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

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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.

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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.**

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.

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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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.

C 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.

C 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

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.

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.

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 1993 1994 1995	$39m $62m (93.5% in industrial $36m process technology) $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 2000 goal 2010 goal	5.9% 15% 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 plans seem also to include a return to China after a period of years working in the United States, primarily in high-tech firms.

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.

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)

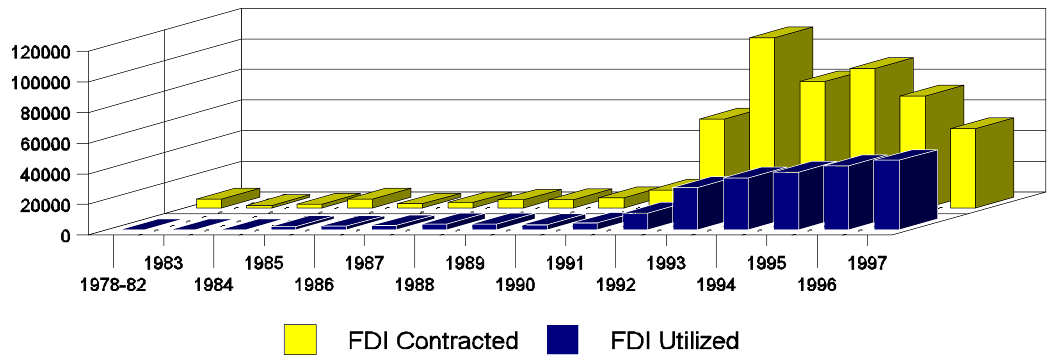
With the opening of China's economy in the late 1970s came new sources of foreign investment and technology transfers, including the United States, Japan, and Eastern and Western Europe, followed by "Greater China" (including Hong Kong and Taiwan), and Southeast Asian states. This new infusion of capital 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:

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

- *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)

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*

	"Encouraged"	"Restricted"	"Prohibited"	"Permitted"
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 aircra	**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*

	"Encouraged"	"Restricted"	"Prohibited"	"Permitted"
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).

"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

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;

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

- **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]

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*
	Septembe r	"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*
	Septembe r	"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.