to the Soviet science and technology research system while providing the typical Chinese "iron-rice bowl" benefits for their workers. Jiang Xiaojuan, "Chinese Government Policy Towards Science and Technology and Its Influence on the Technical Development of Industrial Enterprises," *Chinese Technology Transfer in the 1990s*, p. 144; *US Army Area Handbook*.

11. This figure is from a report in December 1995 in a leading Chinese newspaper (*China Daily*) and cited in Bates Gill, "China and the Revolution in Military Affairs: Assessing Economic and Socio-cultural Factors," Strategic Studies Institute, Conference Series, National Defense University Press, May 1996. The United States and Japan were ranked number one and two, respectively for the number of influential patents in 1991. The United States for that year had over 100,000 patents while Japan had over 75,000. These and other economic, industrial, and scientific data are compared for China, Japan, Germany, Russia and the United States in Samuel Kim, "China as a Great Power," *Current History*, September 1997, p. 250.

12. This information is taken in part from a summary of "Science and Education for a Prosperous China," provided by the US Embassy in Beijing. The report itself was reportedly written for Chinese government and party officials by the State Science and Technology Commission (SSTC). See "Chinese Challenges in Absorbing and Producing New Technology," A report from US Embassy Beijing, December 1996 [http://www.redfish.com/USEmbassy-China/sandt/STNUTEK7.htm].

13. *Innovation and Technology Policy in the People's Republic of China*, Office ofTechnology Policy, US Department of Commerce (draft paper, 1997), pp. 34; 40.

14. Throughout this analysis, "non-state sector" denotes an enterprise that is owned or run by a group of individuals and whose assets and revenues are derived from non-governmental sources. These enterprises are typically called "collective" or "private" enterprises. This does not necessarily mean, however, that the enterprise is "private" in the Western sense of the word. Rather,

"private" connotes only a non-state-owned or non-state-run organization.

15. W. Frieman, p. 23.

16. This statement is found in an English- and Chinese-language brochure describing China's National Engineering Research Centers.

17. *Innovation and Technology Policy in the People's Republic of China*, Office ofTechnology Policy, US Department of Commerce (draft paper, 1997), p. 43. China's number one personal computer company, Legend, is a spin-off from the Chinese Academy of Sciences, as was Beijing's first non-state sector electronics firm, Cathay Silicon Valley. In the latter case, the founder left CAS altogether in order establish a separate enterprise to have access to more modern technologies and to pursue creative, new ideas. Barry Naughton, "The Emergence of the China Circle," *The China Circle: Economics and Technology in the PRC, Taiwan, and Hong Kong*, Barry Naughton, ed. (Washington, DC: The Brookings Institution, 1997), pp. 27-28; and Scott Kennedy, "The Stone Group: State Client or Market Pathbreaker?," *The China Quarterly*, December 1997, vol. 152, pp. 746-777, specifically pp. 750-767.

18. China's "ivy-league" equivalents would include Beijing University, Tsinghua (or Qinghua) University —also known as "China's MIT"— in Beijing, and Fudan University in Shanghai. There are also a number of technical or regional institutions (such as Jiaotong or Zhongshan University) in various regions, primarily along the eastern coastal areas, that rank among the top universities in China.

19. These ideas are presented in a discussion of significant changes in China's scientific community over the last several years by Wendy Frieman, pp. 18-21.

20. State Science and Technology Commission (SSTC), "China's S&T Policy: A View from Within," in *Science and Education for a Prosperous China*, a Report from the US Embassy Beijing, December 1996.

21. Foreign enterprises are involved indirectly in China's various technology development programs through joint venture collaborations, but are not allowed direct access to Chinese government funding specifically allocated for such programs. *Innovation and Technology Policy in the People's Republic of China*, Office ofTechnology Policy, US Department of Commerce (draft paper, 1997), pp. 34; 40.

22."Summary: Visit to China by Assistant Secretary Graham Mitchell," Travel Report, July 4-17, 1997.

23. According to Chinese estimates, 5.9 percent of total PRC exports can be attributed to advances in science and technology. The target by the year 2000 is 15 percent and 25 percent by 2010. State Science and Technology Commission (SSTC), "China's S&T Policy: A View from Within," in *Science and Education for a Prosperous China*, a Report from US Embassy Beijing, December 1996 (text available on US embassy China website). The Office of Technology Policy, Chinese Economic Area provides 6.8 percent as the amount of high-tech products as part of total Chinese exports for 1995. (The discrepancy may be due to total export dollar figures.) The percentage of high-tech imports for that same year was 16.5 percent of total imports.

24. State Science and Technology Commission (SSTC), "China's S&T Policy: A View from Within," in *Science and Education* for a *Prosperous China*, a Report from the US Embassy Beijing, December 1996.

25. It is not clear to what extent Sino-foreign collaboration on R&D is resulting in actual new products being manufactured. This increase in US-sponsored research and development in China complements the growing trend of US-funded R&D abroad, which now totals twice as much as domestic R&D. Total US R&D abroad in 1987 came to $5.2 billion and grew to $9.8 billion in 1993. Research funded by US firms abroad is mainly found in allied nations but increasingly in developing countries as well. Donald Dalton and Manuel G. Serapio, Jr., "Globalizing Industrial Research and Development," US Department of Comerce, Office of Technology Policy, Asia-Pacific Technology Program, October 1995.

26. State Science and Technology Commission (SSTC), "China's S&T Policy: A View from Within," in *Science and Education for a Prosperous China* (text available on US embassy China website).

27. It was previously thought that Chinese students, scientists and the like who came to the United States were then "lost" to China. This may have been the case during the Cold War, but it is certainly not the case today. As one expert points out, visiting Chinese scholars in the United States make full use of the modern communication channels available today, such as fax, e-mail, and telephone as well as Internet and the world-wide-web. This is possible as Chinese scholars in the United States mostly come from government or university institutes in China, most all of which are connected (or soon will be) to the internet, or have e-mail and fax capabilities. This allows them to remain in contact with their home institutions, often on a daily basis. It is reasonable to conclude, therefore, that the benefits accrued from studying or doing research in the United States today are much more dynamic and wide-ranging for the individual as well as for colleagues back in Chin than in the past. As a result, there is likely more transfer of intellectual and technological know-how than previously possible. W. Frieman, pp. 14-15.

28. Both Legend and Founder reportedly have research enterprises in the United States. Legend's research/design center is located in Silicon Valley. "State Science, Technology Commission on PRC Development," in *Xinhua*, September 9, 1997; and Wendy Frieman, p. 7.

29. This statement and many of the ideas presented above come from Wendy Frieman, "The Understated Revolution in Chinese Science & Technology: Implications for the PLA in the 21st Century," draft paper prepared for AEI 1997 Conference on the People's Liberation Army (American Enterprise Institute, September 1997 conference).

30. "Warning Issued on Brain Drain," *South China Morning Post* (Hong Kong), March 11, 1997.

31. *US Army Area Handbook*.

32. Kyna Rubin, "Go West, Look East," *Far Eastern Economic Review*, October 10, 1996.

33. "Warning Issued on Brain Drain," *South China Morning Post* (Hong Kong), March 11, 1997. According to the *US Army Area Handbook*, "between 1979 and 1986, China sent over 35,000 students abroad, 23,000 of whom went to the United States." If these figures are anywhere near correct, the percentage of students coming into the United States over the last decade is enormous. *US Army Area Handbook*: Chapter 9.02: Science and Technology in the 1980s," Document identification no. 538.

34. Elizabeth Bukowski, "A Western Virus Among China's Leaders," *The Wall Street Journal*, June 19, 1997.

35. *Far Eastern Economic Review*, October 16, 1997, p. 13 (citing World Bank figures).

36. "In recent years, less than a fifth of mainland Chinese students in the US have returned home, where material comforts are scarcer and the road to business ownership can be rough." Kyna Rubin, "Go West, Look East," *Far Eastern Economic Review*, October 10, 1996.

37. The bond to be posted by students studying abroad beginning in 1998 is reported to be $6,000, which would be an enormous amount for many in China to forfeit. Returning students, however, will get their money back with interest, according to the Xinhua News Agency. "China to Fine Students Going Abroad," *Associated Press*, August 12, 1997.

38. Sally Stewart, "Technology Transfer and the People's Republic of China," *Technology Transfer in the Developing Countries*, Manas Chatterji, ed. (New York, NY: St. Martin's Press, 1990), p. 347.

39. "China to Recruit More Foreign Experts," *Beijing Review*, vol.40, no.25, June 23-29, 1997. According to statistics provided by China's State Bureau of Foreign Experts, "over the past two years, some 160,000 cultural, technical and managerial experts have worked in China. Among them about 120,000 worked in foreign-financed enterprises." "China to Recruit More Overseas Talents," *Facts and Figures*, Newsletter no. 199711, November 1997, PRC Embassy, Washington, DC.

40. See Richard J. Heffernan, and Dan T. Swartwood, *ASIS Special Report: Trends in Intellectual Property Loss*, The American Society for Industrial Security (ASIS), March 1996; and "ASIS Releases Special Report on Intellectual Property Theft and Corporate Espionage," March 15, 1996, press release. This report is the third of a series of reports published every two years by ASIS.

41. Joint ventures, cooperative research and exchange agreements are among the collection methods listed in the *1997 Annual Report to Congress on Foreign Economic Collection and Industrial Espionage*, June 1997. Although the data collected for this report focuses primarily on foreign activities in the United States, it is reasonable to conclude that similar activities may occur in joint ventures abroad. The report states that "through joint-venture negotiations, US contractors may reveal unnecessarily large amounts of technical data as part of the bidding process" (pp. 8-9).

42. According to a recent press report, "China, which is trailing behind the West in science and technology, is following the example of the KGB in stepping up the work of stealing scientific and technological information from the West." In terms of PLA involvement in US commercial enterprises, the most recent and balanced reporting on this problem is by James Mulvenon *in Chinese Military Commerce and US National Security*, Center for Asia Pacific Policy, RAND Corporation, MR-907.0-CAPP (draft) July 1997. Mulvenon has carefully reviewed the record of PLA involvement in the US economy and found there to be many misconceptions regarding the difference between the uniformed services of the PLA and the civilian defense industrial sector, a division that is often misunderstood or ignored by the media. However, his report also concludes that "the acquisition of advanced dual-use technology by Chinese military and defense-industrial companies in the United States as well as technology 'leakage' through US joint ventures with companies in China pose the most serious national security concerns for the United States, although these activities are not as highly coordinated as recent media stories would suggest."

43. Wang Zhile, "An Investigative Report on Transnational Corporations' Investment in China," in *Guanli Shijie*, May 24, 1996.

44. Other problems include the vast exodus of laborers or "floating population" (estimated at over 100 million persons) who have left the central or Western regions for the coastal areas in search of greater job opportunities, higher pay and living standards, etc. The central and Western regions also are lacking sufficient infrastructure needed for rapid industrial development, which may hamper central government plans to entice more foreign investment in these areas.

45. US Trade Representative, *1997 National Trade Estimate Report on Foreign Trade Barriers* (Washington, DC: USTR, 1997), p. 43.

46. US Trade Representative, *1998 National Trade Estimate Report on Foreign Trade Barriers* (Washington, DC: USTR, 1998).

47. Ding Jingping, " Using Imported Technology to Transform Existing Enterprises in China," *Chinese Technology Transfer in the 1990s*, pp. 96-114; see especially table 5.3 comparing FDI for 1992 and 1993, p. 104. Although 1993 showed the highest level and change in FDI, the comparison between these two years clearly shows the trend in the most preferred or selected type of foreign investment in China. In addition to joint ventures, the other types of FDI include cooperative operations, cooperative developments, and foreign-owned enterprises. Figures on foreign investment in China in 1996 by Arthur Andersen's China Investment Center citing MOFTEC statistics also show that joint ventures (equity and cooperative joint ventures together) outnumber WFOEs in terms of number of contracts and per-contract dollar value, with cooperative joint ventures averaging US$5 million per project.

48. China's greatest single source of FDI, Hong Kong, has been seriously affected by the financial crisis, mostly in terms of higher prices. Although the crisis could lead to a slowing of Hong Kong investments, the cost differential may lead Hong Kong investors to invest further into China, where costs are significantly lower. See Craig S. Smith, "Foreign Capital Turns to Trickle in China," *Wall Street Journal*, October 29, 1997, p. A17.

49. Harry G. Broadman and Xiaolun Sun, *The Distribution of Foreign Investment in China*, Country Operations Division, China and Mongolia Department, Asia & Pacific Office of the World Bank, February, 1997.

50. Much of this information was gleaned from the "Strategy for Technology Acquisition in China," Office of Technology Policy," US Department of Commerce, 1997, website.

51. Shenzhen was a small municipality bordering Hong Kong before becoming the most famous and successful of China's SEZs. Zhuhai (which borders Macao), Xiamen and Shantou (in Fujian and Guangdong Provinces, respectively, which are across the Taiwan Strait from the Republic of China) were also among the first SEZs to be established. Hainan Island (off China's southeastern shore) also became a separate province and an SEZ in 1988. *China: EIU Country Profile 1996-97*, The Economist Intelligence Unit Limited, 1996, p. 9.

52. Numerous problems resulting from establishment of the SEZs worried Chinese leaders at the time, including a lack of skilled Chinese labor to work in foreign-invested enterprises, expensive infrastructure construction and improvement costs (such as upgraded factories, roads, railways, airports, etc.) needed to attract foreign investment, corruption, black market activity, and crime as well as a surprising rise in Chinese imports (leading to a large trade deficit in 1979-80). See Jonathan D. Spence, *The Search for Modern China* (New York: W.W. Norton & Co., 1990), pp. 673-675.

53. As is discussed later in this report, China's SEZs have in the last few years become hubs for low- and high-tech electronics firms, both foreign and domestic.

54. The 12 official ETDZs are Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Fuzhou, Guangzhou, and Zhanjiang. The northern cities of Harbin and Shenyang are officially designated as "key economic hubs" but can also be considered to fall under the ETDZ category. See Central Intelligence Agency, *Handbook of International Economic Statistics*, 1996.

55. *International Business Practices*, US Department of Commerce in cooperation with Federal Express Corporation, January 1993, p. 171.

56. Most HTDZs include a number of "Science and Technology Industrial Parks" (which occasionally results in these terms being used interchangeably).

57. Only high-tech investors, foreign and domestic, are given preferential treatment. See David Wall and Yin Xiangshuo, "Technology Development and Export Performance: Is China a Frog or a Goose," *Chinese Technology Transfer in the 1990s* (1997), p. 173. China is also opening some of its Science Parks to members of APEC. According to a recent article, "these parks target industrial development in areas including micro-electronics and electronic information services, space and aviation, optics, machinery and electronics, life science and biological engineering, new materials, new energy resources, ecological science and environmental protection, medical science and bio-pharmaceutical technology." These parks were first established in 1985 (thereby pre-dating the HTDZs), and they currently number 110. Cui Ning, "Science Parks to be Opened for APEC Members," *China Daily*, September 16, 1997.

58. The Haidian District is home to the Chinese Academy of Science, Qinghua University and Beijing University, as well as numerous government-run think tanks or research institutes, including the Ministry of State Security's think tank, the China Institute for Contemporary International Relations (CICIR).

59. The HTDZs are governed by regulations (*Relevant Policies and Regulations on National High Technology Development Zones*) established by the State Council in 1991.

60. While most observers found Tung's overall plan to be typical of past Hong Kong economic policies, a few critics noted that the technology provision seemed to be rather more intrusive than is usual in Hong Kong's traditionally *laissez-faire*, market economy. According to George Leun, of the Hong Kong and Shanghai Bank, the new high-tech plan was "quite a change in direction in terms of government involvement in Hong Kong's future." See Andrea Ricci, "Hong Kong's Tung Launches HK$88 Bln Five-Year Plan," *Reuters*, October 8, 1997.

61. Joseph Kahn, "China to Give Back Some Perks to Foreign Firms," *Wall Street Journal*; Cheung Lai-Kuen, "Incentives to Lure Hi-Tech Investment," *South China Morning Post*, October 7, 1997, p. 18.

62. Statistics are from the *China Statistical Yearbook, 1996* and the China Statistical Information and Service Center 1997 as cited in Thomas Klitgaard and Karen Schiele, *"The Growing US Trade Imbalance with China,"* Current Issues in Economics and Finance, vol. 3, no. 7, Federal Reserve Bank of New York, May 1997, p. 4. The figure for the share of total Chinese exports contributed by FIEs for 1995 is listed as being 31.2 percent in *China: EIU Country Profile 1996-97*, The Economist Intelligence Unit Limited, 1996, p. 51.

63. See "China and Mongolia," EIU Country Report, 1st Quarter 1997 (London: The Economist Intelligence Unit Ltd., 1997),.p. 22.

64. As one report states, "Preferential policies have been designed to attract more investment into central and Western provinces. The government hopes to encourage the development of labor intensive industry in the interior regions, while the coastal areas focus on technology." *Asian Wall Street Journal* (HK), December 6-7, 1996.

65. Approximately 55 percent of China's military/defense industrial enterprises are thought to be still located in the "Third Front" area. John Frankenstein and Bates Gill, "Current and Future Challenges Facing Chinese Defense Industries," *The China Quarterly*, no. 146, June 1996, p. 43.

66. The central province of Sichuan is set to become a new major foreign investment location due to its preferential investment and tax policies, government-funded infrastructure projects (including intercity connecting highways), the presence of a highly skilled and educated workforce due to the location of China's "Third Front" military and scientific institutions in this region, and the new status of the provinces' largest city (Chongqing) as a municipality of Beijing (as are the cities of Shanghai and Tianjin), meaning it answers directly to Beijing rather than to provincial authorities in Chengdu. Such direct control typically results in preferential

policies and increased funding from Beijing leaders. See "Alternative Investment Locations in Sichuan," *Business China*, May 26, 1997, p. 5; and Choong Tet Sieu and Matthew Miller, "Lift-Off in Chongqing: Can the Mega-City Reverse Fortunes in the Impoverished Heartland," *Asiaweek*, September 26, 1997.
However, China's nuclear weapons laboratories, and, in particular, institutions identified in June 1997 on the Bureau of Export Administration's Entities List, namely the research institutes that come under the Chinese Academy of Engineering Physics (CAEP) are located in Mianyang, in Sichuan Province. Mianyang has also reportedly become the country's This includes institutionssecond-largest electronics hub. "State Science, Technology Commission on PRC Development," in *Xinhua*, September 9, 1997.

67. "Overseas Investment Rises," Newsletter no. 199717, PRC Embassy in Washington, DC (available on website).

68. In January 1988, China's State Council issues the *Detailed Rules for Implementation of Regulations on Administration of Technology Import Contracts*. The "Detailed Rules" govern technology transfers from foreign enterprises.

69. The *Technology Contract Law*, which governs technology transfers among Chinese enterprises, was approved by China's National People's Congress in June 1987.

70. Among these restrictions are provisions "unreasonably restricting the sales channels and export markets of the recipient" and "forbidding use by the recipient of the imported technology after expiration of the contract," both of which are considered discriminatory in terms of international legal trade practice.

71. *1997 National Trade Estimate Report on Foreign Trade Barriers*, p. 45.

72. In addition to GDP growth, China has shown impressive progress in decreasing poverty (a 60 percent decline over the last twenty years), illiteracy (now under 10 percent), low infant mortality, and improving life expectancy. World Bank figures in "China: Country Brief," The World Bank Group, September 1997.

73. This discrepancy in data is largely due to the inclusion of transshipments via Hong Kong in US statistics, which are not included in PRC Government figures. There are bilateral efforts being made to reconcile these discrepancies.

74. This concern seems to be increasing in China, as first generally noticed in the publication of the book, *China Can Say No* (based in part on an earlier version based on Japan's experience). A number of recent articles have appeared in the Chinese press that sound a note of caution with regard to a perceived growing dependence on foreign investment and products. See, for instance,"Given Too Many Loopholes in Foreign Capital Introduction, Think Tank Puts forth Eight Suggestions on Tightening China's Policy on Introducing Foreign Capital" *Hong Kong Ping Kuo Jih Pao*, February 3, 1997)

75. *Ibid.*

76.*Innovation and Technology Policy in the People's Republic of China*, Office ofTechnology Policy, US Department of Commerce (draft paper, 1997), p. 2.

77. *China Commercial Guide, 1996-97.*

78. Li Peng, "Report on the Outline of the Ninth Five-Year Plan for National Economic and Social Development and the Long-Range Objectives to the Year 2010," Delivered at the Fourth Session of the Eighth National People's Congress on March 5, 1996.

79. Douglas C. Market and Randy Peerenboom, "The Technology Transfer Tango," *The China Business Review* (Washington, DC: The US-China Business Council, January-February 1997), pp. 25-29; 29.

80. *1997 National Trade Estimate Report on Foreign Trade Barriers*, p. 50.

81. State Science and Technology Commission (SSTC), "Chinese Challenges in Absorbing and Producing New Technology," in *Science and Education for a Prosperous China*, Report from US Embassy Beijing, December 1996.

82. Publication of the auto industrial policy was also surprising given the timing of it, which coincided with talks on China's accession to the WTO. Many of the terms included in the auto industrial policy would probably violate international trade and WTO practices.

83. Cheung Lai-Kuen, "Incentives to Lure Hi-Tech Investment," *South China Morning Post*, October 7, 1997, p. 18.

84. The word "integrate" is sometimes translated as "combine." See "New Defense S&T Strategy to Emphasize Technology Transfer to Civilian Use," China Military Science (*Zhongguo Junshi* Kexue), no. 3, August 20, 1995, pp. 131-136; and *China's Defense Conversion*, China Economic Press.

85. This is referred to as "the two combinings" meaning defense spin-offs to the commercial/industrial sector and spin-ons from the latter to support defense efforts. Thus, "the 16-character program is both the military industrial construction policy of China and the policy for the development of the national economy." *China's Defense Conversion*, China Economic Press. For a Western view and interpretation, see John Frankenstein, "China's Defense Industry Conversion: A Strategic Overview," in Chapter One of *Mixed Motives, Uncertain Outcomes: Defense Conversion* in China, pp. 3-34.

86. Statement taken from Chart depicting "China's Defense-Industrial Trading Organizations," Defense Intelligence Reference Document PC-1921-57-2 (U), October 1995. An expert on Chinese military matters describes COSTIND's role as that of "oversight on defense research, development, testing and evaluation (RDT&E), defense production/conversion, nuclear weapons testing, and satellite launches. It also has some input on arms control matters, relating to both international treaties and export controls. Bureaucratically, it serves two masters...acting as a bridge to coordinate R&D and procurement between military-industrial producers and PLA consumers." James Mulvenon, *Chinese Military Commerce and US National Security*, MR-907.0-CAPP, a report for RAND's Center for Asia Pacific Policy (draft, p. 8, July 1997). The China Association for Peaceful Use of Military Industrial Technology (CAPUMIT) was also formed in 1982 under COSTIND and serves as the primary link between China's defense industrial sector and foreign investors interested in projects related to China's defense conversion program. Jorn

Brommelhorster, "Concluding Perspectives: Comparing Conversion in China and Russia," In *Mixed Motives, Uncertain Outcomes: Defense Conversion in China*, pp. 232-33.

87. See "New Defense S&T Strategy to Emphasize Technology Transfer to Civilian Use," China Military Science (*Zhongguo Junshi Kexue*), no. 3, August 20, 1995, pp. 131-136. The decision to accelerate S&T in the defense sector coincided with a similarly renewed effort in the civilian/industrial sector. (See endnote 5.)

88. In fact, the part of the Chinese military budget that was until recently allocated to the Commission on Science, Technology, and Industry for National Defense (COSTIND) —the department created in 1982 and charged with overseeing China's military industrial production, procurement policies, and R&D— is not officially published. As a result, Western estimates of China's defense budget range all the way from a low of $7 billion a year to a high of $100billion. As always, the real number is thought be somewhere in between, probably near the $50-60 billion range. For estimates of China's defense budget, see Arms Control and Disarmament Agency (ACDA), *World Military Expenditures and Arms Transfers* (annual), David Shambaugh in "World Military Expenditures," *SIPRI Yearbook 1994*, Oxford: Oxford University Press, 1994, pp. 441-48, and Arthur S. Ding, "China's Defence Finance: Content, Process and Administration," *The China Quarterly*, June 1996. For a comparison of the accounting methods used the resulting wide range forecasts, see Richard Bitzinger and Lin Chong-Pin, "Off the Books: Analyzing and Understanding Chinese Defense Spending," (paper presented at the 5th Annual AEI Conference on the People's Liberation Army, Staunton Hill, June 1994. For discussion on the data dilemma, see Bates Gill, "China and the Revolution in Military Affairs: Assessing Economic and Socio-cultural Factors," Strategic Studies Institute, Conference Series, National Defense University Press, May 1996; and Eric Arnett, "Military R&D in Southern Asia," in *Military Capacity and the Risk of War*, pp. 244-245.

89. *China White Paper on Arms Control and Disarmament*, Xinhua News Agency, November 16, 1995 (issued by the Information Office of the State Council of the PRC).

90. A new book has been published of collected, translated articles by several Chinese military scholars —*Chinese Views on Future Warfare* by Michael Pillsbury (published by the National Defense University in 1997 and revised in 1998). This book has caused much debate among China-watchers due to its main assertion that Chinese military planners are, indeed, thinking about, writing about, and ostensibly planning on "local-wars under high-tech conditions" and the use of information technologies, commonly referred to as the Revolution in Military Affairs (RMA) concept. This revelation was startling and very worrisome to many or seemed unnecessarily alarmist to others. The point to be made here, however, is that the high-tech warfare exhibited in 1991 has apparently become a goal to emulate for the Chinese leadership. How this might be accomplished given China's comparatively limited technological capabilities in this area is unclear.

91. An expert on Chinese military/security matters states that "the Allied victory in the Gulf War had a profound impact upon the thinking of China's military leaders. More than any other event, the rapid, successful conclusion of that conflict settled lingering questions about the proper direction for developing China's future military capabilities." Ronald Montaperto, Testimony before the Senate Foreign Relations Committee Subcommittee on East Asian and Pacific Affairs Hearing on "The Growth and Role of the Chinese Military," October 11-12, 1996 (US-GPO 20-332 CC, p. 47). With regard to development of new weapons, a former Ambassador to China cautions that there is a "need to improve our research collection methods on an important, but neglected topic—that is, China's attempts to 'leapfrog' if you will the United States by developing or purchasing advanced weapons systems. These weapons systems include technology that specifically targets the US military's information systems, including anti-satellite weapons, electronic warfare aircraft, and high powered microwave and laser weapons systems to destroy electronic equipment. One might think of this as a form of what some have referred to as "information deterrence." Articles by officers in the People's Liberation Army of China have specifically written on the need for a strategy to attack vital links to the US military including power stations, civilian aviation systems, broadcast stations, telecommunications center, computer centers, and so forth." Ambassador James Lilley, Testimony Before the Senate Select Committee on Intelligence on "Economics in Command: The Linkages Between Economic and National Security in China," September 18, 1997.

92. *Gearing Up for High-Tech Warfare?: Chinese and Taiwanese Defense Modernization and Implications for Military Confrontation Across the Taiwan Strait, 1995-2005*, by Richard A. Bitzinger and Bates Gill (Washington, DC: Center for Strategic and Budgetary Assessments, February 1996), p. 7.

93. One of the ways in which these reforms have been manifested is the PLA's creation of "rapid response units," which are conceived as small, elite, marine-type forces that will maintain a high degree of readiness to be rapidly deployed in case of conflict anywhere in China or on China's borders. Furthermore, many of the demobilized PLA soldiers are believed to have been transferred to the People's Armed Police Force, which is concerned with domestic security.

94. *China White Paper on Arms Control and Disarmament*, Xinhua News Agency, November 16, 1995 (issued by the Information Office of the State Council of the PRC); and *China's Defense Conversion*, China Economic Press.

95. "Among the eight big automobile manufacturing bases in China, three —Beijing Jeep, Chongqing Changan [with Japans' Suzuki], and Guizhou Aviation— belong to the defense industrial system." Feng-Cheng Fu and Chi-Keung Li, "An Economic Analysis," Mixed Motives, Uncertain Outcomes: Defense Conversion in China, John Frankenstein and Jorn Brommelhorster, eds. (Boulder, CO: Lynne Reinner Publishing Co., 1997), p. 48.

96. An example of this relationship is NORINCO, the successor organization of China's Ministry of Ordinance. NORINCO officially comes under the civilian authority of the State Council. However, NORINCO runs China's tank, armored vehicle, and small arms factories, and is involved in selling military hardware abroad. So, the question is whether the profits made from these businesses in any way assists the China's military, the PLA. The answer seems to be no, not directly. However, as on e analyst explains, "to say that the profits from defense-industrial companies do not end up in the coffers of the PLA is not to say, however, that these profits never benefit the military. In fact, it could be argued that the profits of these companies often provide a variety of indirect

benefits to the military and its modernization. For instance, the profits or technology acquired by China North Industries Corporation (NORINCO) might be used to modernize China's ordnance industrial base, which would improve the quality of small arms and vehicles eventually delivered to the military." James Mulvenon, *Chinese Military Commerce and US National Security*, MR-907.0-CAPP, a report for RAND's Center for Asia Pacific Policy (draft, July 1997), p. 8.

97. The most recent example of this dynamic is perhaps the undersea cable project, in which AT&T ended up having only a relatively minor role due to deft manipulation and inclusion of numerous foreign investors by Chinese officials. Nations represented in the newly formed consortium include the United States, Korea, Japan, Singapore, Hong Kong, Malaysia, and Great Britain. For a history of the negotiations, see Steve Glain, "Sea Change: How Beijing Officials Outnegotiated AT&T on Marine Cable Plans," *The Wall Street Journal*, July 23, 1997, pp. A1&A14.

98. Brian Nelson and Timothy Miles, "Personal Computers and the Golden Projects," US Department of Commerce, ITA, Office of Computers and Business Equipment, March 1997.

99. Chinese President Jiang Zemin made this clear in his recent remarks before China's 15th Party Congress, in which he said, "Wherever conditions permit, research institutes and institutions of higher learning should combine production, teaching and research by entering into association or cooperation with enterprises in various ways so as to solve the problems of segmentation and dispersal of strength in the management systems of science, technology and education. Innovation, competition and cooperation should be encouraged." "Hold High the Great Banner of Deng Xiaoping Theory for an All-round Advancement of the Cause of Building Socialism with Chinese Characteristics to the 21st Century," September 12, 1997.

100. "Western Companies Go Slow on China R&D Operations; Quality, Intellectual Property Are Concerns," *Research-Technology Management*, May/June 1997, vol. 40, no. 3, pp. 2-3.

101. According to "IBM China News" (Nov. 1996), "The donation is a part of the long term relationship on the joint effort in research and development of microelectronics technology between IBM and Tsinghua University. It also includes cooperation on designs of semiconductor applications."

102. According to a May 1996 company press release, "Each center has been equipped with the latest IBM computers and equipment, including the RS/6000, AS/400, PCs, networking, printers, software development tools, databases and network management software." See "Competition Heats Up in China's Computer Market," *Xinhua News Agency*, August 12, 1997 and "The State Education Commission & IBM Hail the Establishment of IBM Technical Centers in 23 Chinese Universities," *IBM Information in China*.

103. *Technology Transfers to China*, Office of Technology Assessment, 1987, p. 97.

104. "Altera Establishes Advanced Technical Training Center at China's Prestigious Tsinghua University," Press Release, February 12, 1996.

105. "IBM News," May 1996 -website.

106. Catherine Gelb, "Installing a Software Sector," *The China Business Review*, September-October 1997, p. 36.

107. The latter were established "to foster ties between the academic community and the semiconductor industry around the world, to help train engineering students in the most advanced technologies, to promote cooperation on research between industry and academia and to fulfill IT's corporate commitment to being a good corporate citizen." "Texas Instruments Expands University Program in China, Opens TI Tsinghua Technology Centre," TI News Release, BJ96010, September 20, 1996.

108. State Science and Technology Commission (SSTC), "China's S&T Policy: A View from Within," in *Science and Education for a Prosperous China* (text available on US embassy China website). For a longer list of US corporate research and development-related activities in China, see "Foreign Corporate Research Collaboration and Technology Transactions," a Global Strategies Essay, Office of Technology Policy available on-line at [http://www.ta.doc.gov/AsiaPac/china/corplink.html]

109. Intel was chosen as an example simply due to the discovery of a list of Intel's achievements in China on an Intel press release, from which this table is adapted. Wherever possible, the exact language found on Intel's website is used. See "Intel China: Since 1985" [http://www.intel.com].

110. This is according to Dan Stanzione, president of Bell Labs, as cited in "Bell Labs to Set Up R&D Facilities in China," *Xinhua News Agency* (via *Reuters*), May 7, 1997.

111. "Western Companies Go Slow on China R&D Operations; Quality, Intellectual Property Are Concerns," *Research-Technology Management*, May/June 1997, vol. 40, no. 3, pp. 2-3.

112. *Ibid.*

113. Announced in *China Science and Technology Newsletter; Xinhua News Service* in March 1996; and cited in OTP essay on "Strategy for Technology Acquisition in China."

114. Wages for workers in foreign-invested enterprises are typically higher, due to competition for skilled labor, than for workers in state-owned enterprises. New regulations issued in 1997 require foreign joint ventures to abide by a new pay-scale that requires FIE wages to be at least as high as SOE pay, but does not provide a wage cap for joint venture employees as it does for SOE workers. SOE employees, though often receiving a lower wage, receive other benefits such as free or inexpensive housing. In order to attract and retain skilled workers, more FIEs are finding it necessary to provide similar benefits. Kristi Heim, "China's New Wage Rules May Force Foreigners to Use Collective Bargaining," *The Wall Street Journal*, September 30, 1997, p. A19.

115. "Java: IBM Goes on 24-Hour-a-Day Cycle to Speed Java Application Development: Highly Skilled Software Developers in Belarus, China, India, Latvia and the US in Virtual Team to Create JavaBeans," *Edge: Work-Group Computing Report*, vol. 8, February 24, 1997, p. 3.

Part 2

US PERSPECTIVES ON TECHNOLOGY TRANSFERS TO CHINA

US GOVERNMENT POLICIES AND PERSPECTIVE ON TECHNOLOGY TRANSFER

Although the US government, and the US Department of Commerce in particular, generally prefers a laissez-faire approach to US business and trade abroad, the technology transfer or offset requirements of numerous foreign governments are a serious concern for several US government agencies. The US Government (USG) has identified "three areas of global trade and technology transfer that are occurring with increasing frequency and that have the potential for broad national security or economic impact. Sales and contracts with foreign buyers imposing conditions leading to technology transfer, joint ventures with foreign partners involving technology sharing and next-generation development, and foreign investments in US industry that create technology transfer opportunities may raise either economic or national security concerns."[1] It is clear from analysis in Part 1 of this study that at least the first two of these three criteria are areas of serious concern with regard to China.

The effects of technology transfer and offsets in the commercial sector, however, are not yet well understood or tracked, especially in developing countries such as China. Furthermore, technology transfer requirements are merely one of many barriers to market access about which the USG and US industry are concerned. Several bilateral agreements have been reached with China in an effort to address various trade issues and practices, the most important of which is the 1992 Memorandum of Understanding (MOU) signed by the United States and the People's Republic of China on market access.[2] Although China has made efforts to further liberalize its trade and investment policies in accordance with this agreement and in efforts to join the World Trade Organization (WTO), much progress remains to be realized.[3]

Since the end of the Cold War, US export controls on dual-use high-technology items have decreased significantly and across a range of modern technologies. The Coordinating Committee for Multilateral Export Controls (COCOM) regime has been replaced by the Wassenaar Arrangement and supported by a system of export controls based on national discretion. In the United States, this has resulted in large-scale decontrol of technologies mainly in the electronics, computer, and telecommunications sectors, primarily for use in the civilian sector. As a result, export licenses are required for countries of concern such as China according to the end user or end-use, depending on whether they are civilian or military, as well as according to set technological standards or levels of sophistication (which, by necessity, are changeable). This has two consequences for US commercial technology transfers to China. On the one hand, as discussed above, determining the nature of either the end use or the end user is a very difficult task, one which is now primarily the responsibility of the licensee. On the other hand, the decontrol of information technology hardware and software has facilitated an enormous amount of trade and investment in these sectors between the United States and China over the last few years. Given the size of the US trade deficit with China, this new influx of trade and investment may serve to alleviate some of the current imbalance.

Chinese officials, however, contend that the current trade imbalance is due mostly to remaining US export controls. This may explain a small portion of the deficit with China, but certainly not the bulk of bilateral trade. As the analysis in Part 1 makes clear, China's trade and foreign investment policies are aimed at export growth, and in this they are succeeding. Nevertheless, US export controls remain in place for China for potential dual-use items, and licenses are reviewed on a case-by-case basis. As a result, the number of dual-use export license applications is down but the percentage of denials has increased. Despite the existing review process, however, the potential for significant levels and types of commercial technology transfers to China as the price of market access remains quite high.

US BUSINESS PERSPECTIVES

The potential of China's market is simply unparalleled, and the prospect of selling most anything to over one billion people, in one place, is irresistible for most companies. This popular way of thinking about the China market, however, overlooks one critical fact: China's market is not as open as it would appear. Numerous tariff and non-tariff trade barriers exist that, in addition to restrictive foreign investment regulations, make selling a foreign-made product directly to China's 1.2 billion consumers a difficult, if not an impossible, prospect.

The dynamism of China's relatively rapid economic liberalization since 1978 has overshadowed in large part China's industrial goals and policies that are explicitly designed to restrict and manage foreign investment in order to protect and bolster China's domestic industries. As a result, foreign investment has until recently been limited to China's coastal regions and is only now being allowed into some central and Western regions in accordance with central government plans. Furthermore, the technologies accompanying foreign investment are increasingly advanced as China's foreign investment and import regulations become more restrictive and selective.

China's is a buyer's market. As such, the leverage of an enormous potential market allows Chinese officials to frequently play foreign competitors against one another in their bids for joint venture contracts and large-scale, government-funded infrastructure projects in China.[4] While numerous complaints have been registered by US companies with the USG (formally and informally) regarding unfair trade practices in China, many companies are hesitant, if not unwilling, to complain publicly or even privately about the numerous difficulties inherent in doing business in China.[5] It is not surprising then, that despite the fact that the majority of industry representatives interviewed for this study clearly stated that technology transfers are the price of doing business in China, most also were optimistic about their future business prospects in China in the future and did not think the entry "price" had yet become too high.

What is not in dispute is the enormous *potential* of China's market. However, the various Chinese policies restricting foreign investment in certain industrial sectors, in particular regions, and to sophisticated technical levels result in missed opportunities and lost benefits for both foreign and domestic entrepreneurs in China. A key restriction in many industrial sectors is the requirement to establish manufacturing joint ventures in China in order to sell to the China market, and then only indirectly as distribution channels are often available only to Chinese companies. Even where this is not the case, the combination of high tariffs and numerous non-tariff trade barriers make the prospects of selling many US-made products to Chinese consumers commercially impractical. Mandated export quotas based on the percentage of total output in sectors such as electronics also make it extremely difficult to sell products in or to China. As a result, the USG estimates that more liberal Chinese trade policies would probably permit an additional $500 million a year in US exports to China, which would make at least a small dent in the over $50 billion US trade deficit with China.[6]

According to a recent joint survey conducted by *Business China* and AT Kearney, foreign investors in China are finding it tougher to realize a profit or return on investment, with 3.6 years the average time expected for break-even revenues and 6.4 years on average expected before realization of global return on investment. Furthermore, almost half the companies surveyed (47 percent) found their expectations for the China market "were not just different but lower than those in other countries." Finally, the survey concludes as well that despite 1) the increasingly complex investment environment now in place in China; 2) the low expectations of foreign investors for return in the near-term; and 3) the survey result that shows foreign investors view advanced technology as increasingly important over the next half decade, the authors also note that market leaders "appear willing to invest their best technology and products — an approach that appeals to Chinese officials and companies which are often only interested in dealing with industry leaders and their best products."

For survey data, see "Local Heroes," Business China, June 9, 1997, pp. 1-3.

Furthermore, US companies, including high-tech firms, seem to believe that it is more important to establish a foothold in China than to make profits or even gain more than limited access to its market. Thus, if Chinese policies mandate a manufacturing joint venture and commercial technology transfers in exchange for market access in China, many companies are ready to do so. This is not to say that these firms are wholly unaware or unconcerned about giving away proprietary information, infringements of intellectual property rights, or various other dangers inherent in foreign joint ventures. Rather, most companies seem to think that these problems are either 1) easily prevented by taking proper precautions or 2) worth the risk. Even in industry sectors such as software, where piracy is above the 90 percent range, American and other foreign firms are not deterred from trying to manufacture or develop and then sell their products in China.

There are certainly some benefits for US firms in having a high-tech joint venture in China, such as low labor costs for more simple manufacturing or assembly processes and the opportunity to work with Chinese workers in developing products specific to the China market (such as Chinese-language software). More US firms and other multinationals (MNCs) are reportedly turning toward "off-sourcing," which entails preliminary production conducted in China in order to take advantage of low labor costs, but with final production occurring in the US.[7] However, the risks associated with production in China would seem to outweigh the benefits in the high-tech sector, which does not necessarily require what China's economy naturally serves best: labor- or land-intensive industries or low-tech, high-volume products.

So, why are US and other foreign high-tech firms in China? The answer heard most often in our interviews and survey of press reports is that one cannot *not* be in China, lest a competitor get a foothold first. China desires and certainly needs advanced technologies, and many US high-tech firms appear willing to pay the price — commercial technology transfers — in exchange for limited market access.

China has captured the imagination of entrepreneurs around the world. China's potentially enormous market may not, however, materialize as expected or hoped for, at least not for foreign enterprises currently manufacturing products in China. As the following industry case studies show, being in China does not necessarily open all doors to China's market.

INDUSTRY CASE STUDIES: Automotive, Aerospace, Electronics & Telecommunications

Below is a brief look at the current status of each of these high-tech industry sectors in China. Each of these industries is assessed on the number, type, and practices of US joint venture manufacturing enterprises in each sector as well as the overall technological level achieved by

each industry in China. However, economic and financial data regarding China are notoriously difficult to attain and often contradictory, if not wholly suspect. Thus, the degree to which China has developed indigenous capabilities in these sectors is not absolutely clear and may better reflect the advances made by Sino-foreign joint ventures. Nevertheless, in these important high-tech sectors, it is often the Chinese partner(s) who maintains an equal or majority share of the joint venture. Any technological advances made by the joint enterprise, therefore, can appropriately be considered beneficial to the Chinese partner as much or more than for the foreign partner.

The first industry sector studied is China's auto industry. Although not generally considered to be "high-tech," this industry was chosen because of the critical infrastructure and dual-use technologies necessary to develop this industry, the existence of a published auto "industrial policy" in China, and the relatively early entry of US auto companies into China. Moreover, this industry is strategically and economically important due to the dominant role this industry plays in supporting a range of other critical industries (e.g., the steel, machine tool, bearings and other industries). This section is followed by similar case studies on China's aerospace and electronics industries.

Automotive

China's auto industry provides a good example of the policies and difficulties with which foreign investors in China must contend. These include the following: 1) status as a "pillar industry," which affords preferential treatment in terms of government resources and funding for new or existing facilities in this sector; 2) an official, published auto "industrial policy" designed to develop an indigenous auto industry by utilizing technologies acquired from foreign companies; 3) numerous trade barriers; 4) competition from the large state-owned enterprise sector; and 5) problems related to China's infrastructure as it relates to this industry.

"Pillar Industry" Status

China's leaders view the auto industry as strategically important (as does the USG) given the upstream technologies necessary in automaking. Chinese officials have thus proclaimed the auto industry to be among China's "pillar industries." This label confers the benefits of increased government funding and assistance to China's struggling domestic auto industry, much of which has emerged from converted defense industrial enterprises. The PRC government plans to merge and consolidate the existing state enterprises, and to give preference to eight Chinese companies partnered with foreign automakers, in order to establish autos as a "pillar" of the Chinese domestic economy by 2010.[8] The ultimate goal is to create a Chinese version of the "Big Three" American automobile makers.[9]

TABLE 16
Goals for China's Automotive Market

<u>All vehicles</u>	1.28 million units	1993
	1.6 million units	1996
	2.7-3 million units	2000
	6 million units	2010
<u>Cars:</u>	1.2-1.5 million	2000
	4 million	2010

Goals Set by Ministry of Machine-Building Industry

In order to meet the goals set out in China's auto policies, however, growth in China's automobile industry will need to average over 12 percent growth per annum to reach the production level of three million vehicles by the year 2000.[10] If realized, this type of growth would represent a significant growth spurt in China's auto industry, which is unlikely given the current overcapacity in China's own market as well as in the global auto industry.[11]

China is currently ranked 11th in terms of world auto production. China is also the world's largest producer of motorcycles (since 1995), due in part to production from converted defense industrial enterprises[12]; other parts of the auto sector and other industries may soon follow this trend. China's production capacity for passenger cars is already two to three times as much as current production levels. This low utilization of capacity is in part a result of an austerity program over the last few years restricting capital (and thereby limiting government purchases of vehicles, by far the largest customer) as well as low market demand (though not desire) among China's emerging middle-class to purchase a car. The market demand for passenger cars is low due to auto prices that remain out of reach for most Chinese consumers (and that are set by the central government for all cars — foreign and domestic). Nevertheless, reports show that Chinese consumers' *desire* to drive and own automobiles is surprisingly large, evidence being the number of people applying for drivers' education and licenses. Autos have become one of the "must-have" items among China's emerging middle class, despite the impracticality of owning a car. Environmentalists argue that this is just as well — for China and the rest of the world— given the pollution factor of so many additional vehicles on the worlds' roads.

China's auto overcapacity is also a consequence of redundant and widespread state/provincial investment in the auto sector in response to defense conversion and foreign investment incentive programs. The result has been a fragmented domestic industry that produces comparatively low quality and low-tech, though perhaps durable, automobiles. Although China's converted defense industrial enterprises produce higher quantities of motor vehicles (mostly trucks), the non-state sector plants produce higher-quality vehicles using less labor and are therefore more efficient and likely more profitable.[13]

Industrial Policy

In February 1994 China's State Planning Commission adopted the "Automotive Industry Industrial Policy" (AIIP), which was published on July 4, 1994 in the *People's Daily* (*Renmin Ribao*).[14] The auto industrial policy was the first such document to be published by Chinese officials in an effort to provide more transparent investment guidelines for prospective foreign investors. What it made clear, however, was the extent to which Chinese state planners are managing the development of China's auto industry, which is largely dependent upon the acquisition of foreign technology.

TABLE 17
Requirements for Establishing an Auto Manufacturing Joint Venture in China

*	"An office responsible for technological research and development must be set up within the enterprise. The office will have the capacity to update products"
*	"The enterprise must have a capacity for manufacturing products which attain the international technological levels of the 1990s"
*	"The joint venture enterprise will obtain the foreign exchange it needs mainly through exporting its products"
*	"The joint venture must give priority to locally made spare or component parts when they need them"

Source: Article 31, Chapter Six: "Policy on Using Foreign Funds," of China's 1994 Auto Industrial Policy.

The plan includes, for instance, very explicit mandates for high levels of local content: 40 percent local content at start up (that had previously been required only after the third year in operation), 60 percent by the second year and 80 percent by the third year for passenger cars. Similar local content requirements exist for auto components, and the levels for trucks are even higher. Local content requirements are not unknown in developing nations, but they are rarely so high. The USTR notes that the AIIP "explicitly calls for production of domestic automobiles and automobile parts as substitutes for imports, and establishes local content requirements, which would force the use of domestic products, whether comparable or not in quality or price."[15]

Nevertheless, Chrysler's joint venture, along with several other foreign automotive joint ventures, had already reached greater than 80 percent local content by end of year 1994.[16] In order to reach this degree of quality local content, however, a foreign business has two options: to either encourage their suppliers to also come to China (as does Ford Motor Co., among others) or to train local workers to produce quality products (as many foreign companies opt to do). Either way, technological know-how is transferred to China.[17] Thus, the publication of this industrial policy served to make China's intentions and motivations for allowing foreign investment more clear, but not more comforting for prospective investors. The local content provisions would also appear to violate provisions eliminating import substitutions under the Sino-US 1992 MOU on market access.[18]

Trade Barriers

Even before publishing its auto industrial policy, the PRCG was (and still is) able to protect its domestic auto industry while still attracting foreign investment and technology. This is accomplished mainly through foreign joint venture manufacturing facilities in China coupled with prohibitively high tariffs and non-tariff barriers on foreign autos and auto parts. In addition to the 17 percent value-added tax (VAT) imposed on all imports, foreign autos are tagged with an excise or "consumption" tax as well as tariffs reaching up to or over 100 percent for passenger cars, 30-80 percent for commercial vehicles, and anywhere from nine to 100 percent on parts.[19]

Infrastructure

A key factor restricting China's market demand for automobiles is limited infrastructure. Traffic gridlock already exists in China's major cities, and there are very few parking lots, street parking, or gas stations to be found on the Mainland. The auto industrial policy attempts to rectify these critical shortages by mandating that new or renovated buildings have sufficient parking and for new gas stations to be built. These shortages can only be alleviated over a long period of time, probably a decade or more.[20] A lack of good roads is also a problem in China. As of 1994, China's entire high-speed expressway system would not span the distance from New York to Chicago.[21]

US Experience

China continues to attract foreign investment in its automotive industry, despite mandated technology transfers (in the form of local content, import substitution, and technology development center requirements) included in China's auto industrial policy; limits on foreign auto investors to certain auto sectors; an extremely limited infrastructure necessary for a sizable auto industry; and the fact that China's contribution to the global overcapacity in auto manufacturing is of growing international concern. American automakers have been no better able to resist the draw of the China market than have businessmen in any other industry.[22]

US auto companies in the China market include Chrysler, General Motors, Ford Motor Co., and several of their suppliers. These three major automakers have had quite different experiences in the China market, however, and their investment and technology transfer strategies provide a useful means of comparison.

The Chrysler Corporation

The Chrysler Corporation has been in China longer than most, beginning with the acquisition of their only joint venture, the Beijing Jeep Corporation in 1987. Despite almost a decade of relative success in producing both the Jeep Cherokee and a wholly locally produced military-style jeep (the BJ2020 series), by 1995 Chrysler had pulled out of its bid to build a new minivan joint venture enterprise in Shanghai out of complete frustration. According to press accounts, Chrysler executives were expressly concerned over licit and illicit technology transfers. Chinese officials were demanding more advanced technology than seemed appropriate or necessary to Chrysler.[23] Chrysler's concerns were amplified when Chrysler CEO Robert Eton was made aware that knock-offs of Chrysler's Jeep Cherokee had been seen on the streets of Beijing. When complaining about this to Chinese officials, he reportedly was told that this (the ability to copy Chrysler's Jeep Cherokee) was a good sign of progress in China's auto industry, about which he should be pleased.[24] Apparently he was not, and Chrysler soon canceled plans to go ahead with the Shanghai plant. According to interviews conducted for this study, given the experience in Beijing, Chrysler executives were made even more wary of the technology transfers, proposed licensing deal, and export quotas being requested as part of the Shanghai deal and decided that the risk was simply too great when it came to what was for Chrysler a relatively new car (the minivan) and, therefore, advanced technology.[25] Chrysler currently has no plans to expand its investment ventures in China.

General Motors Corporation

General Motors has a bold and ambitious strategy for the China market. GM beat out other prospective foreign partners with a more than $1 billion bid to produce a variation of Buick sedans with the Shanghai Automotive Industry Corp. (SAIC) in Shanghai's Pudong District, the only automobile joint venture deal expected to be approved by Chinese officials before the year 2000.[26] One of the major factors, if not the main impetus for the subsequent contract award, was GM's willingness to transfer a good deal of "state-of-the-art" technology. The Buick sedan variation has been described in press reports as "more or less current technology."[27] The fact that technology transfer was, indeed, the price extracted from GM for the joint venture contract is confirmed by internal GM documents.

GM's technology transfers are primarily in the form of joint research and development projects as well as training of Chinese workers and managers. GM's Chief Technology Officer for GM China noted in at a 1996 industry conference that, "As part of the agreement [with SAIC], technology institutes have been set up in conjunction with the vehicle programs...[adding that] GM's technical center in Warren, Michigan, is acting as the technology integrator for research being done at six Chinese universities and through seven joint ventures."[28] This accords with China's 1994 Auto Industrial Policy, which states that Sino-foreign automotive industry joint ventures are required to "set up within the enterprise" a research institute devoted to developing technology.[29] Both GM and Ford have established a number such institutes in China, and often at the same universities.[30] It is unclear to what extent these and similar institutes, centers, or labs are involved in actual research and development or simply training of local hires.

Ford Motor Company

Ford has also been willing to establish research and development centers in its efforts to invest in China's auto industry. The only vehicle joint venture Ford has established in China to date is with Jiangling Motors (in Nanchang, Jiangxi Province) to produce "Transit" minibuses, for which production began in December 1997 as planned.[31] Locally manufactured content for the Transit minibuses will start at 50 percent and grow to the 90 percent local content target.[32] Ford also has established several joint ventures for auto parts and has reportedly entered into a joint research project with the State Science and Technology Commission (SSTC) to develop alternative fuels (as has GM).[33] Ford's strategy for building a presence in China is based on much more dispersed and smaller investments than is GM's, though this may be of necessity rather than by choice. Nevertheless, Ford seems content to maintain a presence in China without expending enormous capital or technology for the privilege.

These three strategies — Chrysler's cautiousness, GM's boldness, and Ford's middle-of-the road approach — have not resulted in significantly different returns. Despite large investments in China's auto sector, US automakers have yet to realize significant gains in terms of market share in China's passenger car industry. Furthermore, according to numerous press reports and interviews conducted for this study, few if any foreign automakers in China are realizing a profit or even a return on their investment.[34] Statistics for 1994 also show that US automakers averaged no more than 10 percent market share compared to Japanese and European auto ventures in China who have achieved up to 40 percent shares.[35] US market shares have, if anything, declined since then.

As the new GM and Ford plants begin producing vehicles over the next few years, their market shares may increase. However, it is interesting to note that the US automaker with the longest experience in China is the most cautious with regard to manufacturing modern vehicles in China under current government policies. Nevertheless, the consistent answer to why these and other foreign firms persist in attempting to penetrate the Chinese auto market is the fear that a competitor (foreign or domestic) will benefit by being in China when China's market potential becomes a reality. The question and the concern for US industry in terms of China's auto sector, however, should not only be when, but whether, the market potential and stated goals will be realized. That is, by the time this happens, China's auto makers could well have garnered most, if not all, of this market for themselves, using capital and technologies supplied by foreign investors along the way to develop a substantial domestic auto industry.

TABLE 18
Research in China by US Automotive Industry

General Motors

GM has set up three R&D centers in China to date (at least two more are expected):

- The "GM in China Technology Institute" at Qinghua University in Beijing for R&D, post-graduate education and training in auto-making (1995). R&D work includes fuel quality studies, piston ring package development, crash injury and airbag module studies, and pedestrian protection test modeling[36]
- The "Powertrain Technology Institute" with Jiaotong University (1995)
- A new, $4 million center for R&D with its Shanghai joint venture partner

Ford Motor Company

Ford has established R&D centers and Labs as part of its joint venture with Jiangling Motors:

- Two R&D centers: one with Qinghua University in Beijing (China's equivalent of MIT) and one with Jiling University in Xian
- Two "Labs": one with Jiaotong University (Ford's C3P Laboratory involving the latest software for advanced computer-aided design, manufacturing, design; product information management; and training of PRC employees) and a recent agreement with Fudan University's Institute of Electronics in Shanghai to establish a "Joint Research Institute of Automotive Electronics."[37]

State of China's Automotive Industry

China's auto industrial policy clearly outlines China's plans for a self-sufficient and export-oriented auto industry. This has had a clear effect on China's auto trade balance. According to Chinese statistics, in 1986, 80 percent of all cars in China were imports, whereas currently less than 10 percent of China's automobiles are imports. By 2010, China hopes to achieve zero imports of foreign automobiles and auto exports of ten percent of auto production.[38] In the meantime, China continues to maintain extremely high and prohibitive tariffs (150-180 percent) on fully assembled foreign vehicles, and Chinese joint venture partners, who are often chosen by the PRCG, must hold a majority share in the enterprise. The apparent strategy, therefore, would seem to be a continuation of tariff and non-tariff trade barriers while protecting and supporting the domestic auto industry. Negotiations with regard to China's accession to the WTO may alleviate the problem of trade barriers in this sector but are unlikely to alter China's plans to develop as quickly as possible an indigenous auto industry.

An emerging trend in foreign investment in China's auto sector is a rise in auto part manufacturing joint venture enterprises. US component manufacturers in China include GM subsidiaries Delphi Automotive Systems (with 14 joint ventures in auto components), Delco Electronics, Hughes Electronics (electronics for autos and more), and although recently spun-off from GM, Electronic Data Systems (information technologies). Borg Warner Automotive/Beijing Warner Gear Co. (transmission cases), the Dana Corporation (axles),[39] and TRW (components, which include seatbelts, engine valves, "switches, control systems and other electrical/electronic

products" and possibly steering gears, air bags, crash sensors, and fasteners as well)[40] are also in China as is Meritor Automotive (formerly Rockwell, truck axles), and others.[41]

US trade figures indicate that US imports of auto parts from China have risen dramatically since 1992, almost tripling in value by 1996-97 and far outpacing growth in global US auto imports. The majority (about 70 percent) of US auto parts imports during this period consisted of brake drums, rotors, radiators, and parts as well as other miscellaneous auto parts (see table below for figures). China's overall share of total US auto parts imports, despite being small compared to total US auto parts imports, has grown as well.

> **"Productivity levels in the PRC auto parts industry, in particular, have benefitted from foreign investment."**
> *Source: Wayne W.J. Xing, "Shifting Gears," The China Business Review," November-December 1997, pp. 8-17.*

Although the import statistics do not clearly indicate a direct connection to US joint venture production and exports, given the high percentage of exported product required of foreign auto joint ventures in China, it is likely that some, if not many, of these imported parts are produced by US plants in China. If so, this could have serious implications for the auto industrial base in the United States in the future as more suppliers follow the "Big Three" into China. Given the high requirements for local content, it is likely, too, that foreign auto parts manufacturers in China will be increasingly involved in producing more sophisticated products (for example, airbags).

TABLE 19
US Imports of Auto Parts from China: 1992-1997 ($Thousands)

Category	Description	1992	1993	1994	1995	1996	1997
HTS 8708	**Total Motor Vehicle parts**	**$58,276**	**$62,672**	**$95,291**	**$129,303**	**$154,765**	**$188,310**
HTS 870839	Brakes and Parts thereof	$8,188	$16,724	$33,933	$50,966	$58,203	$74,194
HTS 870891	Radiators	$3,643	$4,390	$10,565	$13,285	$15,245	$11,478
HTS 870899	Parts and Accessories, NESOI	$33,660	$29,296	$30,983	$40,720	$48,373	$58,748
Subtotal for HTS Categories Above		$45,492	$50,410	$75,480	$104,971	$121,821	$144,421
Percentage of Total Auto Imports from China		**78.1%**	**80.4%**	**79.2%**	**81.2%**	**78.7%**	**76.7%**

Source: US Census Bureau

Chinese automakers control the distribution system for autos (primarily through former military and defense industry channels) and seem to have mastered the basic manufacturing and assembly of vehicles. However, they remain dependent on foreign components and have an insufficient understanding of the complete auto-making process from cradle to grave (i.e., management and marketing skills, customer service, quality control and reliability, etc.). The International Trade Administration (ITA) estimates that "with the exception of the Tianjin Automobile Industrial Corporation, which produces 60,000 passenger cars a year on a licensing arrangement with Daihatsu, all production in any scale and with any real quality has been done

with the help of a foreign partner in a joint-venture agreement. As with most investment in China, the foreign partner is expected to contribute money and technology."[42]

Although China's auto sector may be overcrowded and fragmented and its products of lesser quality than foreign-made products, there are indications of development. According to PRC domestic auto industry data, "altogether, there are now 122 automobile plants, 516 refitting enterprises, 109 motorcycle plants and more than 2,000 component manufacturers [in China]. There are also 32 technological centers and research institutes, three car testing centers and 12 quality control centers for auto products."[43] Foreign enterprises have also contributed to developing China's auto sector. According to Chinese sources, "By 1995, the [foreign] sector has introduced 313 foreign technological items, including 26 for whole car production, 30 for motorcycles, 25 for main assembly, and 153 for spare and component parts. Also in this period, 350 automobile and motorcycle joint ventures were set up, employing US$1.5 billion. All these efforts helped improve the industrial structure."[44] The number of new enterprises and institutions may or may not connote real development in China's auto industry, but the addition of technological research and development centers are sure to assist in advancing China's auto sector. The unveiling of China's first, domestically produced family car, the "Lucky Star," may provide a concrete indication of just how advanced China's indigenous automaking capabilities have become. [45]

Conclusion

> **"Foreign investment generally has helped the PRC auto sector upgrade its technology and efficiency levels...Other foreign firms have helped diversify China's auto market.** *Source: Wayne W.J. Xing, "Shifting Gears," The China Business Review," November-December 1997, pp. 8-17.)*

Although the influx of foreign investment and technology into China's auto industry have assisted in upgrading China's domestic auto-making capabilities, China's auto sector does not currently pose a direct competitive threat to the US auto industry as a whole. The current output of all of China's auto plants would not equal that of one of America's "Big Three" automakers.[46] However, the rapid development expected in China's indigenous auto sector is not only a question of market share or production levels. As noted above, much of the development of China's auto industry is the result of defense conversion programs and other industrial reform efforts. The application of auto manufacturing technology and processes to the defense sector (spin-ons) is possible, but not a likely scenario in the near future, particularly given the China's lack of external threats at present.

Demand in China's auto industry, however, is not expected to outpace production capacity any time soon, thereby providing time for China's domestic auto industry to develop and for Chinese auto exports to grow. Asia is currently the largest auto-producing region in the world. The result is that all of Asia is now witnessing overcapacity in the auto industry, approximately 15 percent of which is due to overcapacity in the China market. As China's auto sector develops, the global problem of excess capacity will only continue to worsen, by which time, most if not all foreign investors may have abandoned the China market.[47] The point to be made here, however, is that a good deal of technology transfer could occur in the interim with slim near-term returns to US companies.

Although initially attracted by China's potential auto market, several foreign automakers (including Peugeot, Toyota, Mercedes Benz, and Chrysler) are now reconsidering, slowing, or pulling out of their investments in China. GM is the obvious exception, as they intend to make their new Shanghai joint venture the hub of GM's Asia auto system. The UAW, however, has

sounded a note of caution, stating that "most industry analysts predict that demand in the PRC will lag behind production capacity significantly in the years ahead, creating the potential for exports of automotive vehicles and parts from the PRC that compete with US production."[48]

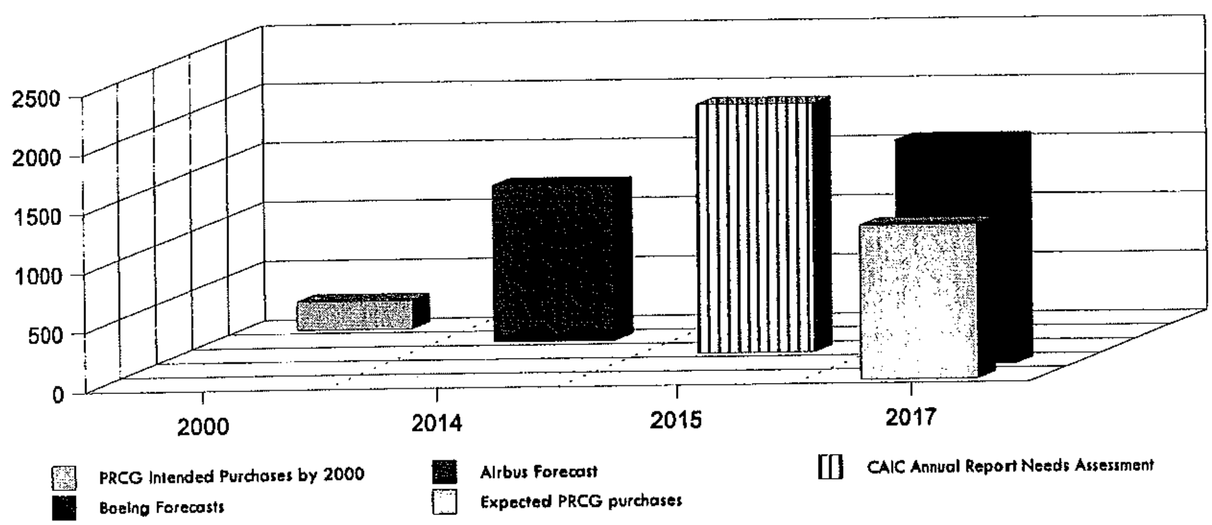
Finally, the difficulties experienced by foreign automakers in China and the strategies developed by Chinese officials to manage the industry in a way that restricts and discriminates against foreign investors (but does not appear to significantly stem foreign investment or technology transfers) are not unique to the auto sector and may foreshadow problems and areas of concern for future high-tech foreign investment in China.

Aerospace

Not an Official "Pillar Industry" Nor an Official Industrial Policy

China's aerospace market also demonstrates the effects of managed foreign investment focused on technology acquisition. Although the aerospace sector has *not* been officially designated a "pillar" industry, Chinese officials certainly regard this as a strategically important sector and have allocated significant funds for development of its civilian aviation industry (along with other infrastructure projects). It should be noted also that there is no official, published policy requiring technology transfers in the aerospace sector. However, analysts argue that no such status or policy is necessary. Foreign aerospace technology is available to China and is likely to grow. As with other industry sectors, Chinese officials pursue a strategy of playing foreign investors off one another.[49] There is no better example of this than in the competition for China's aviation market between the United States' Boeing Company and the European Airbus consortium.

Chart 2
Projections for Chinese Commercial Aircraft Demand



Sources: China Aviation Industrial Corp, under Civil Aviation Administration of China (CAAC); "The Boeing Company and China."; "And Then There Were Two," Asian Wall Street Journal (HK), December 17, 1997; "Boeing Takes Most of 1996's Aircraft Orders," South China Morning Post (HK), January, 4, 1997; "Airbus Makes Bid for 100 Planes," Reuters (UK) report, March 4, 1997; Annual Report by China Aviation Industrial Corp, under Civil Aviation Administration of China (CAAC), cited in "China's Needs for Planes Increases," China Economic Information (PRC), March 15, 1997 all cited in China Commercial Quarterly, Dec. 10, 1996-April 1997; Tony Carter, "Strategic Customer Development in China," The Columbia Journal of World Business, vol. xxxi, no. 4, Winter 1996, pp. 56-64;60.

Unlike the auto sector, the projections for China's demand for commercial aircraft are more realistic, although the estimates cover a wide range over the next 20 years (see chart below). The demand for air travel in China — both foreign and domestic travelers — is enormous and will surely require numerous Chinese purchases of foreign aircraft. Accordingly, Chinese officials plan to spend over $1 billion on infrastructure projects, including airport construction, and "technological renovation projects" (such as upgraded ticketing systems). This figure is in addition to monies set aside for purchasing aircraft and local airport-related projects.[50] It is not surprising, however, that PRC officials are concerned about dependence on one aircraft manufacturer, Boeing, whose planes comprise approximately 80 percent of all planes flying in China today (279 out of 354 jetliners in mid-1997). For this reason, as well as for political leverage, Chinese officials have increasingly alternated purchases of civilian aircraft between Boeing and Airbus.[51]

Trade, Trade Barriers, and Technology Transfers

One in every ten Boeing planes produced is intended for sale to China, making Boeing the largest single US exporter to China.[52] This ratio is likely to increase as Asia, led by China, is the fastest growing market for US aerospace exports, comprising almost 14 percent of total US aerospace exports in 1996.[53] Despite the obviously enormous opportunities present in China's aviation sector, however, US aerospace companies, represented now primarily by Boeing (due to the recent merger with McDonnell Douglas) and several parts suppliers, appear to be willing to make significant concessions to Chinese state planners in co-production agreements in return for increased market access.[54]

According to the United Auto Workers (UAW), "US-based aerospace firms have already agreed to onerous conditions in order to win access to the market in the PRC by acceding to co-production deals and technology transfers."[55] The UAW is not alone in its criticism of the apparent *quid pro quo*.[56] Examples of commercial offset agreements by US aerospace firms include donations by Boeing of two multi-million dollar simulators to the Civil Aviation Flying College (CAFC) for training as well as other pilot training programs, a spare parts center in Beijing, and millions of dollars worth of "infrastructure development" in China.[57] Boeing is also not alone. Rockwell (purchased by Boeing in 1997) has also set up automation training centers with three Chinese universities.[58] In addition, a senior representative of AlliedSignal noted in a media interview the importance of offsets as a means of getting a foothold in the China market. With regard to China he stated that, "Obviously, we're hopeful that our presence there and all the technology transfer will have an impact on equipment selection for the AE-100. We'd like to leverage our presence into higher content, but it's more of a recognition by senior management that there's just a tremendous future market potential for aerospace in China, and we need to be there."[59] Arguably, these agreements also benefit Boeing, AlliedSignal and the traveling public as a whole. However, contracts based on co-production in China and accompanied by commercial offset provisions will likely increase in number and in terms of advanced technology transfers over time.[60]

TABLE 20
US Aircraft Parts Co-Produced by Chinese Joint Venture Partners

737	vertical fins, horizontal stabilizers, forward access doors, tail sections
747	trailing edge ribs
757	cargo doors, empennage
MD80	nose section
MD82	plane co-production and "kit" assembly (up to 20 percent Chinese content)
MD90	final plane assembly in Shanghai; nose section, component fabrication, and "significant sub-assembly production" (up to 80 percent Chinese content)
Airbus Industrie Aircraft Parts Co-Produced by Chinese Joint Venture Partners	
A300	access doors, machined parts
A310	access doors, machined parts
A320	fin-ribs, emergency exit doors
A330	access doors
A340	access doors
AE31X/AE100	assembly line production [program has since been cancelled]

Source: Boeing Company press releases; for Airbus information, "Airbus Equity-Sharing Wins Chinese AVIC Partnership," Countertrade & Offset, vol. xv, no. 17, September 8, 1997, p. 3.

Competition from the State-Owned Enterprise Sector, Infrastructure Concerns, and the Status of the Chinese Aerospace Industry

Aerospace and Aviation

Growth projections for China's civilian fleet are high due to the increasing demand for air travel in Asia and in China. The current size of China's civilian fleet is thought to be comparable to that of the United States in the 1950s.[61] Most of China's civil aviation market was "corporatized" in the early 1990s, and air traffic control (ATC) is increasingly coming under civilian control.

Boeing has done business with China since President Nixon's first initiative in 1972 to renew ties with the PRC and has collaborated in industrial co-production since 1980. As a result, Boeing claims that "there are approximately 2,000 Boeing airplanes currently flying worldwide that include major parts built by China." Other US aerospace firms are now in China as well. Pratt & Whitney (P&W), whose jet engines currently power almost half (45 percent) of China's civil aircraft, became in February 1996 the first foreign company to establish an aviation parts manufacturing joint venture in China (with the Chengdu Engine Company) to produce manufactured parts and assemble engine parts.[62] In addition, AlliedSignal Aerospace has a parts repair joint venture that refurbishes advanced technology carbon brake disks. As of May 1997, Raytheon had contracted to install nine air traffic control (ATC) radar systems, the latest of which "includes

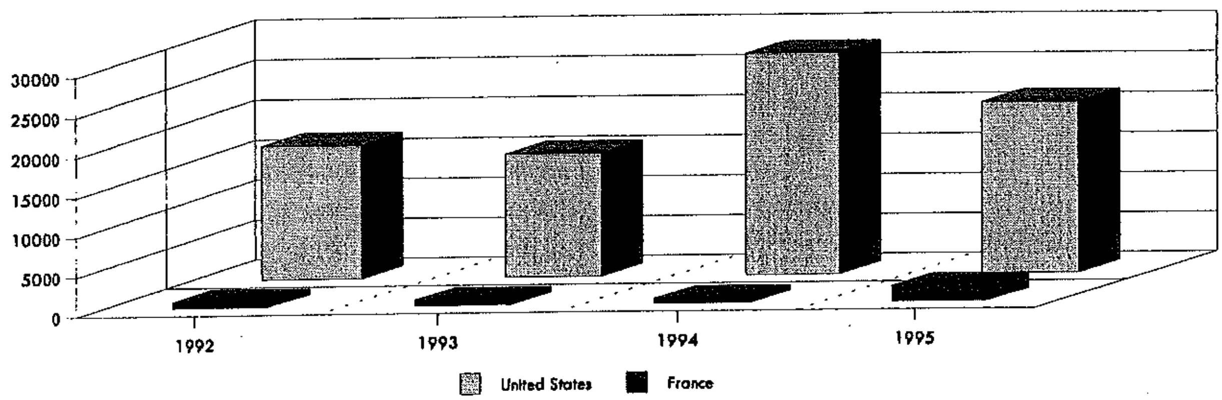
primary and secondary surveillance radars, communications, training, and spares for the new airport in the southern city of Guangzhou."[63]

It is not only from US aerospace companies such as Boeing (and McDonnell Douglas) but also European companies such as the Airbus Industries consortium and their respective suppliers from whom China is gaining aircraft manufacturing know-how. Chinese aircraft companies engaged in these co-production and manufacturing projects do appear to be learning from these experiences. Taking Chinese industry export statistics as an example, of the transport and equipment category (SITC 79), airplane or helicopter parts were the top Chinese export item to both the United States and France for each year running from 1992 to 1995 according to Chinese trade statistics submitted to the United Nations, although the US far outpaces France in this category (see chart above). US trade figures (for HTS 8803300610) confirm these figures but show that although US imports of aircraft parts from China increased between 1992 and 1995, the percentage of total US imports in this category remained at about one percent through 1997.

The opportunity for US technological know-how to indirectly assist the PLA Air Force (PLAAF) modernization efforts does exist. Foreign aerospace joint ventures are typically established with or located near China's military aerospace factories, namely the Xian, Shenyang, and Chengdu Aircraft Factories (this includes Boeing and former McDonnell Douglas ventures) in addition to various other locations such as Shanghai.[64] For example, in addition to co-producing the parts for Boeing, the Xian Aircraft Company manufactures China's H-6 bomber (first produced in the late 1960's under license from the USSR) and various civilian passenger aircraft. These three companies are each attempting to manufacture new-model fighter/combat aircraft for indigenous use as well as for export. Foreign partners and components are being sought for co-development but are having to depend largely on domestic technologies due to the break off of military assistance beginning in 1989. However, state-owned military aerospace industry corporations have shown a preference for focusing on commercial, profit-making endeavors rather than devoting energy, time or resources to the primary task of defense production.[65] Chinese President Jiang Zemin's July 1998 directive that the PLA dissociate from its commercial enterprises is expected to affect the type of work these enterprises focus on in the future.

There are also significant barriers to China's ability to realize military gains from civilian aircraft-related US commercial technology transfers. Chief among these, of course, is the fact that sanctions stemming from reactions to the Tiananmen Square incident in 1989 prohibiting military sales to China remain in place.[66] Internally, China's abilities and reputation in terms of military aircraft manufacturing and reverse-engineering capabilities is notoriously poor and does not seem to have improved. According to a survey of China specialists conducted by Robert Sutter in 1997, "Chinese military engineers and other technicians have endeavored to develop their own technologies and weapons, in the process new Chinese weapons systems have often taken a long time to move from the planning stage to deployment, and many have not made it to deployment."[67] Since Sino-foreign co-production projects only really began in the late 1980s, it is unlikely that much significant progress in attempting to spin-on this technical know-how to military purposes has occurred thus far. Another factor that is likely to impede military benefits accruing from foreign aviation co-production agreements is the fact that Chinese airlines have been rapidly deregulated and have been made more autonomous in their dealings with foreign aircraft suppliers. Thus, decisions as to which foreign aircraft and aircraft parts manufacturers are chosen for Chinese joint venture agreements have become more political and commercial in nature rather than decisions based primarily on military objectives.

Chart 3
Chinese Exports of Airplane or Helicopter Parts: 1992-1995
($Thousands)



Source: *United Nations*

Nevertheless, despite the overall modest capabilities of China's military air force, some of the technologies involved in Sino-US joint ventures could potentially assist China's military as well as commercial aviation sector. The areas in which China's air force is seriously lacking coincide with some of the high-tech foreign investment areas in China. For example, among the PLAAF's most serious deficiencies are high-volume, high-quality production of aircraft and a limited command and control network. Foreign (including US) joint ventures in the aerospace and telecommunications sectors are involved in manufacturing technological products that could potentially be used to improve these military capabilities (e.g., air traffic control or global positioning systems). In late 1996, Rockwell announced plans to form a company to design, develop and build commercial GPS navigation receiver systems with Chinese partners in Shanghai (Rockwell press release). An agreement was signed in 1986 between the Federal Aviation Administration (FAA) in the United States and the Civil Aviation Administration of China (CAAC) for technological assistance in the civilian aviation sector, mainly in terms of air traffic control. [68]

Foreign technology transfers will do little to alleviate the chronic problems of China's existing antiquated military aircraft, limited training and combat experience, or the PLA's bureaucratic and logistical problems. Nevertheless, the long-term effect of foreign commercial technology transfers in the aerospace sector (as well as telecommunications, discussed below) could potentially be of greater benefit to the PLA than is either expected or desirable.[69]

Chinese Satellite and Space Programs

Satellite technology is another area in which US businesses are restricted by US trade sanctions stemming from the Tiananmen era, although three US companies (Lockheed Martin, Hughes, and the Loral Space and Communications Co.) have been allowed under Presidential waiver to sell or launch American-made satellites in China. At present, the United States maintains a 50 percent market share in China for satellites and related parts despite the restrictions. A bilateral agreement on commercial space launches was reached in 1989 (and updated in 1997) to allow limited numbers of satellite launches by China at set costs. Because, by US law, US satellite launches and equipment in China must be very carefully controlled and supervised by American representatives, the opportunities for significant technology transfers to China are limited in this sector.

Confidence in China's launch capabilities was severely strained following a series of accidents in 1995-1996. Perhaps for this reason, the category for "parts for spacecraft and associated equipment, launch vehicles (nesoi)" is among the relatively few categories in which US imports from China have declined, according to data supplied by the PRC to the United Nations.[70] After almost a year delay, China seemed in 1997 to have recovered from these technical difficulties.[71] China's launch services will be in greater demand due to the implementation of various Low Earth Orbit (LEO) satellite-based projects such as the McCaw-Gates Teledesic, which must out of practical necessity rely on a wide range of launch providers.

According to a recent report on the industry, US and European global market shares for international commercial satellite launches are 32 and 52, respectively, with China and Russia currently maintaining eight percent each.[72] If China is able to retain international confidence in its ability to launch commercial satellites, China's share of this important market is certain to increase due to China's comparatively low pricing for such launches and the number of commercial satellite launches expected over the next five to ten years.

The issue of technology transfers may become more critical if and when the Tiananmen sanctions are eased or ended completely. Satellite technology is dual use but also in high demand and commercially available around the world.[73] As in most industries, however, China endeavors to become fully self-sufficient in this sector.In fact, it is the expressed goal of the Chinese government to "continuously try to catch up with and exceed the advanced world level in remote-sensing science and technology under China's high-tech research and development program."[74] Accordingly, the desire for "co-development" is among the "four principles for international cooperation" set by Chinese leaders. This principle applies to the satellite industry as well.[75]

China also has ambitious plans for its space program. Chinese leaders hope to develop a space vehicle and to begin manned space flights by the year 2010. According to Chinese press reports, some recent progress has been made in this effort, with Chinese-made space vehicles described as "smaller than those of the United States and less expensive to maintain." However, talk of ambitious space programs has been heard in China dating back to at least the mid-1980s, with little known progress reported.[76]

Finally, it is important to note that China views the space and satellite industries as key to its overall economic and industrial modernization plans. The plan for the 1990s is that "satellite applications and manned space flight technologies will promote high-tech industries, including mobile and optic-fiber communications, biology and marine engineering, and new energy sources, thereby creating another leap forward in these areas." It should also be noted that despite foreign expectations, China's scientific community has in the past been successful in rapidly developing advanced technologies when provided with strong government support, funding, and motivation. If made a priority, this could also be applied to the space and satellite industries. International prestige and 'face' also potentially play an important role in this high-tech sector.[77]

Conclusion

A 1982 internal feasibility study for the Chinese military based on China's aerospace technology at the time concluded that "China should import from foreign countries certain critical technologies and actively modify the aircraft in service and develop new types of aircraft."[78] This is exactly what Chinese military/civilian aerospace companies appear to be trying to accomplish, by establishing joint ventures with foreign aerospace firms. Co-production agreements and other commercial offsets (such as Boeing's and Rockwell's training centers) can be expected as part of future aerospace contracts in China.

The number of contracts is also expected to increase as China's civilian aviation market grows and foreign aerospace firms move more manufacturing into the Asia-Pacific region.[79] However, if the largest US exporter to China — Boeing — begins to move significant manufacturing to China due mainly to commercial offset or technology transfer requirements, then this would probably hasten China's advancement in its plans to develop an indigenous aircraft manufacturing base intended to serve its own market and to provide exports to the rest of Asia. This could also have a more immediate and adverse effect on American jobs and competitiveness in the aerospace industry and for the US economy as a whole.[80] China is, in fact, listed in the US Industry and Trade Outlook among those nations with the potential to become a manufacturing competitor to the United States in the aerospace field.[81] Lastly, the cumulative effect of these technology transfers could potentially be significant advances in China's military aviation and aerospace capabilities that would likely not otherwise be possible over the same period of time.

Electronics & Telecommunications

This is the most difficult industry sector to analyze given the fast pace at which advances are made and new technologies emerge. What constitutes "state-of-the-art" technology one week may be outdated in six months or a year later. Simultaneously, however, the electronics sector also allows "fast followers." In other words, latecomers to this industry are not as disadvantaged as they are in other industries (such as auto or aerospace) and can — given basic capabilities, sufficient resources, and motivation — catch up rather quickly to the industry leaders. Although China lags behind its neighbors as well as the United States, there are indications that China is catching up in some electronics-related sectors as a result of technology transfers. Most technology transfers are in the form of component co-production and assembly as well as access to "soft" technologies (processes, management techniques, accounting methods, etc.) derived from foreign technical assistance and training.

"Pillar Industry" Status

Chinese leaders declared electronics to be a "pillar" industry in 1994. As with other pillar industries, China has developed an internal industrial policy designed to create an indigenous electronics industry. This effort is receiving a great deal of assistance from foreign firms; "Today, every major international component vendor ... is establishing advanced capabilities in China."[82] Shanghai was chosen as the preferred location and hub for this new industry, but the planned growth has not yet materialized as expected. That may change with the existence of new government-sponsored projects, particularly in the semiconductor manufacturing sector (such as the recently awarded "Project 909" to the Japanese firm, NEC). Nevertheless, it is Guangdong and Fujian Provinces that are attracting the majority of both foreign and domestic electronics firms. The majority of Sino-foreign electronics joint ventures are located in these southern regions, including ventures with China's leading domestic electronics firms, such as Legend and China Great Wall. Both are based in Beijing but have established subsidiaries in Guangdong.[83] Primarily as a result of the dynamic interchange among Hong Kong, Taiwan, Japan, and the southern Chinese provinces, there has been a significant flow of foreign technology, capital, and know-how in this sector.[84]

Industrial Policy

Although the exact terms of an official electronic industrial policy have yet to be published, an industrial policy "outline" for the electronics sector is, nevertheless, being implemented by Chinese officials. Numerous Chinese press reports over the last several years state that the policy

includes provisions that call for the following: advanced and continuous technology transfers as part of future joint venture agreements; preferential policies for foreign investors in China's electronics sector[85]; export of 70 percent of joint venture-manufactured products; high-level review and approval of certain electronics joint ventures (such as for production of color televisions, fax machines, computers and monitors, camcorders, mobile phones, etc) that must "conform to the state's industrial policies"; and the export of 100 percent of the products resulting from labor-intensive joint ventures or wholly foreign-owned enterprises in this sector. Lastly, joint ventures will be especially welcome by Chinese officials in "new generation" electronics such as broadband telecommunications as well as digital mobile communications products.[86]

The fact that an industrial policy for the electronics sector has not been officially published (as it has for the auto sector, for instance) leaves US and other foreign firms open to arbitrary decisions and pressure by local, provincial, and central government Chinese officials for technology transfers or commercial offset arrangements in exchange for market access. Member companies of the American Electronics Association (AEA) "have expressed concern about what is commonly referred to as 'market share for technology transfer.' While such technology transfer requirements are not spelled out in Chinese law, the government's practice is to persuade foreign firm[s] to transfer technology for market share."[87] Chinese officials are allegedly unambiguous, however, in making clear during negotiations that market access is available only in exchange for technology transfers and regularly try to play one foreign corporation against another.[88]

The lack of transparency also adds to start-up costs for new firms, who generally attempt to abide by established practices and legal standards at startup in order to prevent problems down the road under the assumption that the policy being implemented will in time become official, published policy. China's industrial policy for the electronics industry (as well as for other key sectors), however, is intended to be continuously updated in terms of investment, trade, and technology transfer provisions by the government as needed. In fact, the policy of China's Ministry of Electronics Industry is reportedly that "China will not encourage technology transfers or establishment of joint ventures in China if out-of-date technologies are involved."[89] For example, China has reportedly issued new technical requirements for more advanced, domestically produced program-controlled switching devices for its telecommunications industry and announced an end to imports of program-controlled switching devices in order "to support the development of domestic enterprises and joint ventures."[90]

China's emerging electronics industry is largely concentrated in the Southern coastal region (primarily Guangdong and Fujian provinces, where China's SEZs were first established) and dominated by non-state sector Chinese enterprises involved in joint ventures with foreign companies. This was not necessarily Beijing's plan. Shanghai was expected to become the main hub for China's new electronics industry. The success and number of electronics firms in the southeastern provinces, however, is due to the regional shift in electronics production from Hong Kong, Taiwan, and Japan to Mainland China but also, ironically, to the ineffectiveness of Chinese industrial policies in the electronics sector.[91] That is, the very success of the electronics industry in these southern provinces is primarily due not to explicit trade and investment provisions included in an industrial policy designed to protect and bolster domestic firms but to the geographical, and more importantly, political distance from Beijing that allowed both foreign and domestic firms more leeway in conducting business.

Chinese leaders have designated six SOEs as key enterprises in the electronics sectors to receive preferential government assistance.[92] The more liberal political and commercial environment found in the Southeastern provinces and SEZs, however, has encouraged more market-oriented behavior among China's more successful state and non-state sector electronics firms such

as Legend, Founder Electronics, the China Great Wall Group, and Stone, all of whom have channeled much of their production to the southern areas while maintaining offices in Beijing.[93] Thus, although the protection provided by China's industrial policy no doubt has assisted Chinese firms in competing against foreign electronics firms, the lack of a heavy government hand in managing these firms in the free-wheeling southeast region has allowed them to benefit from foreign competition, more so than for the selected SOEs.[94] In turn, foreign firms have been more willing to invest in this region, to establish joint ventures or collaborations with the non-state sector enterprises such as Legend and Stone, and to transfer a good deal of technology in the process.[95]

Trade Barriers

China has opened its electronics sector to foreign investment, especially over the last few years in terms of more advanced electronics. In fact, the electronics sector has received more foreign investment overall than any other industry in China, which is evident in the rise in Chinese exports and production of electronics items.[96] By 1994, the category of "electric machinery, tv equipment" (HTS85) had become the number one US import category from China (up from seventh place in 1986).[97]

Significant trade barriers remain, however, for foreign companies seeking to do business in China. In the computer hardware/software sector, China currently maintains a 17 percent VAT on hardware (13 percent on manuals) in addition to a 10 percent withholding tax and nine percent tariff on software and hardware (a 9-20 percent range exists for the latter).[98] High tariff rates (6-12 percent) exist in the semiconductor sector as well. According to the Semiconductor Industry Association, "Chinese tariffs tend to be higher on low-end semiconductors which China can make domestically, and lower on complex devices which must be imported."[99] Once again, this makes the prospect of exporting US products to China a costly one.

A new barrier to trade and a potential technology transfer concern has emerged in the form of inspection certificates for products to be made or sold in China. Chinese officials have periodically updated the list of items requiring safety certificates, the most recent revision of which includes technologically sophisticated items. According to the US-China Business Council, "There is also some evidence that domestic firms are not always subject to the same inspection procedures required of foreign companies. Foreign companies in a number of sectors are finding that many of the PRC's standards, licenses, and inspection procedures interfere with their ability to market their goods in China and, in effect, pose significant non-tariff trade and investment barriers."[100] These problems with licensing and inspection are also included in areas of concern in the 1997 *National Trade Estimate Report on Trade Barriers*. As the list below shows, the items requiring certification are increasingly concentrated in the electronics sector.

In a recent interview, a representative of Dell Computer Co. spoke frankly about the impractical option of exporting directly into China. In answer to a reporter's question asking, "could you right now put up a website in China and have people order PCS directly from you?," the Dell representative answered: "If I wanted to just import product and then buy/sell it myself as a trading company inside of China and pay full import duty because I'm a public corporation and there's the Foreign Corrupt Practices Act that I need to comply [with] —you could do that, in theory, providing the government approved you to do that. But the price points that you would achieve would probably not be competitive."
Don Tennant (Computerworld), "Interview: Aiming Direct at China's PC Market—Dell's Phil Kelly," Market News Update, IDG China, August 12, 1997.

TABLE 21
Foreign Products Requiring Safety Licensing Certification[101]

First Catalogue of Imported Commodities Requiring SACI Certificate (Effective May 1990)	*Second Catalogue of Imported Commodities Requiring SACI Certificate* (Effective October 1996)	*Second Catalogue - Addendum* (Effective October 1997)
1. Automobiles 2. Motorcycles 3. Motorcycle engines 4. Refrigerators (including food processors) 5. Compressors for refrigerators 6. Air conditioners 7. Compressors for air conditioners 8. Television sets (b&w/color) 9. Kinescopes	1. Household washing machines 2. Vacuum cleaners 3. Appliances for skin/hair care 4. Electric shower units 5. Roasters and the like 6. Microwave ovens 7. Electric rice cookers 8. Electric irons 9. Cooking ranges 10. Food processors 11. Appliances for heating liquids 12. Video-cassette recorders 13. Audio equipment 14. Personal computers 15. Visual display units 16. Switching power supplies 17. Printers 18. Electric tools 19. Low voltage apparatus 20. Electric welding machines	21. Telecommunications terminal equipment 22. Security technology protection commodities 23. Fire alarm 24. Medical diagnostic equipment 25. Haemodialysis equipment 26. Hollow fiber dialysers 27. Extracorporeal blood circuits for blood purification equipment 28. Electrocardiographs 29. Implantable cardiac pacemakers 30. Ultrasonic diagnosis equipment and ultrasonic therapy equipment 31. Automotive safety glasses 32. Automotive pneumatic tyres 33. Motorcycle tyres 34. Automotive safety belts 35. Boilers 36. Moveable pressure vessels 37. Fixed pressure vessels 38. Safety accessories for boilers and pressure vessels

Source: Kristin Dubinski, "Certification Scheme of the People's Republic of China," Brochure prepared by Underwriters Laboratories, Inc., updated 1997.

The requirement for such certification does not, in and of itself, constitute a major trade barrier (though it may deter trade and likely contradicts WTO provisions). The problem in this particular case is that in applying for certification, foreign firms reportedly have been required to submit very detailed and even proprietary or confidential information, including technical specifications, manufacturing processes, designs, blueprints, formulas, patents, etc. According to Underwriters Laboratories (UL), the certification process is also extremely complicated, may involve approval from numerous Chinese government ministries (depending on the product), and does not allow for initial US inspection and certification on behalf of US companies. Such provisions/conditions add significant costs to foreign firms (in terms of time required for certification and reimbursement of

travel expenses for Chinese inspectors). These requirements particularly affect those companies wishing only to export their products without setting up manufacturing joint ventures in China. Products in the categories listed not receiving certification cannot be imported into, exported from, or sold in China.[102]

Furthermore, the telecommunications sector as a whole poses a significant problem for prospective foreign investors due to severe restrictions on investment. Foreign investors are not permitted to establish wholly foreign-owned enterprises (WFOEs) in the telecommunications sector,[103] the commercial side of which is controlled by a monopoly, formed by joining the former Ministry of Posts and Telecommunications (MPT) and its former state-run competitor, Unicom, established in 1994.[104] As of 1997, joint ventures are permitted with Unicom, but the foreign partner must hold no more than a 50 percent share in the enterprise. Limits on services and distribution are also areas of concern for foreign investors.

During Chinese President Jiang Zemin's visit to the United States in October, 1997, it was announced that China intends to join the Information Technology Agreement (ITA) as quickly as possible, which means that all Chinese tariffs on information technology products must be eliminated by the year 2000 (or 2005 at the very latest, and only if consent is granted by other ITA members). This is a very welcome sign for US investors in this sector, and may go a long way toward changing Chinese attitudes on adopting market-oriented policies as well as having practical effects on trade. As has been witnessed in the past, however, it is entirely possible that tariff barriers in this sector will be replace by various non-tariff barriers.[105] For this reason, it is incumbent upon US investors and government officials to continue to press China on liberalizing this most vital and dynamic industry.

In May 1997, the State Council announced a "trial" program allowing foreign joint ventures to be established with Unicom in the telecommunications sector provided the foreign partner hold no more than 50 percent equity. Thus, "the scheme does not signal an end to China's ban on foreign ownership and operation of telecommunications networks in China, but it is a further step in that direction." ***(See "Industry Monitor," Business China, May 12, 1997, p. 11.)***

Foreign companies are currently not permitted to *operate* telecom networks in China (which are controlled by the Chinese state/military) but are allowed to sell equipment and provide limited after-sales service.

In August 1998, the State Council announced a ban on so-called "Chinese-Chinese-Foreign" (zhongguo-zhongguo-wai) arrangements between foreign telecom companies and Unicom. These agreements had allowed foreign telecom companies greater freedom of operation despite Chinese regulations forbidding direct foreign involvement in operating telecom systems.

Lastly, the problems of piracy, smuggling, and intellectual property rights infringement persist, especially in the southern province of Guangdong. Although part of China's national anti-crime and corruption campaign, piracy is having deleterious effects on foreign investors, mainly in terms of lost revenue. A Chinese software firm estimates the level of overall software piracy in China to be about 70 percent while the Software Publishers Association (SPA) lists China's piracy quotient at 96 percent (compared to 27 percent in the United States) as among the top IPR violators in the world.[106] As Chinese software firms grow, however, they too are becoming more interested in China's anti-piracy enforcement policies.[107]

Competition from the State-Owned Enterprise Sector

As in other industrial sectors in China, foreign investors in the electronics industry often find themselves up against competition from China's state-owned, heavily subsidized enterprises.[108]

Software programming, for example, has been identified by Chinese officials as a key sector warranting government support. There are at least 200 domestic software development enterprises and over a million software professionals in China that enjoy some degree of government support in their competition against foreign companies (e.g., Microsoft) for market share.[109] Leading Chinese computer and software companies such as Legend, China Great Wall and the Founder Group all originally hail from the state sector (and maintain ties to their former institutions) but are now working with Microsoft, IBM, Oracle, Intel and others in designing software for the China market. In press reports, Microsoft's representative in China, Bryan Nelson, has characterized some of China's domestic software firms as "world class," mainly in terms of their software application programs. Similarly, Intel's China director has termed Chinese computer products as "very advanced systems and very competitive with multinationals."[110] Thus, according to *The China Business Review*, "compared to their counter parts in other emerging sectors in China, foreign firms in the software sector seem willing to impart some (if not all) of their advanced technical know-how to domestic [Chinese] companies, especially in cases where the foreign firm supplies underlying software, such as operating systems or database engines, on which applications tailored to the China market must rely." By doing so, however, the software industry is gambling that technology transfers in software development — despite concerns over IPR infringements and creating competitors — will lead to more gains than losses in the long-term. To date, however, "many foreign software firms have yet to turn a profit, and continue to risk considerable resources on China's market potential."[111] The danger lies in the fine line between collaborator and competitor. With the backing of China's government, Chinese partners may soon prove capable of absorbing the technology, programming skills, and processes needed to move ahead of their mentors. (See Appendix E for a list of recent US-China collaborations on software).

Foreign electronics firms may also be in for increased competition from China's defense-industrial electronics sector. In a 1997 announcement, a top military leader (Liu Huaqing) stated his intention to open up China's defense electronics sector to foreign investment in 1998.[112] Presumably, the idea is to bolster this sector with foreign capital and technologies as well as to entice foreign governments to end Tiananmen-era sanctions on exports of military equipment to China.[113] Chinese officials have designated US$60-70 billion dollars through the year 2000 for the development of a state-of-the-art electronics sector, in large part motivated by Chinese analysis of the contribution of sophisticated electronics-based "smart weapons" and other revolutionary military capabilities demonstrated during the 1991 Gulf War.

How sophisticated is China's defense electronics industry? While some experts characterize China's present defense electronics sector as extremely weak (even as compared to the commercial side), others describe it as being very strong.[114] The disagreement stems from the extremely secretive nature of China's military sector, which makes a definitive assessment impossible. It seems clear, however, that whether or not China's defense electronics capabilities can be considered advanced, the PLA has yet to demonstrate a high degree of integration or upgrading of its forces (air, naval, or ground), and is certainly not up to Western or US standards. The exceptions to this assessment may be in some "pockets of excellence" within the PLA — areas that have received extraordinary support and resources (i.e., nuclear and missile fields). That said, US investors in China's electronics industry must be aware of Chinese defense objectives and the contribution that American commercial technologies could have in assisting China's military modernization efforts.

Infrastructure

Unlike other sectors of the economy, China's severe lack of information and telecommunications infrastructure is, in fact, an advantage. It is much less an expensive prospect,

for instance, to build a new, modern, fiber-optic telecommunications network throughout China than it would be if, as in other developing or developed countries, a system were already in place that would require dismantling or replacement of old equipment. As a result, the lack of such an infrastructure actually allows China in many cases to "leapfrog" over old technologies to install "state-of-the-art" equipment supplied by foreign enterprises.

Distribution of product and services, however, is a problem for foreign investors in this sector as in others. The telecommunications sector poses a particular concern with regard to technology transfers in that the Chinese military has jurisdiction — along with the MII — over a wide range of radio frequencies upon which communications networks in China are heavily dependant.[115] Thus, in order to gain access to these basic frequencies, foreign investors in this sector are having in some cases to deal with enterprises and officials of the PLA. The Chinese partner for a GTE joint venture to build a national paging network, for instance, was the Guangzhou Guangtong Resources Co., reportedly a PLA-affiliated company. The partnership was necessary to gain access to the required radio frequencies and distribution system that only a PLA-affiliated partner could provide.[116]

The Year 2000 problem (referring to the problem computers will have recognizing the date upon the turn of the century) will likely pose fewer problems in China than in the United States for instance given the recent infusion of information technologies into China. However, this approaching problem has not garnered much interest or concern among Chinese programmers, businessmen, or government officials until very recently. China is likely to experience difficulties in terms of its banking, financial, and telecommunications sectors as well as the insurance industry, which could seriously hinder China's ongoing reform efforts.

For a discussion of this issue, see Jared Peterson, "China Lacks Awareness of Year 2000 Problem," Market News Update, IDG China, April 7, 1997.

It is not clear to what extent investment in and revenues from PLA-related enterprises are directly channeled into the military budget and modernization effort. Most of the money collected from these enterprises is thought to go toward improving living standards and providing basic needs for military personnel. Nevertheless, as US investments in this and other high-tech sectors increase, so too will the opportunities for the Chinese military to benefit from US commercial technology transfers.

Lastly, if one considers human resources to be a fundamental infrastructure in terms of the electronics field, China is well-equipped. China's "Open Door" policy has brought increasing numbers of students (mostly at the graduate level) to the United States for training primarily in the scientific, engineering, and mathematics fields. Furthermore, the brain drain from China since 1989 seems to be reversing, with more of these students finding their way back to work in emerging high-tech fields in China. According to *The China Business Review*, "Some foreign companies are reportedly hiring students of science and mathematics universities like Qinghua to undertake programming projects. This practice tended to be informal until a couple of years ago, when the Chinese government apparently began to broker such employment arrangements and require companies to contribute on behalf of the student employees to China's social insurance funds."[117] This practice would seem to fit with the overall trend toward commercial offsets in the form of training, research or development as a part of joint venture contract agreements in China.

US Experience

The US experience in China's electronics and telecommunications sectors dates back only to the early 1990s for many US investors. These sectors, however, have experienced the most rapid growth in China and, arguably, the highest level of US commercial technology transfers. Of the top

US investors in China, half are involved in joint ventures producing electronics, telecommunications or computer-related equipment (though not necessarily as the primary enterprise).[118] This is particularly interesting given the fact that the telecommunications industry is currently closed to foreign telecommunications network operators.

What is driving the rush to China? The motivation does not appear to be profits. Even the American giant, Motorola, appears not to be making much return on its huge investments in China, and is reinvesting in China whatever revenues are realized from its joint ventures. The primary motivation is also not necessarily the availability of labor at low cost, although this is a big factor. Rather, it is to be nearer to the fastest growing electronics markets, which are now in Asia, and where the market demand and government support for electronics is significant. According to a recent study on China's electronics sector, "In fact, all US electronics companies are increasing their Asian investments in R&D to take advantage of favorable industrial-government partnerships and engineering workforces that are highly motivated and well trained (frequently in the United States)."[119]

A key to US market penetration in China in this, as in other sectors and despite the many policy hurdles, is standards. The software industry provides a good example of achieving market share based on early entry into an immature market, where it is still possible to introduce standard technologies likely to be adopted throughout the country and the industry. This is what Microsoft has tried to do in China with its Windows 95 operating system.[120] However, Microsoft has been able to establish itself as a standard operating system in China only in exchange for assisting Chinese programmers in creating a Chinese-language version of the Windows software, a significant transfer of technological know-how.[121] The payoff: foreign companies account for 95 percent of the market for operating systems and 60 percent market share in software. [122] Intel, too, is the standard bearer in China (with an 83.8 percent market share in CPUs in China) as are Oracle, Informix and Sybase in the database sector.[123] These successes, however, are not due solely to product superiority, but are typically accompanied by numerous cooperative development and commercial offset agreements in exchange for market access.

Other US companies such as IBM and Digital, however, have met with mixed results in attempting to spread company standards throughout China. In telecommunications, Motorola attempted to have its preferred standard, the Code Division Multiple Access (CDMA) network (originally designed by Qualcomm) to become China's mobile phone standard as well. But even the largest American investor in the China market was unable to get its way. China Unicom, the one and only competitor to the former Ministry of Posts & Telecommunications adopted the Global Systems Mobile (GSM) network (the dominant global standard) for its new networks. This is not surprising, despite Motorola's commanding presence and investments in the Chinese electronics industry. As stated earlier, Chinese officials are wary of becoming too dependent on one foreign source of technology. The leverage resulting from playing one standard-bearer against another also provides Chinese enterprises with more technology and commercial offset agreements than might otherwise be forthcoming.[124]

TABLE 22
Top US Companies in China
Total Investment (spent/committed)

Rank	Company	$Millions (end of year '96)	Sector(s)
1	**Motorola**	$1,200*	telecommunications (networks & equipment), computers
2	**Atlantic Richfield**	$625	petroleum/energy
3	**Coca-Cola**	$500	food/drink
4	**Amoco**	$350	oil/energy
5	**Ford Motor Co.**	$250	autos (parts, small trucks, vans, minibus)
6	**United Technologies**	$250	elevators/escalators, air conditioners, aviation (P&W engines)
7	**Pepsico**	$200	food/drink
8	**Lucent Technologies**	$150	telecommunications
9	**General Electric**	$150#	medical equipment, lighting manufacturing; aircraft engines
10	**General Motors**	$130	autos & auto parts; electronics
11	**Hewlett-Packard**	$100	computers, medical products, analytical chemical equipment
12	**IBM**	$100	computers, advanced electronics, software

* Projected (end of year 1998); # figure does *not* include $1billion+ Shanghai joint venture.
Source: Adapted from Karl Schoenberger, "Motorola Bets Big on China," Fortune, vol. 133, no. 10, May 1996.

Status of Chinese Electronics Industry

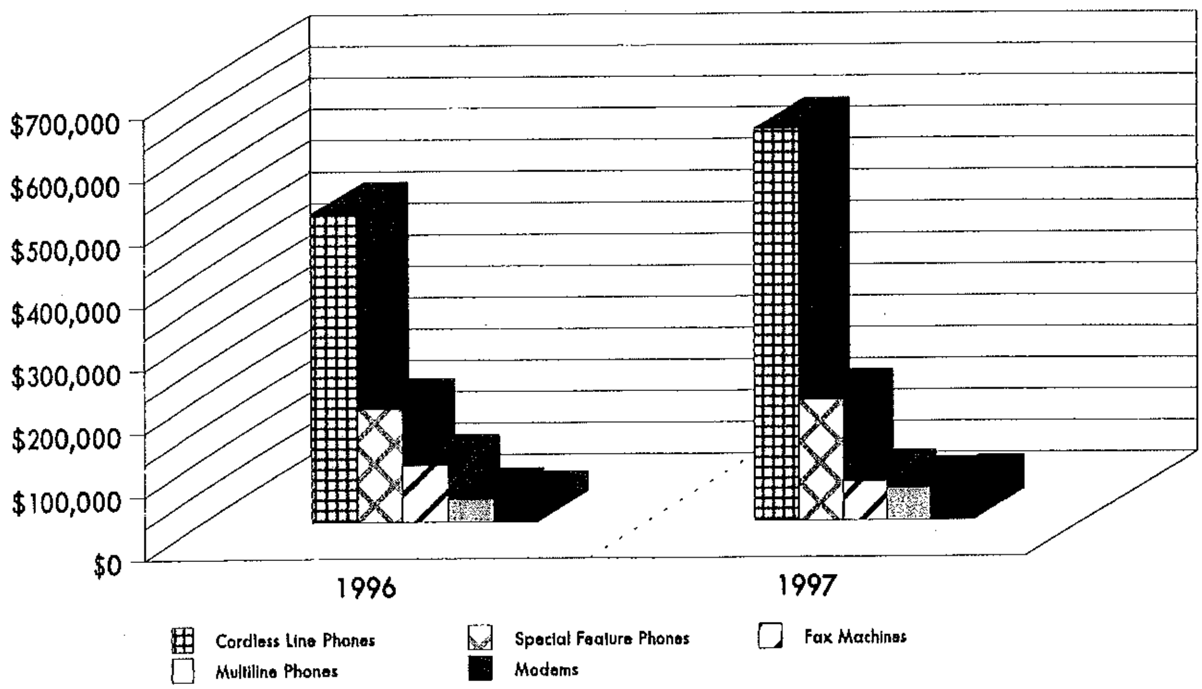
A recent study conducted by the National Science Foundation's World Technology Evaluation Center (WTEC) characterized China's electronics sector as "extremely weak in the early 1990s." By 1997, however, China's electronics industry had improved significantly to the point where the report concluded that "plants in China are now assembling a growing number of final products," and that Chinese enterprises are moving up the technological ladder quickly. This is an important point in an industry with incredibly short "generations" of new technologies. Nevertheless, China still trails its neighbors in this industry sector and relies of foreign inputs in terms of design, marketing, and R&D.

Electronics

According to Chinese statistics, as of 1996 China exports more electronics than it imports.[125] Most of these are relatively low-tech electrical or electronic products such as televisions, refrigerators, radios, electric fans, etc. and this growth due in large part to China's capacity to produce high-volume (though not necessarily high-quality) products. Chinese press reports, however, claim that among electronic exports, "those containing more advanced technologies

enjoyed fastest growth," citing computers (including components/parts), mobile telecommunications equipment, CD players, and fax machines as examples.[126] US data shows that the biggest US import line items from China in 1996 were cordless line phones, followed by special feature phones, fax machines, multiline phones, and modems. The fastest growing US electronic imports (HTS85) from China over the period from 1992 to 1997 were video recording or reproducing apparatus, followed by semiconductors (other than photosensitive), television cameras, fixed carbon resistors, and aluminum electrolytic fixed capacitors which are among the top five.[127] Nevertheless, much of this growth is almost certainly due to production of joint ventures with foreign firms. Thus, the question is whether China's growing exports of electronics translates into real technological advancement. Are commercial technology transfers in the electronic sector having a significant effect on China's indigenous capabilities in this sector? The answer: in some sectors, yes; in others, not yet.

Chart 4
Top U.S. Imports of Electrical Apparatus for Telephony/Telegraphy
($Thousands)



Source: US Census Bureau

<u>Semiconductors</u>

Only a decade or so ago, there was virtually no semiconductor industry in China of which to speak. Today, domestic Chinese semiconductor manufacturing capabilities are generally considered to be relatively advanced at the 1.0 micron level (though 3.0-4.0 levels are reportedly still in domestic production). Foreign joint venture fabrication plants (including Motorola's plant in Tianjin) are beginning to manufacture submicron chips at the 0.8 micron level with plans to go to 0.5 micron levels over the next couple of years.[128] The current standard among leaders in the semiconductor industry is 0.3 microns or below.

China's current Five-Year Plan (1996-2000) calls specifically for development of advanced integrated circuits (ICs) with the express goal of achieving the 0.3 submicron level by the year 2000 (see chart below). The acquisition of foreign technology plays a prominent role in this strategy. Foreign capital and technological know-how is necessary to advance China's domestic IC manufacturing capabilities and to meet the 75 percent of domestic demand for ICs that Chinese firms are currently not able to meet.[129] The result, according to the Semiconductor Equipment & Materials International (SEMI) group, is that "joint venture approval is often restricted to those companies that promise a certain level of technology transfer."

TABLE 23
Goals for China's Semiconductor Sector by the Year 2000

Current Goal	Mass production of the 6-inch, 0.8 micron level of technology
Mid-Term Goal	Industrial production of 8-inch, 0.5 micron technology
Long-Term Goal	Research and development toward the 0.3 micron level, and design and production of advanced ICs to supply domestic electronics demand

Source: Bernard Levine, "China seeks top firms as IC partners," Electronic News (1991), vol. 43, no. 2160, March 24, 1997, p. 1.

As a means of implementing state plans for the semiconductor industry, a new government-funded program designed specifically to advance China's semiconductor manufacturing capabilities, Project 909, was awarded to Japan's NEC in early 1997.[130] The new Shanghai fabrication plant is scheduled to begin production in 1999 at the 0.5 micron level and advance to the 0.35 micron level chips "relatively quickly." Thus, although China's capabilities in the semiconductor sector will continue to rely heavily on foreign capital, technology, and know-how, at the submicron level China will soon be producing chips that approximate those produced today in Korea.[131] China is not likely to surpass or even match the technological leaders in ICs in the near future, but China has matched Taiwan's approximately 10-year learning curve to reach the 1.0 micron level. With efficient use of the vast amounts of foreign investment and R&D support, China could potentially make up the technological gap quickly.[132] If one press report is accurate, the Chinese may have even begun to innovate in this area, reportedly having developed a process that "could produce a low cost route to light-emitting silicon."[133] At present, however, China's semiconductor industry is described as consisting of "relatively small-scale manufacturers with low productivity and low-level process technology."[134]

TABLE 24
Examples of US Semiconductor Firms in China

US Company	Product or Service in China	Location
Advanced Micro Devices	Flash memory and Programmable Logic Devices (PLDs) assembly	Jiangsu Province
Digital Equipment Corp.	Application-specific integrated circuits (ASICs)	Hunan Province
E.I. duPont de Nemours & Co.	Photomask ICs	Shanghai Municipality
Eaton Corp.	Electrical circuit protection devices	Jiangsu Province
Harris Corp.	Complete digital microwave radio system; semiconductor assembly and testing; R&D, manufacturing, sales and support for digital telephone switches and other telecommunications systems; and low- to medium-capacity digital microwave radios	Heilongjiang Province; Jiangsu Province; Guangdong Province; Shenzhen SEZ
Hewlett-Packard Co.	R&D center with SSTC	Beijing
Intel	Flash Memory and Microprocessor assembly and testing facility	Shanghai Municipality
Lucent Technologies, Inc.	Telecommunications ICs	Shanghai Municipality
Micro Electronics	Multi-layer ceramic items	Jiangsu Province
Motorola	Mobile telecommunications ICs (0.8 microns) and semiconductor manufacturing, assembly, and testing facilities; PC production and assembly; R&D for advanced communications and computers.	Tianjin Municipality (WFOE) and Sichuan Province (semiconductors); Jiangsu Province; Beijing
Texas Instruments	Design technology center	Beijing

Sources: Adapted from a table on "Foreign-Invested Projects in the Semiconductor Sector (1995)," by Denis Fred Simon, The China Business Review, November-December, 1996, p. 12; Also, Bernard Levine, "China Seeks Top Firms as IC Partners," Electronic News, vol. 43, no. 2160, March 24, 1997, p. 1.

The lure of what may be the biggest semiconductor industry bonanza ever has brought the world's leading semiconductor companies to China, including leading American firms (e.g., Intel, Motorola, Texas Instruments, IBM, National Semiconductor, et al.). China's internal demand for semiconductors is enormous and growing quickly as more and more chips are needed to supply China's own electronics, computer, and telecommunications markets. As a result, China's domestic semiconductor market is projected to more than double by the year 2000, which would make China the third largest semiconductor market after only the United States and Japan. China is currently ranked as the sixth largest market.[135] By 2010, however, the American Electronics Association projects China could become the world's second largest semiconductor market.

Computer Hardware and Software

Of all the electronic sectors, China's domestic industry is probably most advanced in computer hardware (primarily PC assembly) and software. The growth in this sector has surprised even Chinese officials and entrepreneurs as well as outside observers. However, foreign market share in PCs is declining due to lower-priced, domestically produced computers that are increasingly similar in sophistication and quality to foreign-made brands. In terms of software as well, the US Department of Commerce's International Trade Administration characterizes China's software industry as "the only major source of competition to US firms [in China]. Their products are of varying quality, and improve as the firms gain experience. The technical ability of the best Chinese engineers is first-rate."[136]

The number of domestically produced PCs doubled in 1996 over the previous year, making up almost half (1.3 million) of the three million PCs sold in China. In 1997, China's leading domestic personal computer manufacturer, Legend, took the lead in the fiercely competitive PC market, besting foreign powerhouses such as Hewlett-Packard, IBM, and Compaq in PC sales.[137] Although much of Legend's prowess is in assembling imported computer components and selling the PCs at comparatively low prices, this is still an impressive achievement. The combination of a Chinese-brand name on a high-tech item such as a PC and a low price is what has catapulted Legend to the top of the PC sales list in China. This trend could certainly be followed by other domestic firms who are not far behind the leaders. Meanwhile, China's PC market grew by over 40 percent in 1996, and projections for future growth are even higher. With this extraordinary growth, China's PC market now outranks South Korea's, making China's the largest PC market in Asia according to a recent report.[138]

This rapid pace is all the more surprising given the fact that many foreign-invested enterprises in the PC market did not arrive in China until the early 1990s, most around 1993 (IBM, DEC, Wang and a few others set up shop in the mid-late 1980s but were hampered in China during the post-Tiananmen era). As a result, the majority (over 74 percent at the end of the year 1996) of PCs sold in China today use Pentium processors, which is a sharp increase from just the year before when the majority of PC sales were 486 processors.[139] The more sophisticated PC components (such as the CPU, chips, motherboard, disk drives and CD-ROMs) are typically contributed by foreign companies, with the Chinese partner supplying the monitor, power supply, casing, and other more basic parts. There are exceptions to this general rule, however. For instance, Legend's Hong Kong and Shenzhen subsidiaries are involved in the more sophisticated task of building and designing motherboards and add-on cards.[140]

Legend is not the only shining star among Chinese PC makers.[141] Other well-known Chinese firms or conglomerates in the computer industry are the China Great Wall Group, the Founder Group, and the Stone Group. Each of these enterprises originated (directly or indirectly) from China's state-run research sector. Legend was originally spun off from the Chinese Academy of Sciences, China Great Wall from the Ministry of Electronics Industry, Founder from Beijing University, and the Stone Group (arguably the most independent of the enterprises) from a mix, its founders having come from the CAS, Qinghua University, and a Beijing-based SOE (the Beijing No. 3 Computer Factory).[142] Interestingly, the Chinese enterprise with perhaps the weakest connections with its Beijing institutional roots — Legend — is in the lead, currently outselling both foreign and domestic firms in PCs. Although the fortunes of each of these enterprises have both risen and declined over the years, they remain among the leading companies in China's computer industry and are competing with the world's best computer manufacturers.

TABLE 25 Growth of China's Computer Industry			
Hardware	1990	Exports of computer parts & components	$200m
	1995	Exports of computer parts & components	$3.78b
Software	1990	Sales revenue from software	$22m
	1995	Sales revenue from software	$1.3b
Manufacturing	1990	Chinese hardware manufacturers	191 (+ few software firms)
	1995	Chinese hardware manufacturers	1,000 (+ 1,000 software firms)
Workforce	1990	Chinese workers in computer companies	100,000
	1995	Chinese workers in computer companies	300,000
R&D Workers	1990	Additional workers in R&D institutions	n/a
	1995	Additional workers in R&D institutions	1,500 workers in 50 R&D institutes

Source: China Infoworld, 1995, cited in "China's Electronic Industry," in Electronics Manufacturing in the Pacific Rim, Ch. 3, WTEC Report, NSF, May 1997.

Lastly, the degree to which China has made advancements in supercomputer manufacturing is difficult to ascertain, although it would seem that significant progress has been made over a relatively short period of time. Press reports in 1997 have mentioned an indigenously produced supercomputer, the "Yinhe [Galaxy] III," developed by the University of the Science and Technology for National Defense (USTND, under COSTIND) that is capable of 10 billion or perhaps even 13 billion calculations per second [10,000/13,000 MTOPS].[143] Development of this computer was reportedly begun in 1992, and it was exhibited to the public at about the time as controversy in the United States broke out over the export of numerous US supercomputers to China.[144] A previous Chinese-made supercomputer, the Galaxy II — which was developed in 1992 and, China claims, is capable of one billion theoretical operations per second — is mentioned in the 1995 *China White Paper on Arms Control and Disarmament.*[145] Although these operating levels exceed the current USG limits on sales to either civilian or military entities in China, these operating levels are not particularly impressive compared to current US capabilities in this area.[146] Thus, it would seem that directives from the central government to Chinese military researchers in this area have resulted in significant improvements over two periods. These operating levels, however, still do not appear to rival those of US supercomputers, the high-end of which were at clocked at 20 billion theoretical operations per second back in 1993.[147]

TABLE 26 Chinese Advancements in Supercomputers		
Year	**Supercomputer**	**Capability**
1983	Galaxy I	100 MIPS
1992	Galaxy II	1 billion TOPS
1997	Galaxy III	10-13 billion TOPS
MIPS: million instructions per second; TOPS: theoretical operations per second; MTOPS: million theoretical operations per second		

Telecommunications

Chinese officials have had to constantly revise upward their estimates in the telecommunications sector as growth in this industry has consistently outpaced even Chinese expectations.[148] China claims to already have the third largest mobile telecommunications market in the world today, after the United States and Japan.[149] More importantly, this has occurred despite very limited liberalization or government deregulation in this sector. This enormous growth is mostly due to Chinese government policies that give preference to telecomminications projects. At least $40 billion a year is expected to be spent through the year 2000 on telecom networks, described in one report as "the equivalent of a Bell Canada-sized network each year."[150]

The "Golden Projects," which are coordinated by a Chinese company (Jitong) under the former Ministry of Electronics Industry (now the Ministry of Information Industry), constitute the most prominent of China's telecommunications programs. China reports to have "70 plants specialized in the production of fiber optic cables and ten of them are equipped with imported production lines, capable of producing high quality optic cables.[151] However, the technologies needed to complete these ambitious projects will come primarily from numerous foreign sources, including and perhaps most prominently, Motorola.[152]

As discussed earlier, China's severely limited telecommunications infrastructure has proved to be an advantage in allowing China to "leapfrog" to the latest technologies. As *The China Business Review* reports, "Whenever possible, China has taken advantage of its dearth of mainframe-based systems to 'leapfrog' past generations of outdated technology and, from the start, implement cutting-edge systems."[153] This is a key point in that much of this technology is dual-use and is fundamental to modern warfare capabilities. A 1996 report by the US General Accounting Office states that "the Chinese military is seeking to acquire ATM and SDH [broadband telecommunications] equipment, which may benefit their command and control networks by the end of the next decade."[154] Several foreign companies are involved in joint ventures and/or contracts to provide ATM and/or SDH equipment to China.

China's Golden Projects

China's goals for its nationwide information technology infrastructure and networking are laid out in its ambitious "Golden Projects" plan, which some Western analysts compare to development of the nationwide railway system in the US in the late 1800s. The five major "Golden" projects begun in 1993-94 are: "Golden Bridge" (information superhighway); "Golden Card" (bank & credit card system); "Golden Customs (customs offices network); "Golden Taxes" (government tax information and collection network); and "Golden Macro" (economic and financial information government network).

Conclusion

China's electronics sector, more than the other sectors studied herein, has emerged rapidly and achieved some technological successes. This is because of the sheer size of China's market, the learning curve in the electronics industry (the potential for "fast followers"), the dual-use nature of much of the fundamental technologies used in this sector, the potential for "leapfrogging" to the most advanced technologies (which China's comparatively immature electronics market makes more likely). China's capacity and increasing sophistication in the electronics sector could, if current trends continue, easily make China a leading producer in electronics in the next decade or two.[155] According to a recent study, this potential competition may already be having an effect in that 29,000 American jobs related to consumer electronic devices were reportedly lost due to the US trade deficit with China and Hong Kong.[156] However, China's electronics industry remains heavily dependent on foreign inputs for crucial design, marketing, and R&D.

The *US Industry and Trade Outlook 1998* reports that "as semiconductor companies have increased their offshore investments and entered into more joint ventures, [semiconductor manufacturing equipment] SME companies have followed their customers into the new markets." During the 1970's-1980's, the US supplier base of electronics components became dependent on Japanese supply of underlying electronic technology and components. Some experts have suggested that a similar process could occur in with regard to China as more American electronics companies set up manufacturing ventures on the Mainland.[157]

As the above section details, US electronics firms in China are transferring significant commercial technologies and/or know-how to China through joint ventures. The question, therefore, is how much is too much? Although sophisticated technologies are being manufactured, assembled, and tested in China as part of Sino-US joint ventures, most industry experts (as well as corporate representatives themselves) feel that US companies have a healthy respect for the risks involved in doing business in high-tech sectors in China and, as a result, leave development of the most advanced products at home. An assessment of successful companies in China (in terms of market share and revenues) concludes that companies with the best records have, among other things, "learned how to transfer technology without giving their crown jewels away."[158]

Nevertheless, the key to the US remaining a global competitor in this important sector will be in supporting domestic research and development toward new and more advanced products. According to the the Semiconductor Industry Association (SIA), US firms are investing a healthy 12 percent (on average 1990-95) of revenues into R&D and 14 percent in new electronics equipment and facilities.[159] What is not clear, however, is how much of this capital re-investment and R&D is moving to, and will be concentrated in, China, a trend that is already apparent. As pressure from Chinese officials continues for increasingly sophisticated technology transfers from US firms in return for limited market access, it is incumbent upon these same firms and the USG to maintain a strong US industrial base in electronics as well as domestic R&D capabilities.

In the near future, moreover, it would seem that the reality of foreign firms succumbing to "the Chinese policy of 'technology in exchange for market' that targets the world's largest electronics multinationals, is likely to reinforce the tendency for such high-tech [multinational corporations] MNCs to invest and manufacture in China."[160]

THE VIEW FROM EUROPE AND JAPAN

In an effort to provide a more global perspective, our research also looked at the approaches taken by other governments and economic regions or states toward the China market. Following is a brief analysis on the approaches taken by the advanced economies of the European Union (EU) and Japan.

On the question of whether technology transfers are a means toward gaining increased access to the China market, the governments and multinational corporations of the European Union, Japan, and the United States have come up with three distinct answers: yes, no, and maybe. While the EU has fully embraced technology transfers to China, Japan has been comparatively much more conservative, while the United States' approach has been somewhere in the middle.

The European Union

As a matter of formal policy, the European Union has decided to embrace the transfer of technology to China. The Commission of the European Union's long-term strategy states that "initiatives to promote economic and social reform should offer training and technical assistance to support modernization and market oriented policies in key economic sectors."[161] In practice this has meant that, by mid-1996, over 3,297 technology-transfer contracts worth $26.5 billion had been signed with Chinese officials. According to EU figures, this makes the EU the "main supplier of advanced technology" to China.[162]

A Formal Policy for Technology Transfers

Many of these transfers are conducted via a program called the "Community Framework Programme for Research and Technological Development." By 1996, this program consisted of fourteen different joint research projects, involving collaboration in sectors ranging from agriculture to information technology. Chief among these continuing efforts are the international fora for the automobile and aerospace industries that were set up by the EU government (though run by EU firms), to conduct meetings with their Chinese counterparts.[163] The stated long-term goal of European officials and industry representatives in their meetings with Chinese government ministries is to strengthen trade ties between Europe and China. One of the ways through which this is happening is "industrial training in manufacturing as well as management." In this manner, the European automotive industry is systematically transferring technology to Chinese manufacturers.

Moreover, in 1996 the European automotive and aerospace organizations signed a pact (as part of the EU-China Industrial Cooperation Program) wherein the Chinese government would contribute $53,000, the EU government $177,000 and EU auto manufacturers $532,000 to "assist in the harmonisation of technical standards, to assist industrial training in manufacturing as well as management, [and] to level up quality awareness."[164] It is difficult to say how this translates into actual sales for European auto manufacturers (i.e., whether clear cause and effect are evident). That said, it should be noted that European car makers dominate the Chinese market. The Volkswagen family of cars alone occupies 62 percent of production in China's car market.

The European Association of Aerospace Industries (AECMA) is also in the midst of a two-and-a-half year joint aerospace development program with the General Administration of Civil Aviation of China (CAAC) and the Aviation Industries of China (AVIC). The goals of this program are similar to those in the auto sector: "to build closer ties" and "provide training" for the Chinese. The companies comprising the AECMA will donate $1.2 million to this effort, which will be doubled by the EU government and added to by the PRCG with $760,000.[165] As this program is currently ongoing, one can only speculate as to the benefits accruing to the EU aerospace industry as a result. At the very least, however, these efforts will give EU companies greater exposure in China and to their Chinese

counterparts. In return, PRC companies will not only receive advanced technologies in key industries, but will also receive training on how to utilize this technology.

Financial Assistance

Technology transfers are one part of a two-pronged European approach to the Chinese market. The other part is direct financial aid, of which the EU has given $67 million since 1995. EU aid focuses on five areas: human resource development, support to economic and social reform, business and industrial co-operation, protection of the environment and rural development. Many of these programs are educational in nature, again an example of trading knowledge for exposure and access in China. EU aid is provided to China under various programs, as described in the table below.

TABLE 27
EU Aid to China

Program	EU Contribution ($USmillions)	Program	EU Contribution ($USmillions)
Training / Instruction		***Agriculture / Health***	
China Europe International Business School	16.78	Dairy Development Project II	33.9
China Invest	11.3	Environment Management Cooperation	14.69
Junior Managers Program	11.23	China Europe Cooperation Agriculture	13.9
Higher Education Cooperation	11.02	Support to Village Governance Reform	12.06
Norms and Standards	5.88	Qinghai Potato Development	3.5
IPR Cooperation	5.4	Qinghai Livestock Development	3.5
Training in STD & HIV/AIDS Prevention	3.14	Water Buffalo Project	3.14

Source: European Commission Delegation in China

As with technology transfers of equipment, it is difficult to measure the direct benefit from programs like these for EU firms. This is due in part to the fact that the amount of money being used to create the programs, while significant, is small relative to the size of the private sector funds in the market. In that sense it may seem that EU aid to the PRC has only symbolic value. If so, however, it also fosters goodwill for EU-related firms in China and a greater knowledge of the EU among Chinese citizens. Thus, to answer the key question: will exporting or transferring of technology now provide one with greater market access in China down the road? As a whole, the European Union is clearly gambling that it will.

The EU strategy of transferring technology in return for market share in China may be working (as in the case of Volkswagen). However, almost all of the nations comprising the EU have recently maintained a trade deficit with China (all but Finland and Sweden).[166] See Table 26.

TABLE 28
EU Nations Trade with China (1996, in millions of ECU)

Country	Imports from China	Exports to China	Trade Balance
Belgium/Luxembourg	1,775	685	-1,090
Denmark	635	236	-399
Germany	8,844	5,694	-3,150
Greece	370	37	-333
Spain	1,565	431	-1,134
Finland	293	459	166
France	3,705	1,978	-1,727
Ireland	221	40	-181
Italy	3,175	2,209	-966
Netherlands	2,233	578	-1,655
Austria	487	219	-268
Portugal	183	26	-157
Sweden	847	1,096	249
United Kingdom	5,593	904	-4,686
EU Total	29,926	14,592	-15,344

Source: EUROSTAT

Japan

In contrast to the EU, Japanese firms seem to think that exporting technology now will gain them comparatively little in the future. This is difficult to confirm, however, since there is relatively little information available on Japanese technology transfers to China. That said, in the vast majority of high-technology sectors, Japanese exports to China are about half that of the United States.

Sino-Japanese Relations

Japan's relationship with the PRC is significantly more complex than that of either the EU or the US for both geographic and historical reasons. Geographically, Japan's close proximity to China makes its economic future inextricably linked to that of the Mainland. This has two effects. First, it forces Japan to prioritize stable economic and political relations with China at all times. Second, it causes Japanese leaders to be especially wary of the possibility that China will become a powerful competitor that will compete for the same resources, customers, and influence in the region. Historically speaking, Japan's invasion of China during World War II still casts a long shadow over present-day relations. Specifically, both the PRC and Japan continue to feel that Japan needs to make amends for its past abuses. On many occasions, this has taken the form of large Yen-based loans to China that include very generous terms, grants, and technological aid to the Chinese government. In recent years China has pushed hard to have these technology transfers increased as part of a formal package of compensation for Japanese actions in World War II.

The result of these two factors — geography and history — has been 1) a Japanese industry sector that, while anxious to enter the China market, is quietly reluctant to transfer advanced technologies; and 2) a Japanese government that aggressively uses Official Development Aid to smooth over relations with China.[167]

Reluctant Industry Initiatives

Just five years ago one would have been hard pressed to find a high-tech sector in China in which Japanese firms had a significant presence. It has only been in the last few years that the Japanese have begun to make inroads into the China market, and even then they continue to lag far behind US high-tech firms.[168] For example, by late 1996 General Motors had invested over $2 billion in the Chinese market, and won a billion dollar contract to produce luxury cars in Shanghai, whereas Japanese carmakers have been content until recently to mostly license auto technology to Chinese partners.[169] This situation is in stark contrast to Japan's presence in Southeast Asia, where Japanese carmakers are not only engaging in on-site production, but also dominate the market.

For reasons such as this, many observers (including some Chinese officials) believe that Japan is intentionally withholding its technologies from the China market. Furthermore, as one researcher notes, "most of the products made [in China] by using Japanese technology are restricted to sales in the Chinese market and are unlikely to be exported...Japanese companies only wish to offer technology which is no threat to their overseas markets. They take risk-proofed and cautious attitudes towards their investments."[170] Furthermore, as one American businessman put it, "There's a good reason why they are stingy with their technology, Japan is afraid of creating another Japan."[171] That is, the Japanese are worried that the Chinese will be able to use imported technology to become an industry leader — much as the Japanese did in the 1960s &1970s, and as the US did in the early 1800s. If that is the Japanese sentiment, Japan's desire to maintain good relations with the PRC prevents it from saying so outright. Thus, observers are left to speculate. The statistics however, while not shedding any light on Japanese intent, do confirm the effect.

With the exception of transport equipment (which in Japan's case consists primarily of tankers and other shipping vessels), Japanese industry lags behind US industry in every major technology sector surveyed. Insofar as high-tech exports are an indicator of technology transfers, this data would seem to confirm that the Japanese are keeping their technology from the China market, presumably to stop or at least delay a competitor from developing in their backyard.

A Low-Tech Approach?

Some analysts have said that one way that Japanese companies may be trying to profit from the market without giving up their advanced technologies may be to focus on "low-tech" products.[172] This is confirmed by the data. The sectors in which Japanese companies have made the most progress are decidedly "low-tech" in nature. The sectors where they are the most competitive with the US are in "Transport Equipment" and "Electrical Machinery"[173]— sectors that are relatively low-tech in nature. Conversely, the sectors where Japanese companies are weakest are in "Office and Data Processing Machines" and "Sound Recording and Broadcast Equipment," which tend to be more complex in nature. These examples are particularly striking in light of the Japanese strength in these same sectors in the US market.

Finally it should be noted that while Japanese companies have recently stepped up their operations in the China market, their frustrations with the market have risen accordingly. Surveys by *Toyo Keizai* (a leading economic journal in Japan) and by the Export-Import Bank have shown that Japanese businessmen have more problems in China than in any other region or country in which they have invested.[174] These frustrations are compounded by the possibility of political turmoil that could

follow a Japanese aid and investment withdrawal from China. So bad are the frustrations for some companies that they have even looked to the US government for support. A former senior adviser to the Ambassador at the US Embassy in Tokyo reports that there has been at least one occasion when a Japanese company has come to a US Consulate in China to ask for assistance.[175] This is indicative of a new phenomenon: both Japanese and US companies have found that by teaming up they can multiply their powers of persuasion with Chinese officials. Joining forces has the dual qualities of greatly increasing the amount of leverage brought to bear on Chinese officials and making it more difficult for the Chinese to play one nation or corporation off another. Of course, these sorts of alliances are not always feasible, but companies like Exxon, Raytheon, Dupont and Union Carbide have all teamed up with Japanese companies in China at one point or another.[176]

Government Aid

Whereas Japanese industry may be wary of a Chinese competitor, the Japanese government is concerned about maintaining stable relations. Thus, while the Japanese government does not like to discuss Japan's role in World War II, it can be shamed into action, and the Chinese are masters of this process. China regularly demands war reparations in the form of economic and technological aid, and increases these calls when Japan does something China finds offensive. The result has been a steady stream of financial and technological aid that flows from Japan to China every year. In 1995, China was the number one recipient of both technological assistance ($304 million) and bilateral aid ($1.4 billion) from Japan. By mid-1996 the Japanese government had agreed on another $24.55 billion in direct investment (beyond the $11.9 billion already invested), plus loan packages worth another $140 million. In fact, for all of the 1990s, Japan has been the number one donor to China.[177]

In addition to alleviating Sino-Japanese animosity, this money serves much the same purpose as does aid from the European Union. Indeed, in the past, Japan's Official Development Aid (ODA) has been derided as just another way for Japanese companies to get more business. Nevertheless, it increases exposure to and knowledge of Japanese companies in the China market. Because such a large part of Japanese assistance consists of technical aid, this too must be considered a source of technology transfer to the Chinese.

Conclusion

While the US Government is supportive of US industries' efforts to crack open the China market and is cognizant of its potential, there are limits to how much USG support is possible or desirable. The USG does provide financial assistance to China in the form EX-IM Bank Loans, for instance, but this aid has also been restricted by Congress in certain areas (e.g., the Three Gorges Dam Project) while other aid programs such as the Overseas Private Investment Corporation (OPIC) have been discontinued due to the Tiananmen sanctions of 1989/90. Various USG departments (Commerce, State, and the Office of the US Trade Representative) provide direct aid and advice to US firms doing business in China. However, the USG is loathe to take too broad a role in managing international trade. Nor do US corporations desire a large USG role, except in terms of promoting and enforcing standard business and legal practices abroad. Thus, the most prominent role for the USG is in providing legal advice and support in terms of negotiating with Chinese officials over removing the numerous trade barriers affecting US firms exporting to or doing business in China (such as the Joint Commission on Commerce and Trade). As a result, the USG plays a relatively defensive or passive role in assisting the entry of US firms into the China market. This contrasts sharply with the role of the EU and Japanese governments, which are comparatively more aggressive and pro-active in support of their respective industries in China.

The broad roles played by the governments of the EU and Japan have had the practical effect of gaining market share for EU and Japanese industries in China where this might not otherwise be possible or likely through true international competition. However, the result, at least in the EU case, is probably that more technology is transferred in return for market access than in other contract agreements. This is not to say, however, that European or Japanese firms are faring any better in China than are US firms. All foreign investors in China are becoming increasingly wary of China's industrial policies, emerging domestic industries, and significant trade barriers. It is also not only US firms that are having difficulty making a profit in China or dealing with trade deficits. Nevertheless, these are long-term strategies and may bear out in the long-run. In the meantime, the support of EU and Japanese governments for their respective industries in China is certain to translate into goodwill and *guanxi* (connections), two keys to market access in China.

Lastly, the trend toward international cooperation in prying open China's market with the least amount of offsets is a positive sign. Although this type of arrangement is perhaps not possible across all industries, where it is, there will likely be less technology being transferred or coerced from foreign firms.

Endnotes - Part II:

1. *The National Security Science and Technology Strategy* (1996), p. 23.

2. The two bilateral MOUs reached with China are the *Memorandum of Understanding Between the Government of the united States of America and the Government of the People's Republic of China Concerning Market Access, 1992* and the *Memorandum of Understanding Between the Government of the People's Republic of China and the Government of the United States on the Protection of Intellectual Property, 1992.* The former is the result of threatened trade sanctions while the latter has been, since its signing, the basis for threatened sanctions (in May 1996), which were averted upon verification in June 1996 of Chinese efforts at compliance. In February 1997, the United States and China renewed a bilateral agreement on textiles. See USTR, *1997 National Trade Estimate Report*, p. 43 and Susan Esserman, Testimony Before the US House of Representatives Committee on Ways and Means Subcommittee on Trade, November 4, 1997.

3. The USTR's annual report on foreign trade barriers is harsh in its assessment of China's trade barriers and concludes that "there remains a great deal of work to be done before China's market is sufficiently open to US exports." See United States Trade Representative, *1997 National Trade Estimate Report on Foreign Trade Barriers* (Washington, DC: USTR, 1997).

4. According to Chinese analysts, however, this can cut both ways: "It is unfortunate that when a transnational company comes to China to invest in a particular project, in order to ensure its success it will often choose to conduct simultaneous negotiations with several potential partners. The potential Chinese partners are scattered over different regions or across different departments, and out of their own economic self-interest, they will often engage in internal competition and cut down the price. This is also injurious to the Chinese partner's interests." The researcher goes on to point out, however, that by so doing, foreign investors are also liable to anger their "matchmaker" local government hosts and risk having their products made with another enterprise closed out of the local market. See Wang Zhile, "An Investigative Report on Transnational Corporations' Investment in China," Guanli Shijie, May 24, 1996.

5. This cautiousness is due largely to the concern among company officials that these complaints may negatively affect current or future investment prospects in China. The result, however, is that many of these abuses remain undocumented, and research into this problem is based largely on anecdotal information (and so it is with this study as well).

6. This $500 million figure is used in the *1997 National Trade Estimate Report on Foreign Trade Barriers* (Washington, DC: Office of the US Trade Representative, 1997).

7. David Dinell, "Manufacturers say China is Top Global Contender," *Wichita Business Journal*, July 28, 1997.

8. "China to Invest Billions in Auto Industry," *Xinhua News Agency*, March 1, 1997 in *China Commercial Quarterly*, John Hendryx and Jeffrey Shih, eds., December 10, 1996 to April , 1997; "Automotive Market Fact Sheet: China," US Department of Commerce, ITA, 1994.

9. "China to Use Example of Big 3," *China Daily Business Weekly*, March 2, 1997 in *China Commercial Quarterly*, John Hendryx and Jeffrey Shih, eds., December 10, 1996 to April, 1997.

10. This figure includes production of trucks and other vehicles (see chart). For Chinese auto industry statistics and goals, see "40 years of Chinese Auto Industry," *Beijing Review*, vol. 40, no. 7-8, February 17,-March 2, 1997. The growth rate of more advanced auto markets is generally considered to be less than two percent growth per year. Kathleen Kerwin, "GM's New Promised Land," *Business Week*, June 16, 1997; "China's Auto Plans: Dream Machines," *Business China*, The Economist Intelligence Unit, January 22, 1996, p. 12; Richard Johnson, "Chrysler Favored to Get China Minivan Deal," *Automotive News*, June 27, 1994; "Long March to Mass Market," *The Financial Times*, June 25, 1997, p. 13.

11. Western analysts estimate China's current capacity to be high compared to actual production but low when compared to Chinese production goals. China's current vehicle production capacity is thought to be about 850-860,000 vehicles per year, while actual production is assessed at 350-380,000 vehicles for 1996. See estimates by A.T. Kearney in "The Long Drive Into the Middle Kingdom," *The Economist*, June 8, 1996; and "Call for Halt on New Investments in Overcrowded Auto Market," *Business China*, April 8, 1997. One estimate for China's capacity for car production by the year 2000 is two million cars, which exceeds China's goal. "China's Auto Supply Continues to Outpace Demand," *Business China* (UK), March 3, 1997.

12. China's defense industrial sector produces about nine percent of domestic autos and fully 60 percent of China's motorcycles. *China White Paper on Arms Control and Disarmament*, Xinhua News Agency, November 16, 1995 [issued by the Information Office of the State Council of the PRC].

13. Feng-Cheng Fu and Chi-Keung Li, "An Economic Analysis," *Mixed Motives, Uncertain Outcomes: Defense Conversion in China*, John Frankenstein and Jorn Brommelhorster, eds. (Boulder, CO: Lynne Reinner Publishing Co., 1997), pp. 47-64.

14. For the text of the auto industrial policy, see "Commission Publishes Car Industrial Policy," *Renmin Ribao*, July 4, 1994, p.2. For analysis, see "Automotive Market Fact Sheet: China," US Department of Commerce, ITA, 1994.

15. *1997 National Trade Estimate Report on Foreign Trade Barriers*, p. 48.

16. See "Industry Sector Analysis" on China's automotive industry by Gwen Lyle, US Department of Commerce, ITA, June 1995

17. According to a study on technology transfers via foreign investment, an official of the International Economic Cooperation Research Institute of MOFTEC notes that "An important goal of transnational corporate investment strategy in China is to achieve localization, not only parts localization, but technology development localization as well." The example he uses is Volkswagen's automotive joint venture in Shanghai, which he says "after 10 years of absorption and digestion attained an 87-percent localization rate for its Santana model. Chinese and foreign scientific and technical workers have successfully developed a new

generation of Santanas after a few years' effort." See Wang Zhile, "An Investigative Report on Transnational Corporations' Investment in China", *Guanli Shijie*, May 24, 1996.

18. This is according to the *1997 National Trade Estimate Report on Foreign Trade Barriers* (Washington, DC: Office of the US Trade Representative, 1997). For an overview of the China auto market, see Wayne W.J. Xing, "Shifting Gears," *The China Business Review*," November-December 1997, pp. 8-17.

19. "Automotive Market Fact Sheet: China," US Department of Commerce, ITA, 1994.

20. Articles 53 and 54 of China's Auto Industry Industrial Policy. "Commission Publishes Car Industrial Policy," in FBIS-CHI-04-136, July 15, 1995, p. 30.

21. This information is included in an "Industry Sector Analysis" on China's automotive industry by Gwen Lyle, US Department of Commerce, ITA, June 1995. A similar statistic: "for every 1m Chinese, there are 900 km (560 miles) of roads, 11% of them paved, compared with 24,000 km (42% of them paved) for every 1m Americans." "The Long Drive Into the Middle Kingdom," *The Economist*, June 8, 1996.

22. The following is an example of the thinking that is so prevalent among businessmen when discussing the potential of the China market. An American auto parts supplier on expanding into the China market: "Some people regard these numbers [PRC projections for auto industry growth] as overly optimistic. But the fact remains: there is clearly a need for more vehicles in China. The country is home to about 1.2 billion people — nearly a fifth of the world's total population. This means there is only one vehicle for every 500 people in China. By comparison, there is one car or truck for about every two people in the United States." This logic prevails in many market analyses regarding China. "Destination: China," *Autosmart*, Fall 1995.

23. This accords with a US Embassy comment on China's science and technology plans, which states that "China has consistently rejected digestible technology that is offered which is appropriate to the Chinese market in favor of technology that China cannot absorb and support (this is especially true in the automotive industry)." State Science and Technology Commission (SSTC), "China' S&T Policy: A View from Within," in *Science and Education for a Prosperous China* (text available on US embassy China website).

24. This account is included in John Templeman and David Woodruff, "How Mercedes Trumpted Chrysler in China," *Business Week*, July 31, 1995.

25. Richard Johnson, "Chrysler Favored to Get China Minivan Deal," *Automotive News*, June 27, 1994. See also John Templeman and David Woodruff, "How Mercedes Trumpted Chrysler In China," *Business Week*, July 31, 1995.

26. For information on foreign auto investments in China, see "No Price Too High," *Business China*, The Economist Intelligence Unit, August 19, 1996, pp.1-3; Richard Johnson, "Chrysler Favored to Get China Minivan Deal," *Automotive News*, June 27, 1994; "China's Auto Plans: Dream Machines," *Business China*, The Economist Intelligence Unit, January 22, 1996, p. 12; "Chrysler Corp to Continue Investing Millions in China," *Reuters* (U.K.), February 13, 1997; "Joint Venture Project with GM," *China Daily* (PRC), February 25, 1997; "Volkswagen to Take Control of Sales in China," *South China Morning Post*, (HK), February 27, 1997; and "Long March to Mass Market," *The Financial Times*, June 25, 1997, p. 13.

27. According to one press report, GM has "offered more than any other foreign automotive firm ever has for a slice of a Chinese joint venture that is not yet even approved...GM won a 50% stake in a US$1 billion joint venture to make a two-litre variant of its Buick sedan by offering what other automotive multinationals were loathe to. The company will licence a broad range of component technologies through a series of 'joint ventures with state-owned companies... In addition, GM has thrown in other technology transfer sweeteners that are not linked to individual productive ventures. The American auto giant has pledged US$40m for five technology training institutes, with promises of significant technology transfers in electronics via its Hughes Electronics subsidiary and in information technology via its Electronic Data Systems subsidiary. A large but unspecified part of the design work for the China Buick is to take place in China. In short, as GM's president of China operations, Rudolph Schlaus Jr., put it: 'Through our joint venture, China is going to learn how to design and build a car'." ("No Price Too High," *Business China*, August 19, 1996, p. 1.)

28. Christopher C. Green, "Challenges and Opportunities for R&D in the Global Market," delivered before the SAE Global Vehicle Development Conference, December 3, 1996. Dr. Green is also the Executive Director General Motors Research and Development Center.

29. Article 31, section one of the Automotive Sector Industrial Policy, adopted by the SPC in February 1994 and published in the *People's Daily* (*Renmin Ribao*) on July 4, 1994. See "Commission Publishes Car Industrial Policy," FBIS-CHI-94-136, July 15, 1995, p. 29.

30. Presumably Chrysler, whose joint venture was established prior to implementation of the AIIP, is exempt from this provision. Our research has not revealed any Chrysler-sponsored R&D centers.

31. Ford had also bid on the Shanghai sedan project. "Ford Beats GM to be First to Make Cars in China," *Wall Street Journal*, December 2, 1997, p. A17.

32. "Ford Begins Manufacturing in China," *PRNewswire*, December 2, 1997.

33. "General Motors is considering a methanol vehicle venture with SSTC." Raymond Champagne, "China: A 1996 Automotive Sampling (Industry Overview), *Automotive Engineering*, vol. 104, no. 12, Dec. 1996, p. 24.

34. According to a recent survey of foreign automakers in China, the majority of firms "admitted they were disappointed by their performance in China." For a good review of the current decline in foreign automakers' confidence in the China market, see "The China Syndrome," *The Economist*, June 21, 1997, pp. 63-64.

35. See "Industry Sector Analysis" on China's automotive industry by Gwen Lyle, US Department of Commerce, ITA, June 1995.

36. Tai L. Chan, "Global Technology Integration - A Cornerstone to Globalizing Business Operations," presented to the Technology-Application-Market International Forum, Tsinghua University, Beijing, China, November 7, 1997.

37. For an overview of Ford's approach to the China market and the pressures to transfer technology as part of foreign investment in China, see Richard Pastore, "Emerging Markets: Motor Skills," *CIO Enterprise*, Section 2, September 15, 1998, pp. 50-58, particularly p. 58.

38. This data can be found in "China's Auto Plans: Dream Machines," *Business China*, The Economist Intelligence Unit, January 22, 1996, p. 12.

39. "No Price Too High," *Business China*, The Economist Intelligence Unit, August 19, 1996, pp. 1-2; "Booming Automobile Parts Market," *Beijing Review*, vol.40, no. 25, June 23-29, 1997. According to one report, "Ford encourages its suppliers to come to China" (Raymond Champagne, "China: A 1996 Automotive Sampling (Industry Overview)," *Automotive Engineering*, vol. 104, no. 12, December 1996, p. 2.

40. "TRW Announces First Two Joint Ventures in China," *AutomotiveWire*, April 17, 1996; "TRW, Shanghai Clutch Factory Form Chinese Seat Belt Joint Venture," *Business Wire*, Jan. 16, 1997; and "TRW Expands Scope of China Activities," *Business Wire*, June 27, 1996.

41. Information garnered from Rockwell website.

42. The author of the report goes on to say that "As overseas companies are lining up to get a piece of, potentially, the world's largest automotive market, the Ministry of Machinery Industry is becoming more and more demanding in the 'price of admission' to this market. Companies may find this a very difficult place to negotiate a deal or make a profit in the short-term." Gwen Lyle, "Industry Sector Analysis," June 1995.

43. "40 Years of Chinese Auto Industry," *Beijing Review*, vol.40, no.7-8, February 17-March 2, 1997.

44. See "40 Years of Chinese Auto Industry," *Beijing Review*, vol.40, no.7-8, February 17-March 2, 1997.

45. According to a press report, "The Lucky Star uses a 90 percent localized version of the Suzuki engine and chassis with a new body and only had marginal involvement from foreign manufacturers, a surprise in itself." "Beijing's Family Car Program," EIU Electronic (U.K.), March 3, 1997, in *China Commercial Quarterly*, John Hendryx and Jeffrey Shih, eds., December 10, 1996 to April, 1997.

46. According to a 1995 report, the 100 or so Chinese vehicle models produced in over 100 Chinese complete-car factories would not equal the output of Ford, GM, or Chrysler in the United States. Gwen Lyle, "China: Automotive Industry," Industry Sector Analysis (ISA), US Department of Commerce, International Trade Administration, June 1995.

47. The dangers of global excess capacity in the auto sector are outlined in *The World Automotive Outlook, 1996-2001*. See "Global Excess Capacity to Top 20 Million," *Autofacts - Early Warning Report*, November 1996.

48. "Comments of the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America (UAW) to the Trade Policy Staff Committee on The People's Republic of China's Accession to the World Trade Organization," UAW Office in Washington, DC.

49. Chinese history is rife with examples of this sort of divide-and-conquer strategy and tactic being used against invading "foreign devils." For a description of a more recent example, see Nigel Holloway, "Hostage to Fortune," *Far Eastern Economic Review*, November 14, 1996, pp. 66-67.

50. "China to Boost Investment in Civil Aviation," CBNet (PRC), January 29, 1997.

51. The purchase in October, 1997 of $3 billion worth of 50 more Boeing planes follows several purchases of Airbus planes in previous years.

52. Lou Cannon, "Washington State, Asia Come Together in Trade," *Washington Post*, July 7, 1997, p. A04. Between 1993-95, the figure was one in 12 Boeing planes. Nigel Holloway, "Hostage to Fortune," *Far Eastern Economic Review*, Nov. 14, 1996, pp. 66-67.

53. US aerospace exports to China have also doubled since 1990, according to David Napier, "US Aerospace Trade with China," *AIA Update* (Aerospace Industry Association), June 1997, p. 3. See also, David Vadas, *Pacific Winds Blow in US Industry's Favor*, a report by the Aerospace Industry Association, July 1997; and Barbara Opall, "Asia is Top US Market for Aerospace Exports," *Defense News*, July 28-August 3, 1997, p. 6.

54. It would appear that prior to merging with Boeing, the McDonnell Douglas Co. went to great lengths to increase its market share in China. The MD-90 co-production agreement has been described in media reports as being an important vehicle for significant technology transfer, especially in terms of shared technical data. See Richard Bernstein and Ross H. Munro, "The Coming Conflict with China (New York, NY: Alfred J. Knopf, 1997), pp. 142-143; and Joseph Kahn, McDonnell Douglas' High Hopes for China Never Really Soared," *The Wall Street Journal*, May 22, 1996. Boeing announced that the former McDonnell Douglas plants in China will continue in production under Boeing management. Michael Mecham, "Boeing Begins MD-90 Integration in China," *Aviation Week & Space Technology*, October 13, 1997, p. 30.

55. The authors are thankful to Steve Beckman of the UAW for this and other information. See Steve Beckman, Testimony before the US House Committee on Ways and Means, Subcommittee on Trade, on "The Possible Accession of the People's Republic of China to the WTO," September 19, 1996.

56. Greg Mastel, among other analysts, also makes this point in *The Rise of the Chinese Economy: The Middle Kingdom Emerges* (Armonk, NY: M.E. Sharpe, 1997), pp. 73-74. The recent deal made by Boeing with China's Taikoo Aircraft Engineering Co. in Fujian Province prompted public complaints by the International Association of Machinists and Aerospace Workers (IAM) that the agreement to modify 747 jets in China rather than in Kansas would have serious consequences for aerospace workers in the United States. However, other reports stated that Boeing workers would oversee the modifications being made in China and that all design and engineering work would continue to be done in the United States. See "Machinists Union Blasts Boeing-China Deal," *PRNewswire*, August 12, 1997; "Boeing Joins China Repair Venture," *Reuters*, August 11, 1997; and Paul Proctor, "Boeing Buys Stake in Maintenance Center," *Aviation Week & Space Technology*, August 18, 1997, p. 36. This follows a two-month strike in 1995 by Boeing workers in Kansas at least in part over job transfers to China. Paul Blustein, "China Plays Rough: 'Invest and Transfer Technology, or No Market Access'," *The Washington Post*, October 25, 1997, pp. C1-C2.

57. "Boeing v Airbus: The War in the Air," *Business China*, May 26, 1997, pp. 8-9 and Guy Norris, "AlliedSignal Reveals New Chinese Ventures," *Flight International*, vol. 151, no. 4564, March 5, 1997, p. 6.

58. Rockwell press release dated April 7, 1997. The three universities are the Harbin Institute of Technology, Zhejiang University, and Guan[g]dong University of Technology. According to Rockwell's press release, Rockwell has "provided the latest state-of-the-art automation equipment and software to these universities and training to the lecturers... to train a large number of students in this technology and establish more training centers with other universities in major cities of China."

59. Guy Norris, "AlliedSignal Reveals New Chinese Ventures," *Flight International*, vol. 151, no. 4564, March 5, 1997, p. 6.

60. Foreign co-production of certain parts of modern aircraft is increasingly being used by Boeing, a process that has been highlighted in the global manufacturing process for the new 777.

61. See "Industry Sector Analysis" on China's aerospace industry. Gail Chun, Weiming Yao, and Alison Kaufman, "Aviation, Aircraft Parts & Maintenance," Industry Sector Analysis (ISA), US Department of Commerce, December 1994.

62. The Chengdu Engine Company is listed in the aerospace ISA as follows: "affiliated with AVIC, this company makes WP6 and WP13 military turbojet engines." AVIC —the Aviation Industry of China— is "responsible for managing and allotting state-owned assets, developing new technologies, promoting exports, contracting state projects, and aligning planning for the overall industry with the State Council and the Central Military Commission. China's aircraft and aircraft component manufacturers are under the auspices of AVIC." *Ibid.*

63. Raytheon press releases.

64. *Mixed Motives, Uncertain Outcomes: Defense Conversion in China*, Jorn Brommelhorster and John Frankenstein, eds. (Boulder: Lynne Reiner, 1997);. Gail Chun, Weiming Yao, and Alison Kaufman, "Aviation, Aircraft Parts & Maintenance," Industry Sector Analysis (ISA), US Department of Commerce, December 1994.)

65. Bates Gill, "China and the Revolution in Military Affairs: Assessing Economic and Socio-cultural Factors," Strategic Studies Institute, Conference Series, National Defense University Press, May 1996. See Eric Arnett, "Military R&D in Southern Asia," *Military Capacity and the Risk of War*, pp. 260-261. China is reportedly interested in developing a "large multi-role fighter aircraft to enter service with its air force and navy in around 2015. The XXJ fighter will emphasize air combat and incorporate a 'reduced radar signature design'." "China to Develop Stealth Fighter," *Jane's Defence Weekly*, March 5, 1997.

66. The Tiananmen Square-related sanctions are found in PL101-246, February 16, 1990. According to press reports, China is reportedly receiving significant assistance in this sector from Russia in the form of sales of advanced SU-27 fighter and a co-production agreement. Israel is also presumed to have provided China assistance in developing the J-10 fighter, given the similarities between Israel's Lavi and China's J-10 fighter. The J-10 is being developed at the Chengdu Aircraft Corporation and is expected to be operational soon. See Yitzhak Shichor, "Converting the Military-Aviation Industry to Civilian Use," *Mixed Motives, Uncertain Outcomes: Defense Conversion in China* (Boulder: Lynne Reiner, 1997), pp. 127-128.

67. Robert Sutter, "Foreign Military Assistance to China — Perspectives of US and Foreign Specialists," Congressional Research Service, July 8, 1997 (also available at *http://www.fas.org/spp/starwars/crs/97-0708.htm*).

68. See Gail Chun, Weiming Yao, and Alison Kaufman, "Aviation, Aircraft Parts & Maintenance," Industry Sector Analysis (ISA), US Department of Commerce, December 1994.

69. China's military aviation deficiencies explain why the PLA has turned to large purchases of modern military aircraft from Russia, but also licensed co-production of SU-27 fighter aircraft. Bates Gill and Lonnie Henley, *China and the Revolution in Military Affairs*, Strategic Studies Institute (SSI) Monograph, May 20, 1996. For the definitive study on the modern PLAAF see *China's Air Force Enters the 21st Century*, by Kenneth W. Allen, Glenn Krumel, and Jonathan D. Pollack (Rand's Project Air Force Project, 1995); Gail Chun, Weiming Yao, and Alison Kaufman, "Aviation, Aircraft Parts & Maintenance," Industry Sector Analysis (ISA), US Department of Commerce, December 1994.

70. This data is derived from the United Nations trade database, SITC 79000-79490, for the years 1992-1995. According to this data, in 1992 China exported nearly $8 billion worth of such parts, but by 1995, the value had dropped to only $553,613.

71. "Two in a Row for Great Wall," *Aviation Week & Space Technology*, July 7, 1997, p. 15. As of September 1997, China had had five successful launches of commercial satellites. "China: Sino-US Cooperation in Satellite Launch," *Xinhua*, September 23, 1997.

72. *US Industry and Trade Outlook 1998*, pp. 21-13.

73. Defense estimates are that the PRC's current capabilities in this area consist of launching military photo-reconnaissance satellites (using outdated technology and without real-time data); access to SPOT and LANDSAT commercially available imagery; and meteorological and geosynchronous satellite data. The report also states that "it is expected that China eventually will deploy advanced imagery reconnaissance and earth resources systems with military applications." These assessments were given in answer to the question, "Trends that would lead the People's Republic of China toward advanced intelligence, surveillance, and reconnaissance capabilities, either through a development program or by gaining access to commercial or third-party systems with militarily significant capabilities." US Department of Defense, "Report to Congress Pursuant to Section 1305 of the FY97 National Defense Authorization Act," 1997.

74."China: National Policies, Programs on Space Technology Development, Applications for Sustainable Development," *Beijing Aerospace China*, Summer 1997, vol. 6, no. 1, pp 8-10.

75. This point was made by Baosheng Chen, in "Overview of the Chinese Civil Space Program," a slide presentation before the American Astronautical Society, June 1997. See Wu Bian, "Space Industry Promotes Modernization," *Beijing Review*, vol. 40, no. 1, January 6-12, 1997.

76. Chinese officials were talking about manned space flights and about an astronaut program back in 1986 and again a decade later in 1996. It would appear, therefore, that not as much progress as expected has been made in the interim. This may, in part, be due to the break in military-to-military exchanges and/or cooperation between China and US and European governments after 1989. See Wu Bian, "Space Industry Promotes Modernization," *Beijing Review*, vol. 40, no. 1, January 6-12, 1997; "The Role of the United States in Technology Transfer to China," Chapter 4 in *Technology Transfer to China*, Office of Technology Assessment, 1987, pp. 92-93; and Xinhua, April 12, 1996 as cited in OTP's "Aerospace Factoids" [http://www.ta.doc.gov/asiapac/chinaaerospace.html].

77. As mentioned earlier, China has been able to achieve significant scientific and technological feats, and more quickly than generally expected, when suitably motivated to do so (e.g., nuclear weapons development). A famous quote by Deng Xiaoping is repeated in current Chinese military analyses: "Had China not had the atomic bomb and hydrogen bomb or had it not launched a satellite since the 1960's, it could not have been called a great power with enormous clout or achieved the international standing it now has." Thus, China's quest for international recognition of its deserved place in the world could lead to surprising advances in this industry. However, this would also take significant resources from China's main goal of economic growth. *China's Defense Conversion*, China Economic Press, July 27, 1995, pp. 20-23.

78. Yitzhak Shichor, "Converting the Military-Aviation Industry to Civilian Use," *Mixed Motives, Uncertain Outcomes: Defense Conversion in China* (Boulder, CO: Lynne Reinner, 1997), p. 125.

79. *US Industry and Trade Outlook 1998*, p. 21-3.

80. If one takes a general rule of thumb calculus that every $1 billion worth of exports is equivalent to about 10-20,000 American jobs, then the economic effects of lost exports to China in the aerospace sector could potentially be enormous. See Terence P. Stewart, Testimony Before the US House of Representatives Committee on Ways and Means Subcommittee on Trade Hearing on "The Future of United States-China Relations and the Possible Accession of China to the World Trade Organization," November 4, 1997.

81. "A number of Pacific Rim nations (China, Taiwan, Japan, Indonesia, and South Korea) are becoming significant manufacturers in various segments of the aerospace industry and may in time present a competitive challenge to prime contractors in the United States and in Europe. Already they present competition to subcontractors and suppliers...Among Asian countries whose emerging aerospace industries could pose threats to US aerospace manufacturers are China, Taiwan, Japan, South Korea, Indonesia, Singapore, and Malaysia." *US Industry and Trade Outlook 1998*, p. 21-3.

82. "China's Electronic Industry," in *Electronics Manufacturing in the Pacific Rim*, Ch. 3, WTEC, May 1997.

83. Barry Naughton, "Introduction: The Emergence of the China Circle," *The China Circle: Economics and Technology in the PRC, Taiwan, and Hong Kong*, Barry Naughton, ed. (Washington, DC: The Brookings Institution, 1997), pp. 27-28.

84. A new book examines the emergence of an electronics sector in the "China Circle" or "Greater China" region. *The China Circle: Economics and Technology in the PRC, Taiwan, and Hong Kong*, Barry Naughton, ed. (Washington, DC: The Brookings Institution, 1997). Greater China encompasses Hong Kong, Taiwan, and Mainland China.

85. According to a study by the International Data Group (IDG), "In theory, vendors receive tax rebates of 20 percent on exported goods, however these promises have not been fulfilled by the government for the last two years (1995 -1996) due to budgetary shortfalls. Rebates are again not likely in 1997." "China's PC Makers Navigate the Pitfalls," IDG China, *Market News Update*, July 23, 1997.

86. "Policy to Standardize Electronic Joint Ventures, *Ching Chi Tao Pao* (Hong Kong), October 30, 1995, pp. 16-17.

87. See James Whittaker, Testimony on Behalf of the American Electronics Association and the China WTO High-Tech Coalition before the U.S. House of Representatives Subcommittee on Ways and Means, Subcommittee on Trade, November 4, 1997.

88. This view was expressed consistently during interviews with industry experts, company representatives, and US government officials. Furthermore, there does not seem to be an advantage or added leverage for larger companies, such as Motorola, who have experienced as much or even more pressure to transfer advanced technologies to China. Interviews conducted June through December 1997.

89. "China/WTO: AUSTR Sands Holds Industrial Policy Meeting with Ministry of Electronic Industry, December 18, 1996," DOC Cable (U): 97BEIJIN00866, January 1997.

90. "China's New Telecommunications Rules to Take Effect," *Xinhua News Agency*, August 13, 1997.

91. Jean Francois Huchet, "The Circle and Technological Development in the Chinese Electronics Industry," in *The China Circle: Economics and Technology in the PRC, Taiwan, and Hong* Kong, pp. 254-285; 258. The author goes on to say that "it is widely known that the reduction of the US commercial deficit with Taiwan and Hong Kong and its growing deficit with China has occurred because of the wave of delocalization in China of Taiwanese and Hong Kong labor-intensive industries."

92. The six SOEs do not include the leading state or non-state sector enterprises in the electronics industry, such as Stone or Legend. Scott Kennedy, "The Stone Group: State Client of Market Pathbreaker," *The China Quarterly*, December 1997, p. 767 [fn94]. Some are, however, listed among 39 SOEs chosen by the central government as preferred electronics enterprises with whom to establish joint ventures. See James Whittaker, Testimony Before House Ways & Means Committee Hearing on China's Accession to the World Trade Organization, November 4, 1997. This is not to say, however, that the leading enterprises do not receive some government support and assistance. The Founder Electronics Group, for instance, was identified in 1997 as one of six enterprises (from different industry sectors) selected to receive over $2 million in government funding.

93. B. Naughton, *The China Circle*, pp. 27-28.

94. An example of this the Nanjing Panda Electronics Group, a state-owned enterprise that is not doing quite as well as its southern competitors despite government moral and financial support. Panda is located in Nanjing's High-Technology Development Zone; Nanjing is not far from Shanghai. Panda is a large producer of televisions and is increasingly becoming involved in more advanced electronics such as personal computers, digital switches, liquid crystal displays, and wireless phone systems through foreign joint venture projects. Motorola is also a joint venture partner. Karl Schoenberger, "Motorola Bets Big on China: The US High-tech Company Is Doubling its Stake in What Could Become the World's Largest Electronics Market, *Fortune*, 1996.

95. Whether the companies or "groups" derived from CAS and other state-run institutions can be placed in the state or non-state sector is not clear. According to the Office of Technology Policy, "China's new "high tech enterprises" are considered to be part of the non-state sector but are not privately-owned companies. They are usually collectively owned by the local government and either a university-based research institute or a CAS-based research institute. Individuals are allowed to own shares, but the portion held by individuals as opposed to institutions is comparatively small." See "Summary: Visit to China by Assistant Secretary Graham Mitchell," Travel Report, July 4-17, 1997. This category would include companies such as Legend. What is perhaps more important than a state or non-state label, however, are the actual ties to the former institution, which does not appear to be a close relationship for Legend or other companies doing business in Guangdong.

96. B. Naughton, *The China Circle*, p. 25.

97. US Census Bureau data.

98. US Department of Commerce, Office of Computers and Business Equipment, August 21, 1997 [website].

99. George Scalise, Testimony Before the House Ways & Means Subcommittee on Trade on "The Future of United States-China Trade Relations and the Accession of China to the World Trade Association," November 4, 1997.

100. There are also reportedly complaints by US companies of SACI corruption. The SACI is, as currently set up, a for-profit organization. See Ian K. McDaniels and Meredith Gavin Singer, "Standard Fare: Foreign Companies Now Face a Growing Number of PRC Standards and Inspection Requirements," *The China Business Review*, May-June 1997, pp. 22-28.

101. "Issue Alert: New Requirements Affecting Sales of Information Technology Products in China," July 25, 1996, Information Technology Industry Council (ITI).

102. UL can do follow-on annual inspections/certifications but only at the request of the Chinese State Administration of Import and Export Commodity Inspection (SACI) government organization of the State Council responsible for the SACI certificate. There are two certification certificates: the CCEE Mark (a.k.a. Great Wall Mark) for electrical products either manufactured in China or imported into China; and the SACI certificate, which is more extensive and covers electronic products intended for import/export. Products for which the CCEE certificate is required (effective January 1989) include electric tools, refrigerators, freezers, electric fans, air conditioners, televisions, radio, tape recorders, leakage protectors, power cables, etc. Other items (such as cord sets, motor compressors, household appliances, microcomputers and components, VCRs, etc.) are included in a second, thus far mandatory-compliance, list. Products requiring dual certification can be approved with one inspection. UL has signed an MOU with SACI that would allow US testing and certification of products but this agreement has not been tested due to disagreements (UL concerns) over PRC data and testing standards. Negotiations on this issue are reportedly ongoing. "Certification Scheme of the People's Republic of China," brochure provided by Underwriters Laboratories, Inc.; and Ian K. McDaniels and Meredith Gavin Singer, "Standard Fare: Foreign Companies Now Face a Growing Number of PRC Standards and Inspection Requirements," *The China Business Review*, May-June 1997, pp. 22-28.

103. Motorola's WFOE in Tianjin is the only exception Chinese officials have made to this policy. The exception is likely due to the *guanxi* established by then-Motorola CEO, John Galvin with Chinese leaders, including former MEI head and then-mayor of Shanghai, Jiang Zemin. The $100 million investment commitment made by Galvin to Chinese leaders surely did not hurt. The Tianjin plant was opened in 1993. Although a city located about 70 miles outside of Beijing, Tianjin is a municipality of Beijing, meaning it answers directly to Chinese leaders in the capital. Kevin Maney, "Motorola Stands by China: Patience Is Key to Telecom's Fastest-Growing Market," *USA Today*, November 3, 1997, pp. 1B&C; Carla Rapoport, "Motorola Answers the Call: Telecommunications Giant Realizes Long-Held Dream, as it Dominates China's Vast Pager Hardware Market," *Journal of Commerce*, October 1, 1997, p. 1.

104. Unicom was a subsidiary of the Ministry of Electronics Industry. Unicom was established to provide a state-run competitor to the MPT.

105. Susan Esserman, Testimony Before the US House of Representatives Committee on Ways and Means, Subcommittee on Trade, November 4, 1997.

106. SPA estimates that losses for US software firms in China due to piracy amounted to $250million in 1995. "Global Study Shows Increase in Software Units Pirated: Nearly One in Every Two Business Applications is Pirate Copy," SPA press release, May 7, 1997; Catherine Gelb, "Installing a Software Sector," *The China Business Review*, September-October 1997, pp. 38-36.

107. Earlier this year a bilateral agreement was signed that will allow the USITO to verify software title authenticity for US firms conducting business in China, in accordance with China's commitments to IPR enforcement under the 1995 MOU. Matt Forney, Simon Fluendy, and Emily Thornton, "A Matter of Wording: Microsoft Moves Carefully to Shore Up China Business," *Far Eastern Economic Review*, October 10, 1996; "Leading Software Trade Associations Announce Contract for Joint Title Verification Authorization Office in China," USITO press release, April 23, 1997.

108. The Semiconductor Industry Association complains that China's "state-invested enterprises already control a significant share of the trade in electronics goods into and out of China. For example, the Ministry of Electronics Industry (MEI) controls the China Electronics Corporation (CEC), which in turn owns or controls a significant share of China's electronics industry, including major consumers of semiconductors for consumer electronics and computer production...As a result of the continuing active [Chinese] government role in the electronics sector, there is a significant risk that as Chinese semiconductor production increases both in volume and quality, other state-invested enterprises will be encouraged by Chinese officials to purchase from domestic suppliers. Such discrimination could significantly burden or restrict US semiconductor sales in China in the future." G. Scalise, Testimony, November 4, 1997.

109. Helen Ho, "Buying a Piece of PRC Industry," *The China Business Review*, Jan-Feb, 1996, pp. 34-37; and US Department of Commerce, Office of Computers and Business Equipment, "Information Technologies Market II," April 5, 1996. According to figures released by the China Software Industry Association (CSIA), there are more than 13,000 software development firms (state-owned and non-state enterprises) currently in business, though some of these are firms of only one or two people. Figure cited in Catherine Gelb, "Installing a Software Sector," *The China Business Review*, September-October 1997, pp. 28-36.

110. Catherine Gelb, "Installing a Software Sector," *The China Business Review*, September-October 1997 and Dexter Roberts and Bruce Einhorn, "Going Toe to Toe with Big Blue and Compaq: Suddenly, Chinese Computer Makers are Holding their Own," *Business Week*, April 14, 1997, p. 58.

111. Catherine Gelb, "Installing a Software Sector," *The China Business Review*, September-October, 1997, p. 36.

112. A defense electronics "expo"—the China International Defence Electronics Exhibition—was held in May 1998 in China; foreign electronics firms were invited. William Kazer, "China's Military Backs Foreign Role in Defense Projects," Journal of Commerce, July 16, 1997, p. 4. Since making this announcement, Central Military Commission Vice Chairman, Liu Huaqing —China's leading voice for military reform toward high-tech modernization— has been pushed out of the top leadership by Jiang Zemin during the 15th Party Congress held in September 1997. Liu's plan, however, was likely not his alone and will, therefore, probably be implemented despite his departure. In fact, an official of the Commission on Science, Technology, and Industry for National Defense (COSTIND) reportedly requested foreign firms attend the May expo in Beijing. Nigel Holloway, "Revolutionary Defence," *Far Eastern Economic Review*, July 24,1997, pp. 24-25.

113. The Economist Intelligence Unit, July 1997.

114. See, for instance, "Government strategies (BCG 1994)," Chapter 2 in WTEC report, which states that "Within the government sector, the technology for defense production is at a high level."

115. China's military controls a large portion of the telecommunications bandwidth (particularly cellular communications frequencies) in China, which is gradually being opened to commercial uses. As a result, many of the Sino-foreign joint venture partnerships in this industry sector may be affiliated with China's defense industrial sector or its military sector (PLA). It should be understood that China's military and defense industrial sectors are under separate authorities: the Central Military Commission or PLA and the State Council (civilian authority), respectively. The defense industrial sector does *not* (as far as the experts can tell) directly subsidize the PLA, though gains in defense industries may indirectly aid the PLA modernization effort. A recent study on this concern, however, states that in order for foreign communications companies to gain access to the military-controlled bandwidth "the PLA and its [Chinese joint venture] partners expect a significant infusion of capital and technology." James Mulvenon *in Chinese Military Commerce and US National Security*, Center for Asia Pacific Policy, RAND Corporation, MR-907.0-CAPP (draft) July 1997.

116. "How You Can Win in China: The Obstacles are Huge but Surmountable," *Business Week*, May 26, 1997, pp. 66-68. Another recent example is Prodigy, the first foreign internet service provider to be allowed to establish a presence in China, is partners with among others the China North Industries Co. (better known as NORINCO). Although NORINCO is officially a state-run "corporation" under China's civilian authority (State Council), NORINCO is also known to be involved in military-related activities and the import and export of military products. The deal with Prodigy included NORINCO due to the latter's ability to provide access to satellite communications necessary for the project (i.e., limited internet access, e-mail, fax and voice messaging services). Company Press release. Jared Sandberg and Craig S. Smith, "Prodigy to Launch Internet Service in China," *The Wall Street Journal*, April 28, 1997.

117. Catherine Gelb, "Installing a Software Sector," *The China Business Review*, September-October, 1997, pp. 31-32.

118. The remaining top investors include two in auto manufacturing and auto parts, two in oil/energy, followed by one each in low-tech electronics, with only two catering to China's food and drink industry. Karl Schoenberger, "Motorola Bets Big on China," *Fortune*, vol. 133, no. 10, May 1996.

119. WTEC report.

120. Microsoft's China office is now its fastest growing branch, despite having suffered through initial difficulties in its 1994 entry into the China market. Microsoft Corp. (software) "...manufactures in-country most of the products sold in China, while foreign-language products are its main exports to the PRC." Catherine Gelb, "Installing a Software Sector," *The China Business Review*, September-October 1997.

121. "Rethinking China," *Business Week*, March 4, 1996, pp. 61.

122. This information is according to the CSIA as cited in Catherine Gelb, "Installing a Software Sector," *The China Business Review*, September-October 1997.

123. *Ibid.*

124. This situation is not unlike the Boeing-Airbus rivalry. Simon Fluendy, "Battle of the Standards," *Far Eastern Economic Review*, August 22, 1996.

125. Chinese electronics exports in 1996 were valued at US$18.41billion while imports were US$15.83 billion, according to Chinese statistics. "More Electronic Products Exported," *Beijing Review*, vol. 40, no. 15, April 14-20, 1997. According to a US-based analyst, however, the PRC witnessed its first trade surplus in electronics the year before, when exports of $17 billion exceeded imports of $16 billion. Regardless of the exact figure, however, the trend is clear. Elizabeth Schumann, "China on Fast Track for Building IC Capacity," *Channel Magazine*, SEMI, February 1997.

126. *Ibid.*

127. These categories are 852110, 854129, 852530, 853310, and 853222, respectively. This data is derived from the US Census Bureau at the 6-digit level analysis. The remaining top ten categories include turntables (851939), parts for electrical capacitors (853290), nickel-iron storage batteries (850740), transistors ex. Photosensitive, dissipation rate less <1w (854121), and "electromechanical saws for working in the hand" (850820).

128. Information is included in a SEMATECH document: "SEMI Course Highlights: Doing Business in China," dated March 18, 1997.

129. Denis Fred Simon, "From Hot to Cold," *The China Business Review*, November-December 1996, p. 16; G. Scalise Testimony, November 4, 1997.

130. A number of US high-tech firms considered investing in this project, but industry and USG concerns regarding potential dual-use applications and the need for licensing approval deterred them from pursuing this project.

131. "Who Dares, in China, Can Still Win," *The Economist*, July 6, 1997.

132. Taiwan was able to move from the 5 micron level to production of 1.0 micron chips over a ten-year span from 1980 to 1990. The PRC has made the same advances over a similar ten-year period (1985-1990) but about five years behind Taiwan and further still behind the world leaders. However, advances in this field at submicron levels are only made by devoting significant resources to research and development, which China appears willing to do. In addition, the technological assistance forthcoming from foreign firms is certain to hasten China's progress in submicron chip making, which otherwise might remain concentrated at the 1.0-0.8 micron level for some time. Chin Chung, "Division of Labor Across the Taiwan Strait: Macro Overview and Analysis of the Electronics Industry," *The China Circle: Economics and Technology in the PRC, Taiwan and Hong Kong*, pp. 164-209, see in particular page 195.

133. This is according to a report on international efforts at "discovering new techniques for confining electrons to structures at the nanometer scale, revealing new insights into electronic behavior that may one day have practical applications." The Chinese contribution to this effort was reportedly devised at Nanjing University in Nanjing. See "Confined Electrons Boost Semiconductors," *Electronic Engineering Times*, no. 919, September 16, 1997, p. 36.

134. Denis Fred Simon, "From Hot to Cold," *The China Business Review*, November-December 1996, p. 16.

135. *Ibid.* See also James Harding, "Chinese Switch on to Computer Power," *The Financial Times*, August 12, 1997.

136. Perry Mataya and Huang Zhiqiang, "China: Software Market," Industry Sector Analysis (ISA), June 1995.

137. "Local Computer Maker Takes Lead," *China Daily*, March 10, 1997. Citing figures by the State Statistical Bureau, the article states that "Legend Computer, a domestic computer brand, ranked first in China home sales in 1996 with sales of 200,000 units. This is the first time that a domestically manufactured computer has sold the highest number of units in China's increasingly competitive market that was once dominated by foreign brands. The computer has become the third electronic product with such an important role in the country's domestic market after TVs and refrigerators."

138. This information is contained in a report published by Dataquest, a market research firm. See James Harding, "Chinese Switch on to Computer Power," *The Financial Times*, August 12, 1997; "Chinese PC Maker, Hitachi Link to Fight US Rivals," *Wall Street Journal*, September 30, 1997, p. A17.

139. Key end-users of PCs in China are the PRC government and the aerospace, banking, telecommunications, and transportation industries. US Department of Commerce, Office of Computers and Business Equipment, "Information Technologies Market II," April 5,1996 and Bryan Larson and Timothy Miles, "Personal Computers and the Golden Projects," US Department of Commerce, International Trade Administration, Office of Computers and Business Equipment, March 1997.

140. WETC report; and "China's PC Makers Navigate the Pitfalls," *IDG China, Market News Update*, July 23, 1997.

141. In July 1997, Legend signed an agreement that will allow sales of its products in the US; Legend also has a small research facility located in Silicon Valley, established in 1993. Dexter Roberts and Bruce Einhorn, "Going Toe to Toe with Big Blue and Compaq," *Business Week*, no. 3522, April 14, 1997, p. 58.

142. Scott Kennedy, "The Stone Group: State Client of Market Pathbreaker," *The China Quarterly*, December 1997, p. 752. Kennedy points out that Stone is not, as is often assumed, a "private" company. Rather, it is a type of "collective" enterprise in the non-state sector, but one with more autonomy than most such enterprises.

143. According to one article, the capacity was 10 billion TOPS. The article states that, "In November 1992, when China's first giant computer capable of 1 billion calculations per second, developed by the USTND, was born and the design of the 10 times faster 'Yinhe-III' giant computer began, Comrade Jiang Zemin happily wrote this inscription: "Conquer giant computer technology and bring credit to the Chinese nation." See "China: Jiang's Interest in Defense Technology," *Beijing Liaowang*, no. 30, July 28, 1997. However, the Associated Press reported the same computer, the Yinhe III, as being capable of 13 billion TOPS, which was the level reportedly announced on national Chinese television. See "China Unveils Supercomputer," *Associated Press*, June 19, 1997.

144. "China: Jiang's Interest in Defense Technology," *Beijing Liaowang*, no. 30, July 28, 1997, pp 4-6.

145. *China White Paper on Arms Control and Disarmament, Xinhua News Agency*, November 16, 1995, issued by the Information Office of the State Council of the PRC.

146. Following a review of computer export level reforms in 1995, the 10,000 MTOPS level "emerged as the boundary for militarily significant capabilities that an export control regime might hope to deny to adversaries through 1997." The 10,000 MTOP level is presently available to most of the rest of the world. See Kenneth Flamm, "Controlling the Uncontrollable: Reforming US Export Controls on Computers," *The Brookings Review*, December 1996, pp. 22-25.

The Galaxy II is apparently a successor to China's first supercomputer, known simply as "Galaxy," and listed as having been developed in 1983. The Galaxy II is listed among China's technological achievements in the computer sector in *Technology Transfers to China*, Office of Technology Assessment, 1987, p. 96. The Galaxy series is reportedly designed and developed by the Changsha Galaxy Technology Group, a division the USTND. Min Chen, "Market Competition and the Management Systems of PLA Companies," in *Mixed Motives, Uncertain Outcomes: Defense Conversion in China*, Jorn Brommelhorster and John Frankenstein, eds., p. 213.

147. Figures are by Kenneth Flamm of The Brookings Institution as cited in Paul Blustein, "Computer Evolution: Faster than a Speeding Export Curb," *The Washington Post*, July 3, 1997, pp. E1&E2.

148. In most cases, Chinese government estimates on the amount of telecom equipment, networks, and infrastructure that could be installed by 1995 and then the year 2000 have doubled as the target date approached. See "How Has China Financed Its Telecoms Build-Out?," *Business China*, November 24, 1997, pp. 7-9.

149. Mobile phone usage in China topped 10 million in 1997, an achievement reached in less than a decade. Chinese government statistics predict mobile phone users will reach between 17 and 30 million by the year 2000 (the International Telecommunications Union also projects 30m users). Terho Uimonen, "China's Mobile Phones Push Past 10 Million Mark," *IDG China Market News*, August 8, 1997; "Telecom Growth Estimates Revised Upwards," *China Daily*, December 30, 1996.

150. WTEC report.

151. China is also reported to have begun "to develop optic cables on a large scale during the 1991-95 period." *China Economic Information*, July 1997.

152. Motorola is certainly not alone in participating in China's emerging telecommunications sector, nor are they the only US company experiencing difficulties. Nortel (Northern Telecom Ltd.), for instance, established a joint venture in 1993 to build "state-of-the-art" digital switches. Commercial offset agreements reportedly included research and development projects with government institutes. According to press reports, Nortel's profit margin is slim at best. BellSouth was reportedly planning on establishing a joint venture with China's Unicom to build cellular telephone systems. The deal was also reported to include an agreement to provide training, but a demand made during negotiations by a Chinese official for an additional $10 million investment convinced BellSouth officials to re-think pursuing the venture further. These tales are included in a recent article, "How You Can Win in China: The Obstacles are Huge but Surmountable," *Business Week*, May 26, 1997, pp. 66-68.

153. C. Gelb, *The China Business Review*, September-October 1997.

154. This assertion is reported to be made by DOD officials. United States General Accounting Office, *Export Controls: Sale of Telecommunications Equipment to China*, GAO/MNSIAD-97-5, November 1996, p. 5.

155. M. Borrus, "Left for Dead: Asian Production Networks," in *The China Circle*, p. 140.

156. The apparel industry is listed as the sector most affected, with losses of 146,000 jobs followed by toys (66,000), footwear (60,000), and textiles (58,000). Jesse Rothstein and Robert E. Scott, *The Cost of Trade With China: Women and Low-Wage Workers Hit Hardest by Job Losses in All 50 States*, Issue Brief 121 (Washington, DC: Economic Policy Institute, October 28, 1997).

157. Barry Naughton, "The Emergence of the China Circle," *The China Circle: Economics and Technology in the PRC, Taiwan, and Hong Kong*, pp. 16-13.

158. "How You Can Win in China: The Obstacles are Huge but Surmountable," *Business Week*, May 26, 1997, pp. 66-68.

159. *US Industry and Trade Outlook 1998*, p. 16-4.

160. Chin Chung, "Division of Labor Across the Taiwan Strait," in *The China Circle: Economics and Technology in the PRC, Taiwan, and Hong Kong*, p. 200.

161. "Commission Communication to the Council on a Long Term Policy for China-Europe Relations," European Commission Delegation to China, 1996.

162. By their own accounting, the EU nations were responsible for 49 percent of technology exports to China. See "EU-China Trade," European Commission Delegation to China, 1996.

163. The European automobile industry is represented by the European Automobile Manufacturers Association (ACEA) and the European Automobile Parts and Suppliers Association (CLEPA). ACEA consists of leading European car manufacturers like BMW, Fiat, Ford of Europe, GM of Europe, Mercedes-Benz, Porsche, PSA Peugeot Citroen, Renault, Rolls Royce, Volkswagen and Volvo. CLEPA represents the entire auto supply industry in Europe, comprising fully 3,000 companies. The European aerospace corporations are represented by a trade association, known as the European Association of Aerospace Industries (AECMA). AECMA is led by Airbus Industrie, but the organization also includes Sextant Avionique, DASA, Thomson CSF, Rolls Royce, Sysabel, Lucas Aerospace, Aerospatiale and Siemens Plessey, among others. Airbus, alone, has also entered into technology transfer agreements with the Chinese aviation industry. Airbus was involved in a three-way agreement to produce a 100-seat transport aircraft, the AE31X (also/formerly known as the AE-100) for which the final assembly line was to be in China. (This project has since been cancelled.) Airbus has also established a training and support center in Beijing, an $80 million investment that is reportedly an offset for the 1996 purchase of 30 planes from Airbus. "Airbus Equity-Sharing Wins Chinese AVIC Partnership," *Countertrade & Offset*, vol. xv, no. 17, September 8, 1997, p. 3.

164. EU-China Industrial Co-operation Programme in the Automotive Sector," European Delegation to China, 1996.

165. "EU-China Industrial Co-operation in the Aeronautical Sector," European Commission Delegation in China, 1996.

166. It is possible that these trade deficits are due to investments made in China, the products of which may have been exported back to these economies, although there is no clear evidence that this is, in fact, the case.

167. Japanese reluctance and cautiousness with regard to investing in the China market may be weakening, however. The recently awarded Project 909 advanced semiconductor contract to Japan's NEC is a recent example of an possible change of mind on the part of Japanese industry to transfer advanced technology to China. Some analysts point out, however, that by the time this facility reaches the planned production of submicron chips at the 0.5-0.35 levels, the rest of the industry will have moved beyond this level anyway. If so, NEC's decision to invest may not be such a departure from previous Japanese practice.

168. UN trade data shows a marked rise in hi-tech exports from Japan in 1993 and 1994.

169. Toyota's Daihatsu and Suzuki currently have licensing agreements with Chinese ventures to produce the Charade and Alto, respectively. Honda only very recently became the first Japanese automaker to establish a manufacturing joint venture on the Mainland, having taken over Peugeot's facility in Guangzhou. Daniel Howes, "GM Trails Honda in China Deal," *The Detroit News*, November 4, 1997; Seth Faison, Honda, Beating Out GM, Plans to Build Cars in China," *The New York Times*, November 14, 1997, p. C2. This may also be a sign of Japanese industry having a change of mind with regard to the China market. According to industry experts, "Japanese car makers have been slow to commit to China because of their concerns about the stability of its market, auto executives say. Honda, in particular, is known for carefully gauging demand before building plants" (cited in Craig Smith and Lisa Shuchman, "Honda Beats GM for Deal in China," *The Wall Street Journal*, November 11, 1997.

170. Tang Shiguo, "Sino-Japanese Technology Transfer and Its Effects," *Chinese Technology Transfer in the 1990s: Current Experience, Historical Problems and International Perspectives*, Charles Feinstein and Christopher Howe, eds. (Cheltenham, UK: Edward Elgar Publishers, 1997), p. 157.

171. Harley and Iritani, *Los Angeles Times*, December 2, 1995.

172. William Chen, Director of International Trade and Service Corporation, Shanghai. Quoted in *The Los Angeles Times*, December 2, 1995.

173. "Transport Equipment" in the case of Japan is primarily tankers and other shipping vessels. "Electrical Machinery" refers to items like static convertors and circuit breakers.

174. Atsushi Yamakoshi, "Grappling With A Giant," *Japan Economic Institute Report*, August 30, 1996.

175. Interview on October 16, 1997.

176. Atsushi Yamakoshi, "Grappling With A Giant," *JEI Report*, August 30, 1996. This trend has also become evident among domestic industry competitors. For instance, Microsoft, DEC, and Oracle joined forces in May 1996 in their efforts to sell software in China. *The China Business Review*, September-October, 1997.

177. "List of Countries to Which Japan is Top Donor," Ministry of Finance, Japan.

Part 3
SHORT- AND LONG-TERM IMPLICATIONS OF TECHNOLOGY TRANSFER

US COMPETITIVENESS

How does China's recent growth and progress in several industrial sectors translate into competition for the United States? At present, it would seem that although some progress has been made in China in relatively high-tech industries (as the case studies have shown), there are numerous difficulties and obstacles such as infrastructure deficiencies with which China must still contend. Perhaps the most worrisome issue with regard to China's increasing manufacturing capabilities in high-tech sectors is that of over capacity. China is already the number one recipient of US anti-dumping complaints, and this trend is not likely to change in the near future. The sheer volume of products (even those in high-tech sectors) that China is capable of producing is staggering and could have serious global repercussions (as is already apparent in the auto sector).

Over the last decade China has become a large exporter of electrical items. The "electrical machinery, TV equipment" (HTS85) category, which includes a wide range of electronic and electrical appliances and components, has been the number one United States import category from China since 1994, displacing toys (HTS95) and footwear (HTS64) from the lead positions. As Chinese manufacturing becomes more sophisticated and technical in nature, Chinese high-tech products could potentially undercut similar products of other countries (and therefore jobs as well) as prices fall or are lowered due to excess supply in China.[1] Of course, this presumes that Chinese products would also be of equal or greater quality than foreign products, which will certainly not always be the case. However, as the market for PCs in China demonstrates, Chinese firms have been able to achieve a level of sophistication and quality control sufficient to take the lead in domestic sales when combined with a price lower than that charged for foreign products. Thus, similar situations could conceivably arise in the auto sector, various parts and components, as well as telecommunications equipment and other high-tech areas in the not-too-distant future.

In the most competitive sector — electronics — China may have come a long way over a relatively short period of time, but much improvement remains to be made before Chinese indigenous capabilities become competitive with US products. Results of a survey published by the World Technology and Evaluation Council (WTEC) drafted by US industry experts concluded that the only electronics capability in which China was deemed moderately competitive in 1994 was manufacturing, and even then not very much so in relation to neighboring countries and the United States. For overall R&D, design, marketing and sales, China received only "negligible" or "weak" ratings. However, the report also concludes with a warning for industry leaders: "The competitive pressures to upgrade technological capabilities [throughout the Asia-Pacific region] directly challenge Japanese and US high-technology leadership. Development of the Internet provides for even more rapid transfers of technology than in the past and will challenge even the best firms to keep pace."[2] This would seem to be good advice, especially when one looks at the

technological advances and economic growth made possible primarily in Southeastern China due to the proximity of increasingly sophisticated, newly industrializing nations on China's periphery.

The key to rising Chinese competitiveness in its own market as well as the global marketplace is China's ability to absorb the vast amounts for foreign capital and technology that have come its way this decade. China's well-planned economic, industrial, and science and technology advances will only be realized if more flexibility is allowed for China's bureaucracy, researchers and scholars, as well as entrepreneurs. China's new generation of leaders also realize this to be the case, given their own backgrounds in scientific and technological fields. China's scientists, students, foreign experts and joint ventures will play a key role in determining the degree to which China is able to assimilate and then innovate technology. There are scant examples of this going on in China today, but the idea seems to be catching on quickly in some regions and industrial sectors. As these ideas do take hold, US technology transfers to China, especially those in the form of joint R&D centers, will be increasingly important vehicles for technological improvements. It is, therefore, incumbent upon US industry and the US government to be vigilant in assessing the type and level of technological advances that are taking place in these centers and to protect the rights of US corporations to these results and the technology transfers that will one day flow from China to the United States.

Generally speaking, China at present poses no direct threat to US economic competitiveness in high-tech industries. However, if current projections by Chinese and international financial institutions are correct, China will be a major competitor and world economic power in another decade or two.[3] Under current conditions, this seems inevitable. Indeed, a 1997 survey by Grant Thornton of US manufacturers finds that more US companies view China as a future competitor than any other country.[4] Interviews of industry representatives conducted for this study have also indicated some concern for US competitiveness vis-à-vis China in the not-too-distant future due to technology transfers to China by US firms and others. However, there does not seem to be great anxiety about this on the part of US high-tech firms at this time.

The projections of China's market and economy are largely based on best-case scenarios in terms of expected future economic growth in China and in Asia and do not take sufficiently into account potentially serious economic or political crises (such as the current Asian financial troubles). Similarly, projections made by many foreign firms with regard to the potential of China's market often do not account for the realities of doing business in China today. China's market is not as open as it would appear despite the vast changes obvious in Chinese society since 1978. As a result, significant US commercial technology transfers to China are occurring with only limited access to China's market in return. Moreover, as the country with the greatest trade deficit with China, the United States is also paying the most for the privilege of access to China's market in terms of lost potential exports and job opportunities. How long the present situation continues will determine the extent to which US commercial technology transfers to China will affect global US economic competitiveness.

US NATIONAL SECURITY

The implications of US technology transfers to China for US national security have long been a concern for the US government and have become increasingly difficult to gauge due to the increasing number and types of dual-use items utilized in modern civilian society and military forces. China presents a particular problem due to the uncertainties about the relationship between China's military and defense industrial sectors. These difficulties will only become more complicated as US firms begin to invest in China's central regions where China's main military and

defense institutions are located, along China's "Third Front." Accordingly, determining the end use and the end-user will become more of a burden on US industry and could conceivably lead to increased export license applications, missed business opportunities due to hesitancy on the part of US firms to consider investing or applying for a license, or potentially more cases requiring investigation in the future. (The US Department of Commerce provides a guide for US exporters entitled "Know Your Customer Guidance" to assist US businesses exporting or doing business abroad to determine possible violations of the Export Administration Regulations. These "Red Flag Indicators" can be found on BXA's website: www.bxa.doc.gov).

Despite having reduced the number and type of items still subject to export licensing, US government concerns remain over Chinese intentions and military capabilities. The list of items subject to review has been significantly reduced since the end of the Cold War. Export controls, however, are not and never have been a means to analyze or track the cumulative, long-term effects of US commercial technology transfers on US competitiveness or national security. Given the rapid pace of development and advances in many high-tech industries, it may be too late by the time US industry or the US government as a whole realize there is a problem emerging in either of these areas.

China needs and wants all the high technology the United States is willing to provide. As this study shows, the transfer of advanced technology is often the key to gaining market access in China. US high-tech firms now less hampered by US export controls appear willing to provide a good deal of "state-of-the-art" technology as commercial offsets for even limited access to China's market. These direct and indirect commercial offset agreements involve meeting local content requirements, providing employee training, and R&D collaboration. This situation opens the possibility for harm to long-term US economic competitiveness and national security interests from ongoing commercial technology transfers to China.

However, simply having access to advanced technology does not imply an effective or efficient Chinese use and understanding of the technology. Although China's military leaders may aspire to a Gulf-War type modern military capability, this reality is a long way off for the PLA. The record does not show that Chinese military forces have made, or are likely to be able to make, significant advances in the near future as a result of US commercial technology transfers. According to a respected expert on the Chinese military, "modernization of China's defense industrial base and R&D, as this term is understood in the United States, Europe, Russia, and Japan, remains at least two decades into the future."[5]

CONCLUSION

As this study has attempted to show, China's laws, regulations, and policies with regard to foreign investment and trade include numerous provisions and mandates for foreign technology transfer. These policies are clearly intended to support domestic reform and modernization efforts toward self-sufficiency in high-tech sectors. Furthermore, many of the provisions included in China's existing industrial policies appear to raise questions as to their consistency with international trade practices and bilateral agreements. (These issues are among those being addressed in bilateral and multilateral fora on China's potential accession to the World Trade Organization.) Despite these policies, however, many foreign corporations continue to invest in China, including US high-tech companies. In doing so, these companies often must transfer commercial technology in various forms in order to accommodate Chinese foreign investment and import regulations, which have become increasingly selective in terms of the level and type of technologies allowed. Thus, it is clear that foreign firms are being coerced into transferring

technology (which they probably would not otherwise do) as the price to be paid for access to China's market.

The more difficult question to answer, however, is the degree to which these transfers are "forced." The option certainly exists for foreign corporations to simply refuse to invest in China (or to divest) until significant changes are made in Chinese foreign investment policies. There is leverage here: China is, and will remain for the foreseeable future, dependent on foreign capital and technology for its modernization and reform programs. Such a strategy could prove costly, however, if in the meantime other foreign investors are able to build "beachheads" in China, thereby affording them an advantage if and when China's market takes off. Also lost would be the returns (slim as they may be) from investing in China early on, before other foreign competitors and (in time) domestic producers in China grab most of the market for themselves.

In addition, China's market represents more than a single national economy. China's sheer size, population, and share of the world's economy make the decision on whether and when to invest in China one with potentially global consequences. Thus, foreign investors face a difficult dilemma: to invest early and accept the risks involved in doing so in hopes of minimizing potential losses while creating a market presence and goodwill in China, or to wait and see how China's market and policies develop, investing when the time is ripe and investment policies less discriminatory. The leading high-tech companies — American, European, and increasingly also the Japanese — seem to have decided on the former strategy. It is therefore difficult to conclude that commercial technology transfers resulting from US foreign investment in China are truly "forced."

Furthermore, if technology transfers were genuinely "forced" from foreign investors, one could reasonably assume that there would be significant and obvious advances in each of the industries concerned. However, China's industrial policies have not been uniformly successful in achieving their stated goals. As the industry case studies show, China's industrial policies have had a very mixed record. On the one hand, in the auto sector, Chinese policies appear to be having the desired effect on technology transfers (they are increasing in the form of trade, research, and training), but the industry itself has not yet witnessed significant technological advances as a result. On the other hand, the aerospace industry seems to be progressing on both fronts, whereas the electronics industry shows that technology transfers and advances can occur in spite of explicit industrial policies. Thus, it seems clear that technology transfers are not solely the result of discriminatory trade practices or policies and, therefore, again are not "forced." Rather the degree to which US technology is being transferred to China is a combination of Chinese law and strategic decision-making on the part of US corporations. That is, technology transfer is both mandated in Chinese regulations or industrial policies (with which US companies wishing to invest in China must comply) *and* used as a deal-maker by US firms seeking joint venture contracts in China.

Are Chinese industrial policies sustainable? Perhaps in the short-run, but not over a long period of time. If the investment policies now in place in China are continued without further liberalization and reform, foreign investors are likely to eventually become disenchanted with the China market. However, this would result in the loss of significant amounts of foreign capital and technology upon which China's economic and military modernization are dependent. A serious decline in foreign investment would also make the prospects of increased efficiency, innovation, and competition in domestic Chinese enterprises more difficult. Thus, a strong motivation exists for Chinese leaders and officials to continue the gradual process of opening sectors to foreign investment and increasing trading rights among both domestic and foreign enterprises, which would likely serve to decrease the per-contract level of technology transfers to China.[6] In the

meantime, it is contingent upon foreign investors and their respective governments to encourage Chinese leaders to hasten the pace of liberalization and reform in the foreign investment and trade sectors. Otherwise, the present situation, which is potentially harmful to US economic competitiveness and national security, will persist and result in more technology transfers in the future.

Yet, if Chinese policies and practices were to reach the point of truly forcing technology from foreign investors, the latter would begin to leave China, taking with them the capital and technology China so desperately needs now and for the long-run. Thus, it is unlikely that circumstances will actually reach this point and that the continuously opposing forces at work (China's need for technology and US firms' wariness in transferring it) will serve to maintain some degree of balance. That is, of course, if the prospect of a 1.2 billion-person economy does not continue to mesmerize American business, and if these companies remain sufficiently wary of the risks involved in technology transfers. To date, this does not seem to be the case, however. Rather, during the timeframe in which this study was conducted, it was still largely considered heresy to not be optimistic or enthusiastic about the China market.[7] It would be a greater service to US industry, if the *realities* of the China market for foreign investors, rather than merely the *potential*, were made more apparent to prospective American investors in China.

Finally, it should also be noted that this is not the first time that the China market has fascinated foreign entrepreneurs. There has been an historic cycle of overly enthusiastic expectations followed by a bitter withdrawal from the China market. Early last century, foreign investors from great powers flocked to China to do business with China's even then enormous population only to find their trade rights and market access tightly restricted. Arguably, the situation today for foreign investors in China is not entirely dissimilar. If Sino-US trade, economic disputes and miscommunications or misunderstandings are similarly allowed to fester without noticeable liberalization of the ways of business and trade in China, then it is certainly possible that foreign investors will eventually tire of the China market and turn away bitterly once again. As the final years of the 20th Century approach, however, it would surely be catastrophic for both the United States and for China, as well as for the rest of the world, if the two largest economies were to become estranged.

As Part 1 of the this study shows, China's foreign investment policies have followed a clear pattern characterized by an increasingly targeted focus on high-technology investment and imports. These policies are intended to bolster China's modernization efforts in both the civilian and military sectors. The most significant finding of this study, however, is the degree to which US high-tech firms are collaborating on R&D with leading Chinese universities and research institutions in China, an offset agreement frequently accompanying joint venture contracts. Although there is as yet no clear cause and effect as much of the evidence is circumstantial, Part 2 of the study demonstrates that trends in Sino-US trade are worrisome in that high-technology sector exports (such as electronics) are increasing from China to the United States and elsewhere while at the same time the US trade deficit with China is climbing.

As this study attempts to show, commercial technology transfers to China are the condition upon which American high-tech investors are entering the China market, and this trend is likely to continue. Technology, however, is also a key factor in maintaining US competitiveness in the global economy and fundamental to defending and advancing US national security interests. Moreover, technology transfers are not necessarily detrimental to US business, the US economy, or to national security interests and can, in fact, be mutually beneficial to the parties concerned. However, where technology transfers are unduly required in exchange for access to a foreign market or where foreign investment policies mandate the transfer of advanced technology

regardless of market demand, there exists an artificial incentive to transfer more advanced technologies than would likely prevail under freer market conditions. This is the situation that exists in China today.

Endnotes - Conclusion:

1. According to a recent report on the effects of the US trade deficit with China, while Chinese exports to the US of apparel, toys, and footwear continue to grow rapidly, China is also rapidly increasing its exports of computer equipment and consumer electronic devices. This new trend suggests that job losses among higher-wage workers will grow as the persistent China trade deficit continues to expand." Jesse Rothstein and Robert E. Scott, *The Cost of Trade With China: Women and Low-Wage Workers Hit Hardest by Job Losses in All 50 States*, Issue Brief 121 (Washington, DC: Economic Policy Institute, October 28, 1997).

2. "Asia's Electronics Manufacturing Infrastructure," *WTEC Report*, Chapter 2, May 1997.Tables E1, 2.3, and 2.6.

3. See "China Engaged: Integration with the Global Economy," *China 2020: Development Challenges in the New Century*, vol. 7 (Washington, DC: World Bank, September 1997).

4. From a sample of 257 manufacturing executives, 31 percent found China to be the country posing the greatest competitive threat to US manufacturers. David Dinell, "Manufacturers say China is Top Global Contender," *Wichita Business Journal*, July 28, 1997.

5. Paul Godwin, "Uncertainty, Insecurity, and China's Military Power," *Current History*, September 1997,.pp. 252-257; 257.

6. According to Susan Esserman, China agreed in March, 1997 to "increase progressively the availability of the right to import and export products so that at the end of three years all foreign individuals and companies and all companies in China will have the right to import and export all products throughout China. This commitment represents a major change in China's trading system since only a comparative few companies in China now have the right to import goods directly from US companies. This is an important step in providing national treatment to US exports." Susan Esserman, Testimony before US House of Representatives Committee on Ways and Means Subcommittee on Trade, November 4, 1997.

7. This zeal may well be more evident among executives in the United States than for business persons with experience in China.

Appendices

List of the National Engineering Research Centers

Agriculture
NERC for Comprehensive Agriculture at Changping/ The Chinese Academy of Agriculture Science
NERC for Vegetables/ The Vegetable Research Center of the Beijing Academy of Agriculture Science
NERC for Integrated Agriculture Experiment at Yangling/ The Coordination Committee of Wugong Agriculture Science Research Center of Shanxi Province
NERC for Chemical Industry of Forest Products/ The Research Institute of Chemical Processing and Utilization of Forest Products
NERC for Hybrid Rice/ The Hunan Academy of Agricultural Sciences

Energy
NERC for Renewable Energy/ The Beijing Solar Energy Research Institute
NERC for Coal Water Mixture/ HuaMei CWM Technology Center
NERC for Isotopes/ The China Institute of Atomic Energy

Information & Communication
NERC for Application Specific Integrated Circuit System/ Southeast University
NERC for Application Specific Integrated Circuit Design/ The Institute of Automation/ CAS
NERC for Data Communications/ The Research Institute of Data Communications of the Ministry of Posts and Telecommunications
NERC for Flat Panel Displays/ The Nanjing Electronic Devices Institute
NERC for Parallel Computer/ The Institute of Computing Technology of the CAS and the Jingnan Institute of Computing Technology
NERC for Mobile Satellite Communication/ The Panda Electronics Group Company
NERC for Digital Switching System/ The Information Technology Institute of the People's Liberation Army

Manufacture
NERC for Computer Integrated Manufacturing Systems/ Qinghua University
NERC for Solid State Laser/ The North China Research Institute of Electro-Optics
NERC for Metallurgical Industry Automation/ The Automation Research Institute of the Ministry of Metallurgical Industry
NERC for Power Automation/ The Nanjing Research Institute of the Ministry of Electric Power
NERC for Specific Pump & Valve/ The 11th Research Institute of the China Aerospace Corporation
NERC for Industrial Control Devices and System/ The No. 502 Institute of China Aero-Space Corporation
NERC of Optical Instrumentation/ Zhejian University

Materials
NERC for Liquid Separation Membrane/ The Development Center of Water Treatment Technology-SOA
NERC for Polymer Matrix Composites/ The Harbin Fiber Reinforced Plastics Research Institute
NERC for Fiber Reinforced Moulding Compounds/ The Fiber Reinforced Plastics Research & Design Institute, the State Administration of Building Material Industry
NERC for Silicone/ The Chengdu Silicone Research Center of the Ministry of Chemical Industry
NERC for Structure Plastics/ The Chenguang Chemical Industrial Research Institute - Chengdu Branch - the Ministry of Chemical Industry
NERC for Engineering Plastics/ The Beijing Municipal Chemical Industry Research Institute
NERC for Reaction Injection Moulding/ The Liming Research Institute of Chemical Industry
NERC for Magnetic Materials/ The Beijing General Research Institute of Mining & Metallurgy
NERC for Non-Ferrous Composites/ The Beijing General Research Institute for Non-Ferrous Metals

NERC for Carbon Fibers/ The Beijing University of Chemical Technology and the Jilin Chemical Industry Corporation
NERC for Catalysis/ The Dailian Institute of Chemical Physics of Chinese Academy of Sciences
NERC for CI Chemistry/ The South-West Research Institute of Chemical Industry
NERC for Special Glass Fiber & Its Processed Products/ The Nanjing Fiber Glass Research and Design Institute
NERC for Metallic Thin Film of Functional Materials/ The Shanghai Institute of Metallurgy/ CAS
NERC for Superhard Materials & Related Products/ The Zhenghou Research Institute for Abrasives & Grinding under the Ministry of Machinery Industry
NERC for Powder Metallurgy of Titanium & Rare Metals/ The Guangzhou Research Institute of Non-Ferrous Metals
NERC for Precious Metal Materials/ The Institute of Precious Metals in Kunming under the China National Non-Ferrous Metals Industries Corporation.

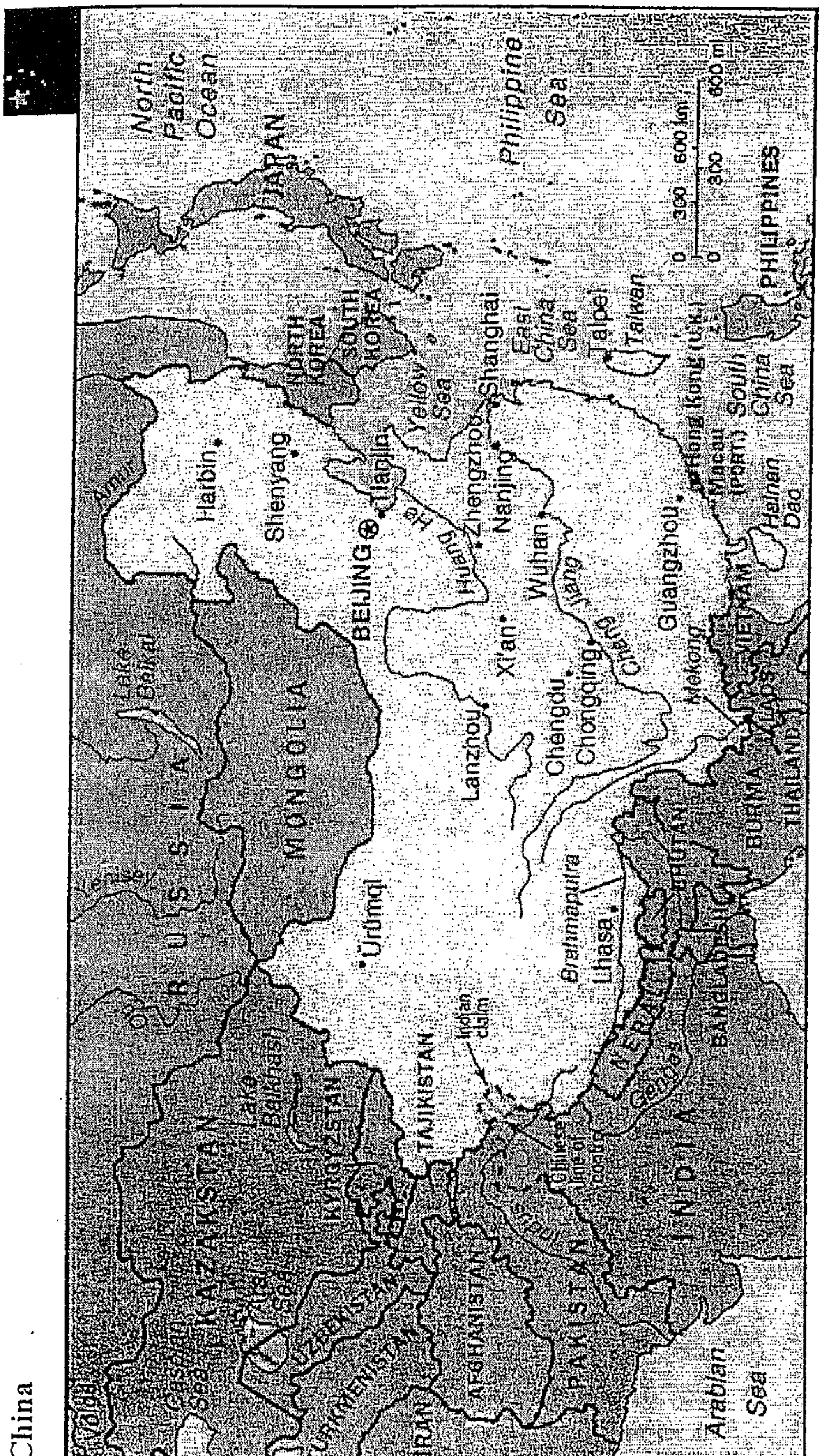
Light Industry & Textile
NERC for Garment Designing & Processing/ The National Garment R&D Center
NERC for Synthetic Fiber/ The China Textile Academy

Resources Exploitation
NERC for Multipurpose Utilization of Non-Metallic Mineral Resources/ The Zhengzhou Institute of Multipurpose Utilization of Mineral Resources under the Ministry of Geology and Mineral Resources
NERC for Further Processing of Non-Metallic Minerals/ The State Administration of Building Materials Industry Suzhou Design & Research Institute of Non-Metallic Minerals Industry
NERC for Comprehensive Utilization of Metallic Mineral Resources/ The Changsha Research Institute of Mining and Metallurgy, and the Beijing General Research Institute of Mining and Metallurgy
NERC for Geological Exploration/ The Institute of Geophysical and Geochemical Exploration, the Ministry of Geology and Mineral Resources

Construction & Environment
NERC for Urban Water & Wastewater/ The North China Municipal Engineering Design & Research Institute
NERC for Road Traffic Management/ The Traffic Management Research Institute under the Ministry of Public Security
NERC for Building/ The China Academy of Building Research
NERC for Industrial Building Diagnosis & Rehabilitation/ The Central Research Institute of Building & Construction under the Ministry of Metallurgical Industry
NERC for Human Settlements/ The China Building Technology Development Center
NERC for Urban Environmental Pollution Control/ The Beijing Municipal Research Academy of Environmental Protection
NERC for Industrial Water Treatment/ The Tianjin Research Institute of Chemical Industry under the Ministry of Chemical Industry

Medicine & Health
NERC for Health Care & Medical Devices/ The Guangdong Medical Instrument Research Institute
NERC for Medical Accelerator/ The Beijing Medical Equipment Institute
NERC for Traditional Chinese Medicine/ The Shanghai Chinese Medicine Corporation
NERC for Chinese Patent Medicine/ Benxi No. 3 Pharmaceutical Factory

China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Harbin
Shenyang
Tianjin
BEIJING
Huang He
Zhengzhou
Nanjing
Wuhan
Chang Jiang
Guangzhou
VIETNAM
Lake
Baikal
MONGOLIA
RUSSIA
Amur
Xi'an
Lanzhou
Chengdu
Chongqing
Mekong
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BURMA
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BANGLADESH
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Indus
TAJIKISTAN
KYRGYZSTAN
Lake
Balkhash
KAZAKSTAN
Aral
Sea
UZBEKISTAN
TURKMENISTAN
AFGHANISTAN
PAKISTAN
IRAN
Caspian
Sea
Arabian
Sea

Appendix C

Nation High and Technology Industry Development Zones (52 Zones)

http://www.chinatorch.com/stipark/english/content.htm

Beijing City

Tianjin City

Hebei Province

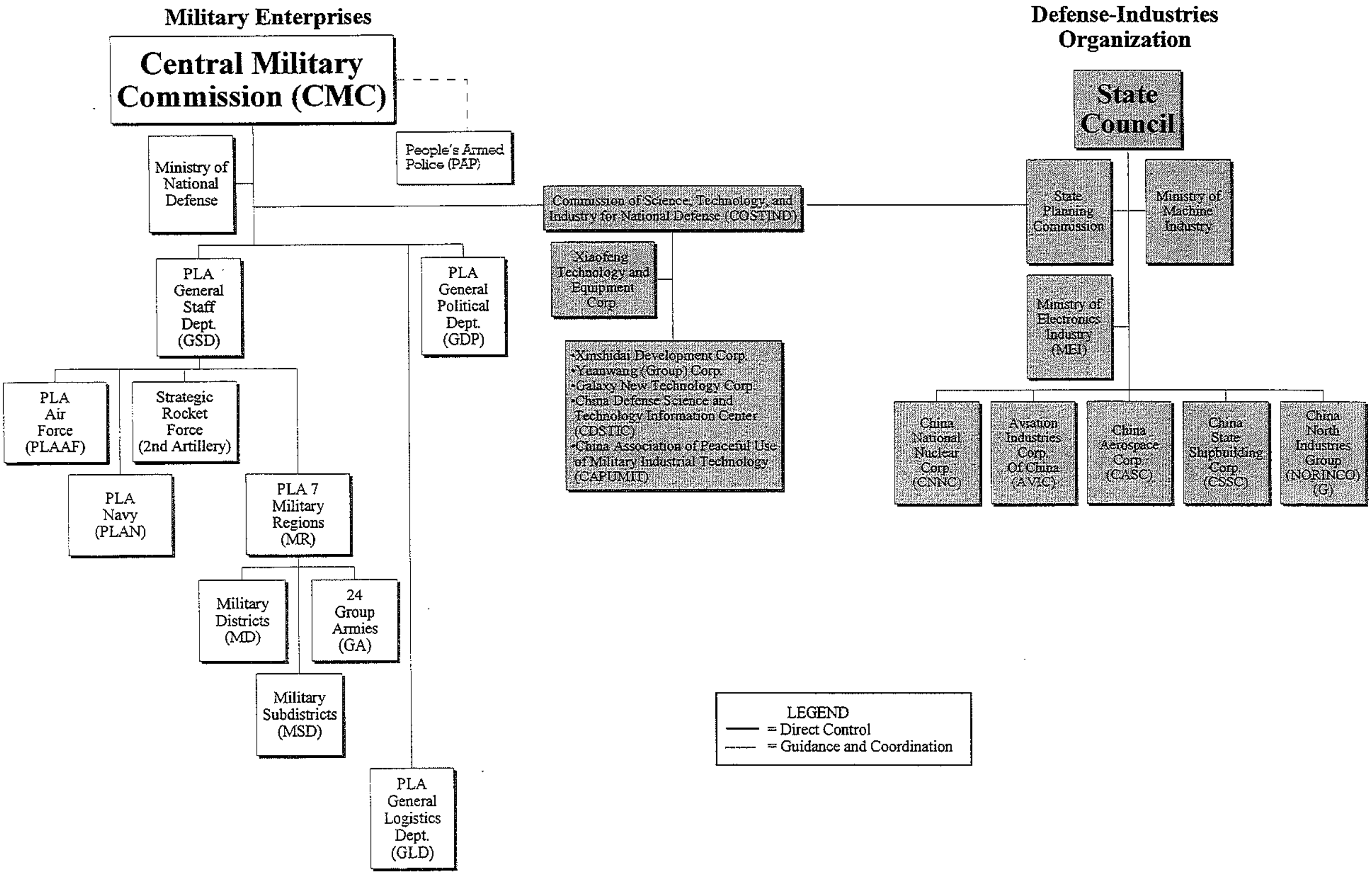
Shanxi Province

Inner Mongolia Autonomous Region

Liaoning Province

Jilin Province

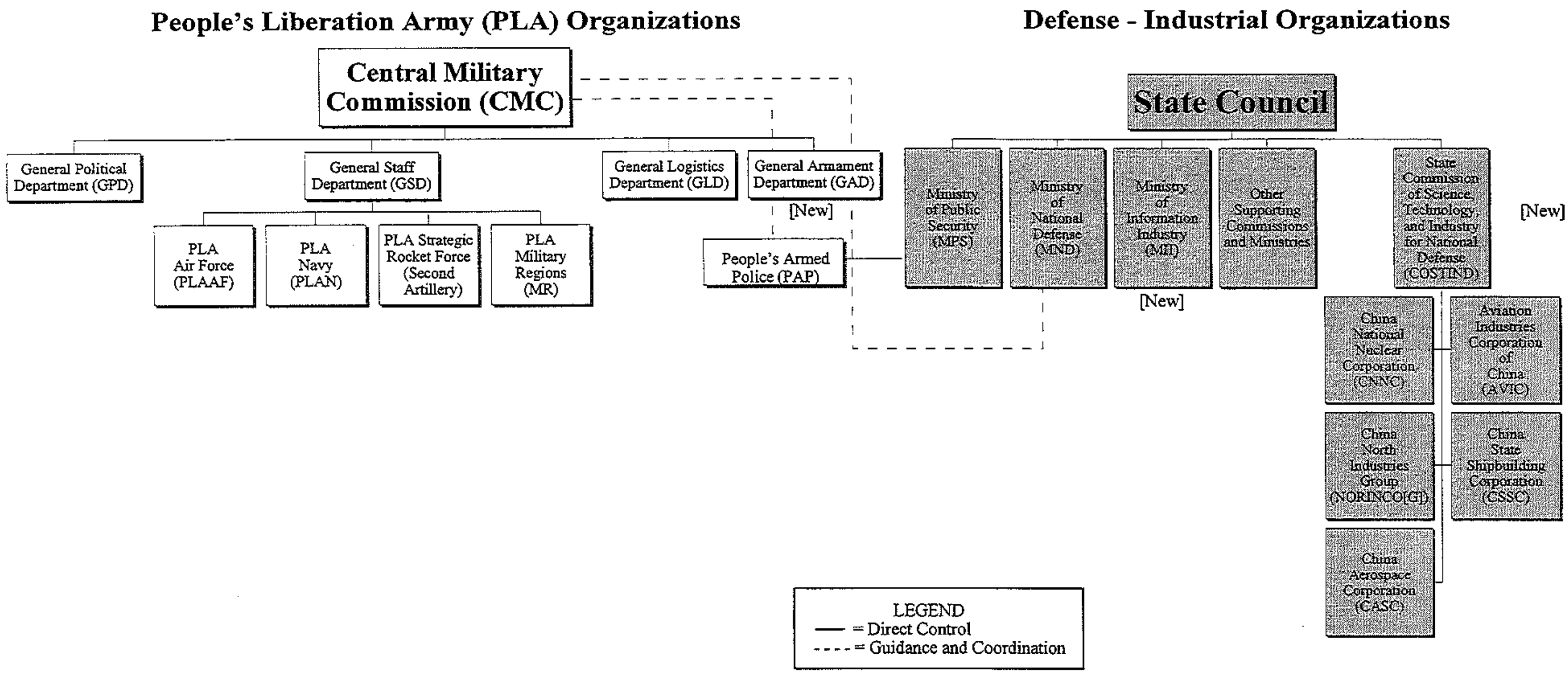
China's International Defense-Industrial Organizations
(Prior to March 1998)



Source: Adapted from Defense Intelligence Agency Reference Document PC-1921-57-95

China's International Defense-Industrial Organizations

(As of March 1998)



Source: Adapted from Defense Intelligence Agency Reference Document DI-1921-60-98

Selected Deals in the PRC Software Sector, 1996-July 1997

Foreign partner/PRC partner	Venture	Date
Apple Computer, Inc. (US)	Announced Apple Advanced Chinese Input Suite software, which allows entry of Chinese characters into a computer using speech, handwriting, and keyboard.	11/96
Apple Computer, Inc., Motorola Inc. (US)	Formed strategic alliance to manufacture computers with MacOS platform in China.	3/96
Advanced Systems Development Corp., a joint venture between IBM Corp. (US)/Qinghua University (Beijing)	Announced delivery of reusable, object-oriented software components and application packs to be marketed through the Internet.	5/96
Cheyenne Software Inc. (US)	Opened representative office in Beijing.	4/96
Computer Associates International, Inc. (CA) (US)/ Fudan University (Shanghai)	Established Fudan CA-Unicenter Technical Support Center to provide CA-Unicenter software and technical support to Fudan University.	10/96
CA/Xunye Group, Zhongzhou Railway Administration (Henan)	Signed cooperation agreement to provide CA-Unicenter railway station management programs to assist in the booking and selling of tickets.	10/96
Digital Equipment Corp. (US), Microsoft Corp. (US), Oracle Corp. (US)	Formed alliance to cooperate in China.	5/96
GeoQuest (US)	Awarded China National Offshore Oil Corp. (CNOOC) contract to supply reservoir characterization and data management software. $2.2 million.	5/96
IBM	Opened an information technology center in Shanghai.	1/96
IBM/PRC State Education Commission	Will set up IBM technical centers in 23 Chinese universities. The centers will be supplied with IBM computers and equipment including software development tools, databases, and network management software.	5/96
Informix, Inc. (US)	Announced that the Chinabyte website is using Informix database products.	3/97
Intel Corporation (US)/The China Software Industry Association (CSIA)	Announced a "new generation" of multimedia software to be manufactured by CSIA and Intel Software Architecture Development (Shanghai) Co. Ltd., which will run on PRC-made personal computers based on Intel Pentium processors.	9/96
Logic International Software Pte. Ltd. (Singapore)/ Solution Science & Technology Co.	Will launch software development joint venture, Solution Logic International Software Development Co. (Singapore: 50%-PRC:50%). $4 million.	7/97
MK Group, an independent business unit of CA	Nanjing Jincheng Machinery Co. Ltd., China's third-largest motorcycle manufacturer, chose MK Group's business software system, MK Manufacturing.	2/97
Microsoft/User Friend Software Co., Ltd.	Established joint venture to develop a new generation of financial and managerial software.	4/96
Microsoft	Signed agreement with China Investment Bank for an advanced computer system based on Microsoft software.	12/96
Microsoft/Legend Group Co.	Reached agreement to pre-install Windows 95 on Legend PCs sold in China.	3/97
Microtec Research Inc. (US)	Signed cooperation contract on establishing the Center of Embedded Software Designing.	12/96
Motorola/Legend Group	Established joint venture to cooperate in software development. $1 million.	6/96
Motorola (Lexicus division)	Released "WisdomPen" handwritten Chinese character recognition software in China.	2/97
NEC Corp. (Japan)	Will train software engineers in China to help adapt NEC's software to accommodate the year 2000 date change.	2/97
Nova Software Development Corp. (Japan)/Beijing Dakai Electronics Technology Co.	Will establish joint venture to produce bilingual computer dictionaries. (Japan:75%-PRC:25%). $200,000.	12/96
Oracle	Will sell software to Rayes Technology Group in Shenzhen to build computer information network China Online. $3.5 million.	3/96
Parametric Technology Corp. (US)	Donated Pro/Engineer software to China's top scientific research institutes and colleges to help develop China's software sector. $10 million.	6/96
RSA Data Security, Inc. (US)	Agreed to appoint the computer center of MOFTEC and the Chinese Academy of Sciences Graduate School's Laboratory of Information Security RSA's exclusive representatives in China.	4/96
SAP AG (Germany), Siemens Nixdorf (Germany)	Will sponsor joint foundation to support business, economic, and information technology research at Qinghua University in Beijing and Jiaotong University in Shanghai.	10/96
Sybase, Inc. (US)/PRC State Information Center	Established Yoxinjia Information System Co., Ltd. joint venture to produce various kinds of application software. (US:49%-PRC:51%).	10/96
Symantec Corp. (US)	Will release Chinese language version of Norton AntiVirus 2.0 for Windows NT.	5/97
System Software Associates, Inc. (US)	Moved its Asia-Pacific headquarters from Hong Kong to Beijing.	1/96
Unify Corp. (US)/PRC General Association of Light Industry	Signed a licensing and distribution agreement that includes a compensation provision for pirated copies of Unify software.	9/96
Verity Inc. (US)/Sino-Software Systems Co.	Will cooperate to bring Verity's Search 97 information search and retrieval product suite of applications to the Chinese market.	3/97

SOURCE: US-China Business Council files
NOTE: These listings are culled from recent press reports of business contracts and negotiations, and are not meant to be comprehensive. For the mo[st] part, the accuracy of these reports has not been independently verified by *The CBR*.

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