Chapter 4

The Role of the United States in Technology Transfer to China

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The Role of the United States in Technology Transfer to China

Although the U.S. Government sets regulations and establishes programs that directly affect technology transfer to China, the actual transfer of technological information and capabilities is generally performed by U.S. companies through direct investment, joint ventures, coproduction agreements, or license agreements. Corporate reasoning by U.S. firms for transferring technology to China includes "getting a foot in the door" of the potentially immense China market, having access to inexpensive labor, and having a presence in the Asian Pacific region for manufacturing, marketing, and distribution.

China's interests in U.S. investment are primarily to improve its technology base and to earn foreign exchange. Foreign exchange derives from various charges to the U.S. firms (taxes, payments for services, labor rates) or through exports of goods created through improved technology. These often divergent interests of the U.S. firms and the Chinese can be the basis for mutually beneficial relationships —or a great deal of friction. The case studies in this chapter illustrate how well the U. S.-China relationship works in actual practice.

FACTORS AFFECTING U.S. COMPANIES IN THE CHINA MARKET

When the Chinese market opened to Western business in the late 1970s, foreign companies were elated. China was a country needing almost everything. It had a huge supply of potential customers and inexpensive workers, and was ruled by an apparently honest and dedicated new (albeit Communist) leadership. The economies of the United States and China were also often viewed as complementary. It was hoped that American high-technology products, capital goods, and industrial materials would help China's development, while the United States would be a growing market for Chinese goods.

In fact, in 1985 the United States accounted for about 10 percent of China's imports and 12 percent of China's exports. [1] The United States ranked as China's third-largest trading partner after Japan and Hong Kong,[2] while China moved up three places to 16th among U.S. trading partners. Table 2 lists Department of Commerce statistics on the composition of U.S. exports to China from 1980 to 1986. Machinery and transport equipment was a major U.S. strength, accounting for almost $2 billion in sales to China in 1985 and over $1 billion in the first half of 1986.

Table 3 lists statistics for U.S. imports from China for 1980-86. Most U.S. imports in this table are in the category of "miscellaneous manufactured articles" (which includes articles of apparel and clothing accessories), representing almost $1.2 billion of trade in just the first half of 1986. Basic manufactures (mostly textiles, yarn, and fabrics) and crude materials (mostly petroleum and petroleum products) also represent significant imports by the United States.

China's Seventh Five-Year Plan (1986-90) envisions a 40-percent increase in the total volume of China's imports and exports by 1990, with the Chinese projecting imports growing

[1] Nai-Ruenn Chen, "U.S.-China Trade Patterns: The Outlook for Two Countries With a Lot to Share," *The China Business Review*, September-October 1986, pp. 16-20.

[2] Japan had a 28.3 percent market share of China's imports in 1986, Hong Kong 12.7 percent, and the United States 10.2 percent (U.S. Department of Commerce, February 1987).

Table 2.—Commodity Composition of U.S. Exports to China, 1980-86 (million dollars)

	1980	1981	1982	1983	1984	1985	Jan.-June 1986
Foodstuffs	1,265	1,334	1,239	541	580	104-	16
Cereal and cereal preparations	1,264	1,332	1,236	536	578	97	6
Crude materials	1,258	1,128	597	298	467	570	224
Hides, skins, and furskins, raw	13	7	11	4	22	30	12
Oil-seeds and oleaginous fruit	156	130	63	0	[a]	13	19
Crude rubber (including synthetic and reclaimed)	5	5	3	5	9	9	9
Cork and wood	41	99	217	234	287	328	123
Pulp and wastepaper	67	69	18	21	18	19	10
Textile fibers and their waste	895	791	273	31	99	122	25
Metal liferous ores and metal scrap	5	[a]	[a]	[a]	21	43	16
Animal oils and fats	16	2	6	0	0	0	[a]
Fixed vegetable oils and fats	58	20	0	0	7	[a]	0
Chemical s	381	406	496	353	644	**514**	197
Organic chemicals	40	44	38	25	71	**87**	39
Inorganic chemicals	22	6	9	20	20	**12**	16
Fertilizers, manufactured	153	131	147	168	267	**152**	18
Artificial resins and plastic materials	120	170	237	92	234	**228**	109
Chemical materials and products	46	53	61	46	46	**23**	9
Basic manufactures	428	447	275	220	189	**370**	91
Leather, leather manufactures, n.e.s, and dressed furskins	49	64	65	26	39	**63**	13
Paper, paperboard, and articles	130	61	36	41	32	**27**	11
Textile, yarn, fabrics, made-up articles, and related products	134	284	128	17	46	**141**	42
Iron and steel	42	8	10	7	4	**12**	7
Nonferrous metals	24	10	23	94	34	**54**	3
Manufactures of metals, n.e.s,	42	20	7	31	29	**67**	10
Machinery and transport equipment	358	212	217	587	910	**1,958**	1,070
Power generating machinery and equipment	14	11	8	56	29	**88**	54
Machinery specialized for particular industries	63	67	71	89	196	**482**	201
Metal-working machinery	7	4	3	25	23	**55**	60
General industrial machinery and equipment, n.e.s. and machine parts n.e.s.	35	34	34	47	61	**153**	83
Office machines and automatic data processing equipment	31	22	36	51	102	**190**	98
Telecommunications and sound recording and reproducing apparatus and equipment,	8	16	12	18	26	**44**	32
Electrical machinery, aparatus and appliances, n.e,s. and electrical parts, thereof.	18	21	25	43	53	101	67
Road vehicles	18	7	9	22	63	99	65
Other transport equipment	164	29	19	236	356	745	409
Miscellaneous manufactured articles	56	71	78	166	202	319	166
Professiona~ scientific, and controlling instruments and apparatus, n.e.s.	46	55	65	145	182	282	129
Photographic apparatus, equipment and supplies, and optical goods, n.e.s., watches and clocks.	2	5	4	5	4	8	5
Miscellaneous manufactured articles, n.e.s,	6	8	8	16	12	27	28
Total	**3,746**	3,598	2,902	2,165	2,992	3,835	1,764

[a]Less than $500,000
n e s —not elsewhere specIfied

SOURCE US Department of Commerce statwtlcs, SITC classIfIcatIons

Table 3.—Commodity Composition of U.S. Imports From China, 1980-86 (million dollars)

	1980	1981	1982	1983	1984	1985	Jan. -J-une 1986
Foodstuffs	65	108	135	129	162	182	109
Fish, crustaceans and mollusks, and preparations, thereof	7	25	19	12	21	32	35
Cereal and cereal preparations	3	4	4	5	5	6	3
Vegetables and fruit	25	44	59	58	77	75	33
Sugar, sugar preparations, and honey	8	9	8	9	6	8	8
Coffee, tea, cocoa, spices, and manufactures, thereof	15	19	37	34	40	47	23
Beverages	2	2	3	5	5	4	5
Crude material s.....	300	657	774	589	794	1,204	524
Crude fertilizers and crude minerals	41	53	60	47	57	53	17
Metal liferous ores and metal scrap	37	52	25	11	17	32	17
Crude animal andvegetable material s,n.e.s.	56	49	42	35	39	41	
Petroleum, petroleum products, and related materials	149	321	615	468	656	1,052	457
Chemical s	107	134	143	145	171	177	100
Organic chemicals	16	26	26	34	45	36	23
Inorganic chemical s	33	39	38	17	33	41	17
Medic ine and pharmaceutical products	10	**20**	20	26	23	28	13
Essential oil and perfume materials, toilet, polish ing, and cleaning preparations	14	**11**	14	16	16	15	8
Explosives and pyrotechnical products	26	**28**	36	33	35	42	30
Chemical materials and products, n.e.s.	8	**9**	8	13	10	10	5
Basic manufactures	246	**394**	407	425	607	665	357
Leather, leather manufactures, n.e.s., and dressed furskins	1	**3**	2	3	6	3	2
Cork andwood manufactures (excluding furniture)	5	**6**	6	8	8	10	4
Paper, paperboard, and articles of paper pulp, of paper or of paperboard	2	**3**	3	3	4	11	3
Textile, yarn, fabrics, made-up articles, and related products	149	**252**	239	255	392	399	251
Nonmetal lic mineral manufactures, n.e. s.	19	**33**	40	50	65	59	31
Iron and steel,	[a]	**6**	7	3	3	3	5
Nonferrous metals	44	**44**	45	31	35	80	18
Manufactures of metals, n.e.s.	26	**46**	63	73	91	97	42
Machinery and transport equipment	6	**44**	48	46	71	97	52
Machinery specialized for particular industries	[a]	[a]	5	6	7	7	3
Metal -working machinery	1	4	5	5	4	3	2
General industrial machinery and equipment, n,e.s. andmachine parts n.e. s..	2	**30**	20	14	16	14	7
Telecommunications and sound recording and reproducing apparatus and equipment	[a]	**4**	6	10	29	36	16
Electrical machinery, apparatus and appliances, n.e. s. and electrical parts, thereof.	2	**3**	5	3	8	20	15
Miscellaneous manufactured articles	417	**650**	916	1,133	1,552	1,855	1,197
Furniture and parts thereof	10	**19**	29	34	38	44	23
Travel goods, handbags, and similar containers	3	**16**	30	45	101	154	90
Articles of apparel and clothing accessories	278	**434**	657	840	999	1,050	768
Footwear. .,	21	**37**	42	38	48	61	41
Miscellaneous manufactured articles, n.e.s..	103	**140**	154	169	355	532	267
Total	1,141	**1.987**	2,423	2,467	3,357	4,180	2,339

[a]Less than $500,000
n e s — not elsewhere spec!f!ed

SOURCE U S Department of Commerce statistics SITC class lflcat{ons

at an average annual rate of 6.1 percent and exports at 8.1 percent annually. Recent figures indicate that U.S.-China trade reached $8.3 billion in 1986, a 33-percent increase over 1985 levels.[3] The growth in this bilateral trade was import driven, however, with U.S. imports from China setting a record at $5.2 billion, a 24-percent increase over 1985. U.S. exports totalled $3.1 billion for 1986, a 19-percent drop from 1985 levels, the first decrease since 1983. The U.S. trade deficit with China reached an historic high of $2.1 billion in 1986, primarily due to China's hard currency shortage and the boom in U.S. imports in the light industrial sector and in clothing, textiles, yarns, and fabrics.[4]

Future trade between the United States and China should come into closer balance. The potential is there since the United States holds a strong competitive position in the energy, telecommunications, electronics, and transportation sectors—all priority areas in the Chinese Seventh Five-Year Plan. For example, despite the drop in total exports from the United States to China in 1986 compared with the previous year, some big gainers for the LTnited States were exports of high technology, such as computers and telecommunications equipment, as well as metalworking equipment (which more than doubled the previous year's level), heating and cooling equipment, and railway vehicles and equipments

The U.S. sales to China described above have been significant and probably will continue to be. China is more interested in investments than direct sales because they promote technology transfer. However, after rushing in with many business proposals when China initiated its open door policy, few U.S. businesses have seen their overtures come to profitable fruition. Many U.S. firms feel that the bloom is off the rose. Indeed China's investment climate, many foreign businessmen say, has steadily deteriorated at least until recently. They complain of soaring costs, arbitrary tax and tariff levies, inadequate labor, and numerous other annoy ances.[6] As U.S. Ambassador to China Winston Lord said in a May 28,1986, speech, "Many business people are frustrated by high costs, price gouging, tight foreign-exchange controls, limited access to the Chinese market, bureaucratic foot-dragging, lack of qualified local personnel, and unpredictability. " Some U.S. companies are making money in China, but they are reluctant to talk about it for competitive reasons. This is partly due to not wanting to let their competition know of a good opportunity, and partly because they fear the Chinese would feel justified in raising their taxes and other local costs.

The Investment Environment

Foreign investment in China from January 1986 to August 1986 fell by 20 percent (to contracts worth $1.24 billion) compared with the same period in 1985, confirming perceptions that the investment climate had been deteriorating. Less than one-third of the 2,600 joint venture companies listed so far have actually gone into business. Of the remainder, many have been scaled down or dropped completely owing to high costs, unfavorable returns, and management problems.[7]

A fundamental problem with joint venture arrangements, according to foreign businessmen, is that the foreign partner usually contributes foreign exchange and technology, while the Chinese contribute property, equipment, and services (such as electricity and water) on which they place an unrealistically high value. The Chinese have recently stated that they will try to remedy this situation. A correlative problem is that the Chinese tend to undervalue the technology contributed by the foreign investor.[8] Trying to find a solution to this basic problem is critical and is much more difficult

[3] Us Department of Commerce data, February 1987.
[4] Japan had a $4.9 billion trade surplus with China and Hong Kong a $3.6 billion surplus in 1986.
[5] U.S. Department of Commerce, February 1987.
[6] James P. Sterba, "Great Wall-Firms Doing Business in China Are Stymied by Costs and Hassles–They Complain of Red Tape, Poor Access to Markets, Even a Shortage of Labor, " *The Wall Street Journal,* July 17, 1986, p. 1.
[7] "Joint-Venture Bliss Ends in China, *The Economist* of London appearing in *The Washington Times,* Aug. 20, 1986, p. 3D.
[8] See, for example, Cao Yan, "Analysis on 'Free' Technology Imports,<' *JISHU SHICHANG BAO* (Tianjin), Oct. 7, 1986, p. 3.

than solving the problem of overvalued Chinese properties or services.

In an effort to improve the investment climate, the Chinese Government adopted "The Law of the People's Republic of China on Enterprises Operated Exclusively with Foreign Capital "in 1986. This law stipulates that companies that bring in advanced technology or export the bulk of their production, can establish wholly foreign-owned enterprises in China.[8] These enterprises may also apply for preferential tax treatment. Once approved by the Government, these ventures will also be protected under Chinese law from nationalization and expropriation, except under "extraordinary circumstances; and if such action is necessary, "legal procedures will be followed and reasonable compensation will be made.

It is expected that foreign exchange receipts will balance any foreign exchange payments. Income tax refunds will be granted when aftertax profits are reinvested in China, but legitimate profits may be remitted abroad. II The definition of what constitutes a legitimate profit is, however, still not clear.

It was recently announced that the Bank of China is going to relax its tight credit policies to give loan priority to enterprises that involve foreign investment. The bank will, in particular, extend help to technology-intensive companies and manufacturers of products for export. Wong Deyan, the bank's president, said that the central bank will amend regulations on the issue of credit for enterprises with foreign funds in a bid to create better conditions for their development.[z]

Foreign businessmen reacted cautiously to these statements of relaxed policies, however, since they do not work toward resolving day-to-day management problems of wages, hiring, training, and others that are also serious. The joint ventures are struggling toward different solutions to these fundamental problems.[13]

The latest attempt by the Chinese to improve the investment climate came in the 22 articles listed under "Provisions of the State Council of the People's Republic of China for the Encouragement of Foreign Investment, ' listed in Appendix A. The intent is "to improve the investment environment, facilitate the absorption of foreign investment, introduce advanced technology, improve product quality, expand exports in order to generate foreign exchange and develop the national economy. The articles spell out various conditions and fees applied to foreign ventures to reduce the uncertainty involved. These new regulations benefit mostly export-oriented and high-technology firms but fall short of meeting some basic investor concerns. Foreign executives were cautious at first, taking a "wait and see" attitude toward the new regulations,[15] but recently, renewed interest in certain joint ventures has been evident.[G]

Schedule Delays, Taxes, Other Costs

Foreign firms in China have complained that the Chinese do not seem to understand that time is money. An example is the McDonnell Douglas venture (covered later in this chapter), which took 10 years to finalize. Eventually McDonnell Douglas won a contract for 30 MD-82s, with a price averaging out to about $25 million per plane. Five have been delivered and are in operation. Twenty-five more will be built in Shanghai.

McDonnell Douglas persevered because it hopes to be involved in the development of a 100-passenger propfan aircraft to be built in

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[8] "Foreign Investor Ruling, " *China Business and Trade,* Apr. 23, 1986, p. 3. The regulations themselves appeared in *China Daily*, Apr. 15, 1986. It should be noted, however, that just because an enterprise is wholly foreign-owned does not mean that it will be free of the problems described previously.

[z] ""Foreign Investor Ruling, " op. cit.

[13] Ibid.

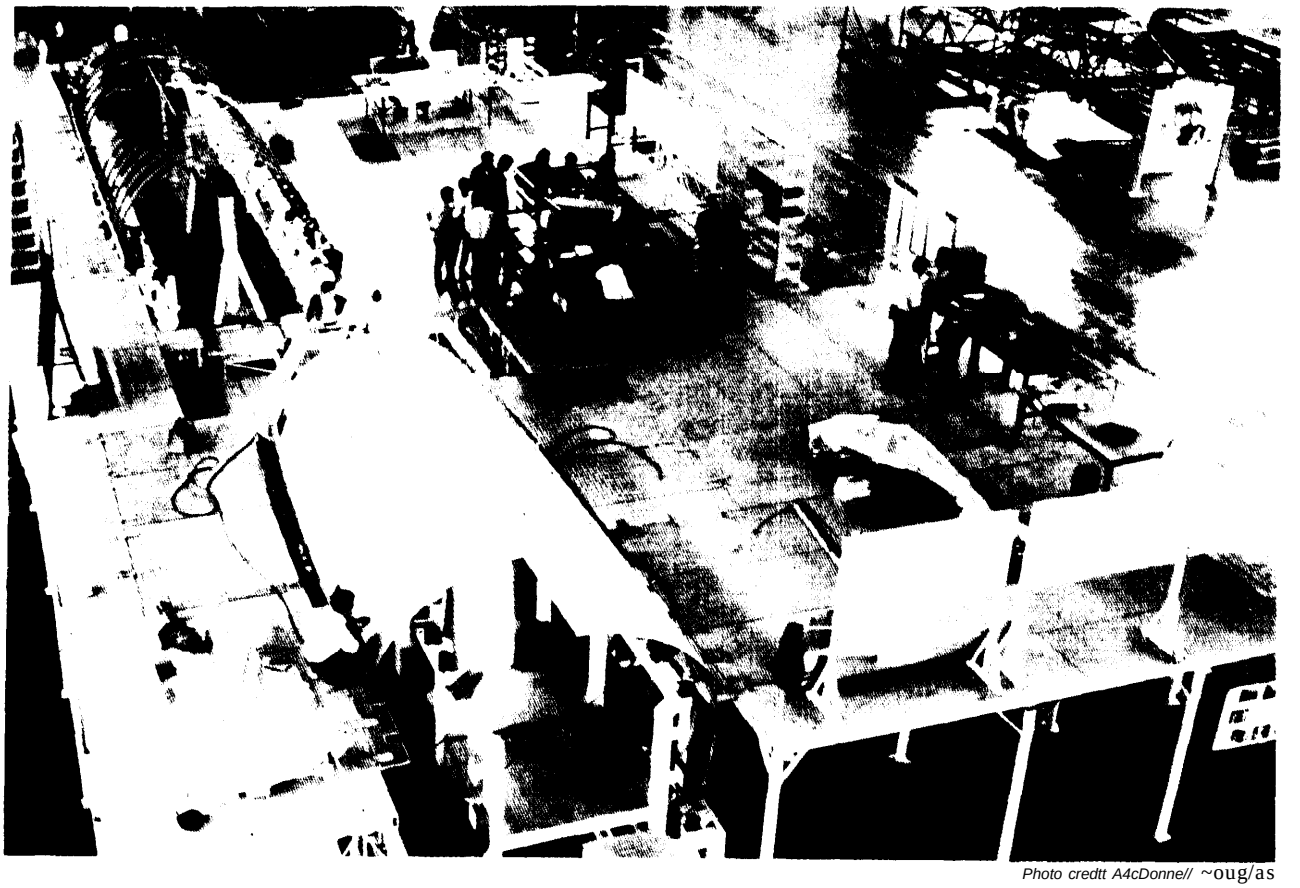
[15] 'China to Ease Credit for Joint Ventures, *Financial Times,* Aug. 8, *1986, p. 4.*

[G] "Joint-Venture Bliss Ends in China, " op. cit.

"U.S. Department of Commerce, February 1987.

[15] James R. Schiffman, "Foreign Executives Wary of China's Pledge to Investors, " *The Wall Street Journal,* Aug. 11, 1986.

"Roger W. Sullivan, "The Investment Climate, " *The China Business Review,* January-February 1987, pp. 8-10. See also Barry Kramer, "Beijing's Course: The Chinese Economy Appears to be Firmly on the Reform Path—But the Pace of Change Slows After Resignation of Hu; Political Reforms on Hold, " *The Wall Street Journal,* May 14, 1987, p. 1.



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Portions of a McDonnell Douglas MD-82 fuselage are shown being assembled at Shanghai Aviation Industrial Corp. facilities. Part of the coproduction contract involves extension of Douglas' Federal Aviation Administration production certificate to the Shanghai facility.

China.[17] The potential market is 500 to 1000 planes over a period of more than 10 years. Thus the McDonnell Douglas effort *is* measured in a few decades, not a few years. McDonnell Douglas hopes that its patience and long-term view in the China market will be rewarded.

As another example, U.S. companies competing for China's proposed purchase of satellites spent large sums of money and devoted much company time to pursue what promised to be both a very substantial sale and a chance to establish a firm lodging in a promising market.[18] When the two proposed purchases were "postponed," these companies were disenchanted with the Chinese market and might refrain from bidding if the opportunity arises again.

The satellite postponement story is not atypical. European nuclear companies had once estimated the nuclear technology market in

[17] First ChineseAssembled MD-82 Nears Completion in SAIC [Shanghai Aviation Industrial Corp.] Facilities," *Aviation Week and Space Technology*, June 1, 1987, pp. 34-35.

[18] Hughes was estimated to have spent $500,000 on the 1979-80 projected sale alone. GE expenditures were estimated at $300,000. See Karen Berney, *CBR*, March-April, 1981. RCA-Astroelectronics (now called GE Aerospace-Astrospace Division) reportedly spent over $1 million in courting the Chinese satellite contracts.

[19] These types of problems occur in countries other than China too, of course. For example, Argentina has been negotiating for *several years* for the purchase of satellites from a U.S. firm. Bureaucratic infighting and the country's financial problems have kept Argentine officials from making a decision.

China to be worth up to $20 billion.'" 2 However, in the past months, the Chinese Government has scaled down ambitious plans for 10 nuclear power stations by the end of the century. The only firm plan for an imported plant is the 1,800-megawatt Daya Bay plant near Hong Kong, for which Framatome of France, Electricite de France, and General Electric Co. of Britain have contracts to supply equipment and assistance totaling $1.7 billion. All other plans have been postponed indefinitely, to the frustration of Framatome and Kraftwerk Union of West Germany, which had spent several years negotiating with the Chinese."

By its nature, international business is risky, and overall, China is probably no riskier than other countries.[23] However, businessmen expect a profit commensurate with the risk, and many companies have found little or no profit in their China business. Especially in very competitive areas, such as nuclear power, China has been able to play companies and countries off against one another to get very low-cost contracts. China maintains that companies should accept a low profit margin in recognition of the potential size of the Chinese market. Some companies such as General Electric (GE) accept this approach, hoping to gain a foothold and do well over the long haul. It is not yet clear how many companies will benefit from this strategy, but many U.S. companies are likely to lack the patience even to try. As has often been noted, American companies tend to focus on opportunities offering quick profits, in contrast to Japanese companies, which are prepared to wait.

Since adopting the open door policy, China has drawn up a multitude of preferential tax laws to woo foreign investors.[24] These include the "Corporate Income Tax Law for Chinese-Foreign Joint Ventures" of 1980, and the 1981 "Income Tax Law for Foreign Enterprises." As for investments in Special Economic Zones (SEZS), the "Special Economic Zones Regulations for Guangdong Province' of 1980 stipulates a preferential income tax rate.

All of these tax laws provide tax reduction or exemption for projects that require a large amount of capital, involve sophisticated technology, or are located in remote areas. Moreover, companies that invest in opened, coastal cities or opened points in several deltas are offered preferential treatment to various degrees. Furthermore, to speed up port development, China has announced that projects in port development will be exempt from taxes for 1 to 5 years, and will enjoy a 50-percent reduction in taxes from the 6th through the IOth year. Imported construction materials and equipment are exempt from customs and the industrial and commercial unified tax. All of these SEZS, the 14 open cities, and the economic development areas like Liaodong Peninsula have an array of special incentives for foreign investment and for the importation of technology for the establishment of new enterprises and the rehabilitation of existing plants.

Despite these tax breaks and tax exemptions, however, foreign businessmen feel that they are being taken advantage of. For many foreign businessmen who have been involved in trade with China over the past few years, doing business in China has not gone as well or been as profitable as they had hoped. One reason for this, they say, is that the tax burden of an investor is not limited to the income taxes listed above. The total burden also includes corporate income tax, local income tax, commerce and industry tax, residence tax, personal income tax,[25] and tax on bonuses paid to Chinese workers.

Apart from taxes, people who do business in China must also pay several types of charges and fines, including local or unit levies, which businessmen say are often capricious.

*"Robert Thompson, "Chinese Studying Nuclear Technology," *Toronto Globe and Mail*, May 7, 1986, p. B-23.

[21] U.S. Congress, Office of Technology Assessment, *Energy Technology Transfer to China, A Technical Memorandum* (OTA-TM-I SC-30, Washington, DC: U.S. Government Printing Office, September 1985).

"Thompson, op. cit.

"See for example, Jackson Diehl, "East Bloc Ventures Face Uncertainties: Currency, Market Issues Plague Joint Efforts with Western Firms, ' *The Washington Post,* Mar. 1, 1987, p. H3.

[24]"'Why Foreign Businessmen Feel They Are Being Milked," JPRS, Feb. 20, 1986, pp. 48-51, article by Yuan Liu, "The Hidden Burdens of Doing Business in China," *Chiu Shih Nien Tai* [The Nineties] in Chinese, No. 12, Dec. 1, 1985, Hong Kong, pp. 64-65.

"Personal income tax is payable by an individual who has been in China for more than 90 days. The incidence of tax is affected by the U.S.-Chinese treaty on double taxation.

A joint venture or a foreign enterprise is responsible for all its workers' wages, allowances, and the social security the state provides the workers when they become sick, grow old, or die. One joint venture for a major hotel in Guangzhou paid wages, bonuses, diligence awards, allowances for dependents, social security, state subsidies, medical expenses, retirement, accident compensation, and food.[26] Besides these wages and allowances, regulations also provide for legal holidays, official holidays, annual leave, sick leave, leave for visiting relatives, maternity leave, and wedding leave. Thus, to run an enterprise in China, the foreign investor has to pay several times the nominal wage rate in addition to numerous taxes and fees. The high rates and many charges for joint ventures are meant to maximize short-run foreign exchange earnings.

Intellectual Property

Almost as soon as China opened its doors to Western technology, U.S. companies became concerned about the lack of legal protection for much of their proprietary technology. In certain cases it was reported that advanced technology would not be transferred to China until there was some form of patent and licensing protection. The Chinese Government, on the other hand, did not want to be stymied by what it considered unfair restrictions on indigenous technology development. Realizing the importance placed by foreign companies on legal protection, Chinese Government officials, after several years of internal discussion, formulated the first Chinese Patent Law, which went into effect on April 1, 1985.[27] Departments are now formulating detailed rules and training patent agents. The special features of the new patent law, according to the Chinese, are that "it absorbs the spirit of patent policies in other countries and allows for China's actual conditions and international practice. Its aim is to encourage and popularize inventions and speed up scientific and technological development and the modernization drive. "[28]

The Trademark Office of the State Administration of Industry and Commerce is responsible for the registration and control of trademarks throughout China. For certain classes of goods, the Trademark Office may prescribe that they should bear a trademark. In this case, no goods within that classification may be sold unless they carry a registered trademark. At present, this applies for all pharmaceutical goods.

The value of the patent and trademark measures in protecting foreign companies has not yet been tested in the courts. Several commentators have expressed skepticism on their protection value.[29] For example, China's patent law fails to provide protection for pharmaceuticals, chemical formulas, or trade secrets. There is no copyright regime to protect published works, computer software, or semiconductor designs. It would also be very difficult for a company to find out if its patent were being violated because of the lack of access to most of the Chinese market.

Local Sourcing, Employment, Export Marketing

Manufacturing facilities must generally obtain many parts, supplies, and services locally to operate efficiently, but in China the quantity and quality of local content is a major problem. This is especially evident in the Beijing Jeep joint venture of American Motors Corp. (AMC), discussed below. The Chinese have ambitious goals for developing a supplier base for the jeep. Domestic content in the jeeps is currently in the range of 10 to 15 percent, but about 75 percent is needed for profitable exports.[30] The Chinese went into this venture

[26] "Why Foreign Businessmen Feel They Are Being Milked," op. cit.

[27] For a detailed discussion on intellectual property issues in China see Tek Ling Chwang and Richard L. Thurston, "Technology Takes Command: The Policy of The People's Republic of China with Respect to Technology Transfer and Protection of Intellectual Property." *The International Lawyer, vol. 21, No.* 1, Winter 1987, pp. 129-167.

[28] *The China Daily,* "Legal Advisor: Your Patent Queries Answered," Feb. 4, 1986, p. 4.

[29] Nigel Campbell, *China Strategies—The Inside Story,* University of Manchester/University of Hong Kong, 1986, p. 115.

[30] Richard Johnson, "AMC, Chinese Move to Save the Beijing Jeep," *Automotive News,* June 2, 1986, p, 6.

Photo *cred{f General E/ectr)c*

Contract negotiations can be cumbersome. The lone GE representative faces whole teams of Chinese in talks leading to the first contract for locomotives.

wanting technology as well as the potential for exports, and thus would like to achieve domestic content of 80 to 90 percent in 5 to 7 years. AMC, however, says this goal cannot be achieved without strong backing from the Chinese Government.

One aspect of dealing in China that is difficult for foreign investors to fathom is that labor shortages can exist in a country with over one billion people. Yet, Chinese bureaucracy has created labor shortages. Foreign companies cannot simply advertise for a needed worker, such as a secretary or an engineer. Instead, they must go through the Foreign Enterprises Service Corp. (FE SCO), which monopolizes Chinese workers and assigns them to foreign companies.[31] The workers are politically screened and trained to keep a watch on the foreign business.[32] Since FESCO cannot meet the demand for workers, the waiting lists are long, and the foreign firms must make do with whoever is finally assigned to them. FESCO can also pull away workers at any time.

In keeping with China's desire to make as much foreign exchange as it can from labor charges, wages set by FESCO are higher than those in most Asian economies. The worker does not draw this wage–as much as 85 percent of it, as well as most of any incentive bonuses, goes back to FESCO. The U.S. Embassy cites an extreme case in which a French oil company reportedly paid $9,000 a month for a highly trained technician. The technician's monthly take-home pay, however, was $51.[33]

Foreign firms may be allowed to bring in expatriate staff, but that is also expensive. Beijing is already among the costliest places in the world in which to maintain expatriate staff: $150,000 to $ZOO,OOO per year.[34] This does not include office rent, which ranges from $50,000 a year at the not very luxurious Beijing Hotel to $125,000 at the Great Wall Hotel.[35]

Lack of labor mobility can also cause difficulties. Getting specialized staff can be a problem because other companies are reluctant to lose their best workers and often prevent their

[31] Sterba, op. cit.

[32] Employees for joint ventures are often recruited through local labor bureaus which are not the same as FESCO, which is a Beijing entity. Thus, they may not be quite so indoctrinated.

[33] James P. Sterba, "Great Wall-Firms Doing Business in China . . . " This assertion about the technician pay has been disputed by a Chinese official in a letter to the *Wall Street Journal.*

[34] Andrew Ness, ''Price Hikes and the Foreign Business Community," *The China Business Review,* March-April 1986, p. 52.

[35] Rents for office space in Beijing's four joint venture hotels now average $11.80 per square foot per month according to a March 1986 report by the U.S. Embassy in Beijing. This makes space in Beijing much more costly than the equivalent space in Hong Kong Central.

leaving. Official reports show that 4,000 of Shanghai's skilled workers recently asked for transfers to more suitable jobs, but fewer than 350 of them were actually transferred.[3]'' At the Shenda Telephone Co., a joint venture between Cable and Wireless (U. K.) and its Chinese partners in Shenzhen (a special economic zone on the border of Hong Kong), Cable and Wireless decided to pay for the education of three potential employees under a Ministry of Education program. "Buying" staff in this way means extra cost and delays but enables the foreign company to plan ahead.[37]

Foreign Exchange Concerns

Foreign exchange concerns permeate every deal in China. For example, the Beijing Jeep Corp., Ltd. (BJC) was recently in a crisis, due primarily to foreign exchange problems. The 3-year-old joint venture began to assemble Cherokee Jeep kits in the fall of 1985. New Chinese Government restraints on using convertible currency quickly undermined production plans, however. AMC received a license for importing Cherokee kits, but shipment was held up because of monetary disputes. Delays in dollar-based payments for these complete-knockdown (CKD) kits (unassembled parts) resulted in a 2-month suspension of production in mid-1986. The impasse on the kits ended when AMC agreed to accelerate local content in Beijing-built Cherokees in return for dollar-denominated (hence potentially more easily repatriated) payments by the Chinese for North American-sourced knockdowns.''[a]

Management Styles, Training, Language, and Cultural Considerations

It has been suggested that a useful characterization of the typical Chinese manager is that of a technically trained, operationally experienced individual whose career and professional skill development have evolved during a period of limited or no market interaction, strict prohibitions against organizational diversification, and limited economic rationality (as we know it in the West) regarding performance evaluation and reward." One of the significant consequences of this situation is a widespread lack of many of the specific functional management skills commonly associated with the concept of modern management. Many of these apparent management skill deficiencies in Chinese managers are identified in table 4. In a more general management context, the average Chinese manager perceives his role as being more of an information conduit from the top of the economic hierarchy

"'Shanghai-The Ugly Daughter Repents, *The Econom"st,* Aug. 9, 1986, pp. 27-28.
[37]'' Joint-Venture Bliss Ends in China, " op. cit.
[38]Johnson, op. cit.

"Appendix 5, Vol. II, "The Transfer of Western Managerial Knowledge to China, " by William A. Fischer, May 1986.

Table 4.—A Sample of Functional Management Knowledge Apparently Lacking in the Chinese Management Community

Marketing:
Market research
Advert i sing
Product design
Industrial marketing
Consumer marketing
Manufacturing:
Total quality control
Managing high-volume/high-variety operations
Value analysis
Inventory management
Manufacturing information systems
Distribution systems
Ethics and comparative management
Contract law
Human resources:
Motivation and incentives
The concept of directorship
The role of the manager
Executive compensation
Organizational design
Leadership styles
Finance:
Investment analysis
Methods of financing
International finance
Accounting:
Establishment of control systems
Auditing
Public accounting
Management of science and technology:
Anticipating technological change
Managing innovation and creative groups

SOURCE Off Ice of Technology Assessment, 1987

to the workers below than a decisionmaker/risktaker.

The coproduction of MD-82s in China by McDonnell Douglas (described below) demonstrates the management challenges that can occur when starting a venture.[40] The challenges included the need to bridge cultural gaps and to meet the rigors of budget restraints and regulatory requirements.[41] Budget pressure was imposed because the project was commercial and not a military coproduction program. Regulatory requirements were imposed to assure that U.S. Federal Aviation Administration (FAA) certification standards were preserved during manufacturing.

Management difficulties arose in the McDonnell Douglas joint venture for several reasons.[42] These included:

- Trying to introduce untrained Chinese workers to the "grid" system of management used by McDonnell Douglas, a system that holds that information and authority flow in different directions depending on the problem to be solved. This system is different from the Maoist "struggle sessions" that replaced productive work during China's Cultural Revolution (although in theory Maoist objectives could be compatible with this system).
- Because of the complexity and quality control requirements of aircraft manufacture, McDonnell Douglas U.S. operations have developed over 600 inhouse manuals of standard procedures (of which only 200 have been translated into Chinese so far). These procedures sometimes go against the Chinese way of doing things. In addition, some Chinese are now frightened of doing anything that is not laid down in the procedures, which leads to decisions being made slowly.

  The usual arguments in Chinese joint ventures over quality were eliminated once the Chinese realized that approval for the finished aircraft from the FAA hinged on meeting explicit, stringent standards.
- Thousands of manufacturing drawings and pages of technical literature had to be translated into Chinese.

Another management concern has been training, which has turned out to be very difficult. Chinese engineers have educational backgrounds and work habits very different from those of their U.S. counterparts. The Chinese tend to be specialists, whereas the Americans are more generalists. The high standards demanded by the MD-82 manufacture had to be made quite clear to the Chinese. To help meld the two groups, 150 Chinese employees are being trained at Long Beach, California, for management positions in the program. About 30-40 senior McDonnell Douglas people are onsite at Shanghai as advisors and comanagers to their Chinese counterparts; this group will eventually grow to about 100. About 1,000 people are employed on the MD-82 program at present, and the peak is expected to be 3,000.

Other, less tangible, management problems must also be faced. Philosophically, the Chinese place much emphasis on human values, whereas the Americans are concerned about productivity and "the bottom line. Managers must learn to emphasize both. Neither American nor Chinese managers have been prepared for the differences in the concepts of trust and respect.[43]

Comparative Investment Environments

To appreciate more fully the nature of the Chinese investment environment, it is appropriate to examine its main features from a comparative perspective. In most categories, especially in business facilitation, China's in-

[40] See also Steven R. Hendryx, "Implementation of a Technology Transfer Joint Venture in the People's Republic of China: A Management Perspective," *The Columbia Journal of World Business*, Volume XXI, Number 1, Spring 1986, pp. 57-66, which deals with Otis Elevator Company of the U.S. and the Tianjin-Otis joint venture.

[41] Richard G. O'Lone, "MD-82 Aircraft Production in China Presents Management Challenges," *Aviation Week and Space Technology*, Feb. 24, 1986, pp. 42-45.

[42] "Joint-Venture Bliss Ends in China," op. cit.

[43] Gareth C. C. Chang, President, McDonnell Douglas China, Inc., Personal communication, September 1986.

vestment climate stands in sharp contrast to the existing situation in places such as South Korea, Taiwan, Singapore, and Hong Kong, all of which have developed very specialized and focused organizations to promote, process, and administer foreign investment projects. In Taiwan, for example, an "industrial development and investment center" was created to link the island's development needs with the interests of potential foreign investors. Because of the strategic role attached to foreign investment, special consideration was given to addressing the specific needs of overseas firms in areas such as foreign exchange remittance, profit repatriation, import of components, labor costs, and overseas training.

In addition, foreign firms usually complete necessary negotiations in a relatively short period of time in these other markets, and their projects are much less subject to government control than in China.

For all of these reasons, China is less competitive in attracting investment. In some respects, many of the firms that began their Asian operations in places such as Taiwan and South Korea seem to anticipate a similar evolution in China. China has gone much further than other socialist countries in allowing equity-based investments, even to the point of accepting wholly foreign-owned projects. However, the general consensus remains that the process of change in China will be slow and that the emphasis on strong control w-ill remain a part of the Chinese investment setting. Doing business with the socialist managers of China's nonmarket economy will never be as easy as doing business in the market economies of Singapore, Taiwan, or Hong Kong.

CASE STUDIES

This section reviews the technology transfer endeavors in China by various U.S. firms in the fields of transportation, satellite telecommunications, and computers and electronics. The U.S. companies involved in China have ranged from very large diversified companies, such as GE and IBM, to small firms selling in specific market niches. The technologies involved range from manufacturing simple circuit boards to establishing satellite telecommunications networks. The case studies that follow cover sales (with a technology transfer component), joint ventures, and coproduction, and give an indication of how things work in practice.

Transportation

Locomotive Sales by General Electric

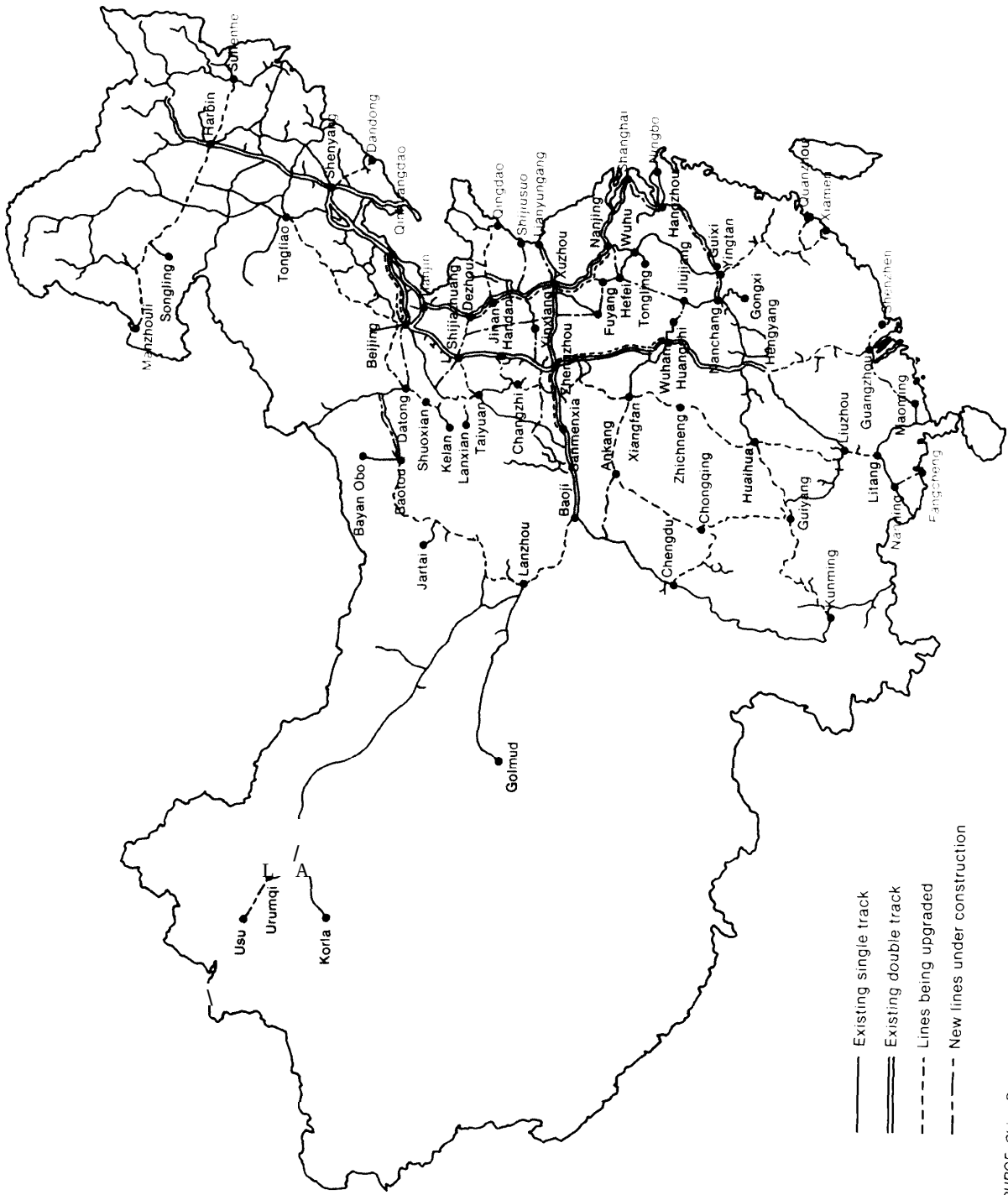
China places particular importance on its railroads. Priority projects presently under way are largely related to coal transport from Shanxi Province to other provinces and ports, and to electrification and double-tracking of existing major trunk lines. 44 The new-line construction between Datong and Qinhuangdao is the largest in scale, with investment totalling over 4 billion yuan. The Seventh Five-Year Plan proposes the construction of 3,600 km of new lines, the doubletracking of 3,300 km, and the electrification of 4,000 km of existing lines.[45]

China plans to replace steam engines with electric and diesel versions. By the year 2000, China hopes to have 20,000 km of electrified railway. China's railroad system is not under the Transportation Ministry but under its own Railroad Ministry, which sets development priorities. China's present rail system and ambitious planned improvements are shown in figure 4.

[44] See for example "Electrification Planned for 3000 km of Railways *XINHUA*, Apr. 12, 1986 or "Modernization of Guangzhou-Shenzhen Railroad," by Dai Quan and Li Zhenxing in *TIEDAO ZHISHI* [Railway Knowledge], No. 4, July 28, 1985.

[45] Seiichi Nakajima, "China's Priority Projects and the 7th Five Year Plan," *China Newsletter, No.* 63, JETRO, 1986, pp. 13-16.

Figure 4.—China's Railroad System and Planned mprovements



SOURCE: *China Business Review*, September-October 1984.

China began to import locomotives in 1958, most of them from Hungary. In the years that followed, China bought locomotives from the United States, the Federal Republic of Germany, France, the Soviet Union, Romania, and the German Democratic Republic. At present, China's Dalian Locomotive and Car Works produces 130 locomotives a year, and its Zhuzhou Electric Locomotive Works produces 80 electric locomotives a year. China has two other factories that build passenger trains. However, China's need for locomotives and related equipment is far from being met by domestic production and imports combined.[4] The United States has become the largest locomotive supplier to China. In March 1985, 220 GE diesel locomotives of 4,000 horsepower each were delivered, with 200 more locomotives on order.

The first contact between GE and the Chinese occurred in 1976, when GE conducted a seminar on diesel locomotive technology in China. Another seminar was given in 1978, after which a Chinese delegation visited U.S. diesel locomotive plants as part of a worldwide tour. As a result of these seminars and tour, the Chinese invited GE to discuss possible diesel locomotive sales.[47] Negotiations began in 1979 but were not completed until 1983, when locomotives were given a high priority by the Chinese in a ranking of major projects.

Right from the start, technology transfer was a prerequisite of Chinese negotiations for any purchase of locomotives. GE purchase of locomotive components from China was also very important in negotiating the two contracts. This type of countertrade will probably become more and more important as Chinese foreign exchange reserves decrease.

Throughout the entire negotiation process, GE worked with the same Chinese officials, who represented the Railways Locomotive Bureau, the Railways General Industry Bureau, and the China National Machinery Import/Export Corporation. Over the years, a good relationship developed, so the second contract took much less time to negotiate.

The first contract stipulates that the technology transfer portion is for a period of 4 years and includes manufacturing and materials technology for certain components of the locomotive, but not design methods. So far the Chinese have not asked for a particular technology that was not appropriate to their needs.

The second China contract stipulates that GE will train Chinese personnel to overhaul locomotives and will provide a factory management training course. Training will be done both in China and in the United States using computers such as IBM personal computers (PCs). Language problems had some impact on the technology transfer process, but the problems were surmountable.

GE apparently had no need for U.S. Government assistance. They felt that they had prepared themselves well and knew whom to contact and how to keep negotiations running smoothly. However, GE feels that several factors affected by U.S. Government policy are important:

- The high value of the dollar at the time of the negotiations hurt U.S. companies' competitiveness in China, just as it did elsewhere. The exchange rate when negotiations began on the first GE contract was 1.80 yuan to the dollar. Today, it is over 3.69.
- The importance of Export-Import Bank financing should be recognized-it is almost the only leverage the U.S. Government has to support U.S. industry. GE believes that other governments provide financial subsidies to companies doing business in China. Financing was not a factor in these GE negotiations since China paid cash, but the availability of official (but unsubsidized) financing could be crucial in the future.

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[4] For a detailed look at several rail technologies needed by China see "A Report Covering the Railroads of the People's Republic of China. Operations, Rolling Stock, Standards and Planning. Effects of Interface and Technology Transfer Between North American Railways, Railway Supply Companies and the Association of American Railroads," prepared by David G. Blaine and William J. Harris, Jr., May 1986 (app. 4, vol. II of this report).

[47] The Chinese use of delegations (both to and from China), technical seminars, conferences, and exhibits are a common informal technology transfer mechanism. Foreign technology seminars in China have been used a great deal and with apparent effectiveness.

- U.S. Government promotion should focus on products in general rather than on company-specific products. It might be useful for the Department of Commerce or other appropriate Government agencies to analyze the Chinese Five-Year Plan and match Chinese needs with U.S. strengths.

The protocol between the Ministry of Railways and the U.S. Government was not particularly useful, but it did not hurt, either. Thus far, export controls have not affected the export of locomotives and locomotive technology to China.

GE was particularly interested in the Chinese locomotive market because it had spent $500 million modernizing its locomotive plant in Erie, Pennsylvania. At present, the market for locomotives in the United States is poor. The two China contracts, even if they produce little or no profit, allow GE to refine technological and design advances while the plant operates. When demand returns, GE will be well placed competitively .48

Beijing Jeep Joint Venture with AMC

China's automobile manufacturing began in 1956 with the production of Liberation trucks at the Changchun No. 1 auto plant. These 4-ton trucks were manufactured using Soviet equipment and technology. The production of Liberation trucks kindled an interest in several types of motor vehicles required to satisfy China's burgeoning needs. In Shanghai, Nanj - ing, and Jinan, a variety of models were produced including the Yellow River and the Leap Forward trucks, the Red Flag limousine, and Shanghai sedans. Today, more than 50 kinds of vehicles in six categories—vans, cross-country vehicles, dump trucks, tractors, buses, and sedans-are in production, with more than 300 types refitted for special purposes.[49] Production by vehicle category is given in table 5, and total automobile production levels are given in figure 5. Production levels are still too small to achieve economies of scale, even for components. In addition, Chinese motor vehicle technology is over 20 years old, which affects vehicle production, fuel efficiency, maintenance needs, and pollution control.

Table 5.—Chinese Production by Vehicle Category

(Unit: 1,000 units)

	1981	'1 983
Trucks. ., ...108.3	(61 .6°/0)	148,0 (61 .7°0)
Jeeps 15.5	(8.8"/0)	18.0 (7,5 "/0)
Passenger cars . 3.4	(2,0 "/0)	5.6 (2.30/o)
Buses . . 1.7	(1 .00/0)	4.4 (1 .8°/0)
Others. 46.8	(26.6°/0)	64.0 (26.70/o)
TOTAL 175.7	(IOO.O°/o)	240.0 (1 OO.O"IO)

NOTE Trailers are Included under Others f they were Included with Trucks the percentage for trucks would reach 85 percent

SOURCE Makota Iwagakl, 'The State of China s Automobde Industry China *Newsletter No* 63, JETRO, 1986

China seeks joint ventures, improved technology, specialization, and mass production, giving special emphasis to heavy-duty trucks and sedans. The China National Automotive Industrial Corporation, founded in May 1982, has actively sought links with foreign companies. It has hosted foreign delegations from auto companies, has sent technicians abroad for research and technical exchange, and has been involved in joint production agreements. In the last few years, the company has introduced advanced technology from the United States, Japan, Italy, France, Britain, and West Germany. In addition to BJC, the Shanghai-Santana is a sedan produced jointly by Shanghai and the German Volkswagen Corp. The Tianjin-Dafa van is produced jointly by Japan and China.

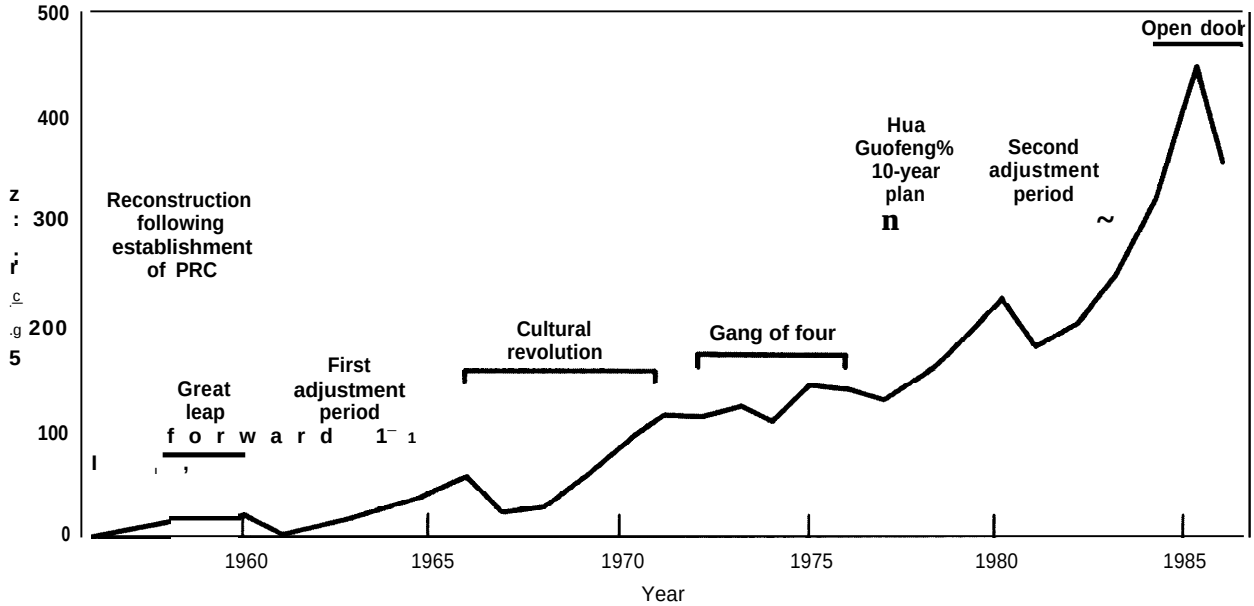
The rising Chinese demand for automobiles had previously been met largely by imports. However, the large-scale importation of vehicles ended in 1986 with a clamp-down on foreign exchange expenditures. It should be noted that direct sales of cars and trucks do little for technology transfer–the backward state of China's own industry necessitated imports, and the Chinese are making efforts to remedy the situation as described below.

AMC and the Beijing Automotive Works formally inaugurated their joint venture (BJC) to produce four-wheel-drive Jeep Cherokees in

[48] Peter Petre, "What Welch has Wrought at GE, " *Fortune,* July 7, 1986, p. 45. See also Barnaby J. Feder, "GE Costly Locomotive Gamble, " *The New York Times,* Jan. 25, 1987.

[49] Makoto Iwagaki, "The State of China's Automobile Industry, " *China Newsletter, No. 63,* NETRO,1986, pp. 9-11, 16.

Figure 5.—China's Vehicle Production History



SOURCE Zhorrgguo *Tongl/ N/an//an* (China Statlstlcs Yearbook), from Makota Iwagakl, "The State of China's Automobile Industry, China News/efter - No 63, JETRO, 1966

Beijing in October 1985. AMC owns 31.3 percent of the joint venture. So far, AMC has invested nearly $16 million in capitalization, production equipment, and living expenses for the expatriate staff.[50]

The first phase is the assembly of CKD Cherokee kits shipped from the United States. This will be done at a plant that for many years has manufactured a modified Soviet-designed jeep, vehicles that are fuel inefficient and, on average, have major drive train failures within their first 12,500 miles. The Chinese are hoping that their experience in assembling Cherokees will teach them how to improve this vehicle. In particular, the improved quality control of assembly and locally sourced parts will be important.[51]

AMC has shipped almost 2,000 Cherokee kits to China, 1,782 of which had been assembled by January of 1987. The largest single buyer of Cherokees is the State Materials Bureau, which purchased 200 of the first 500 vehicles sold, mostly for distribution to other state agencies and enterprises. Other buyers include the Mongolian police department and several foreign companies stationed in China.

Some problems with the joint venture developed early .52 The original 1983 contract called for a $10,000 portion of each $19,000-Cherokee sold in China to be paid in dollars. When the Chinese Government clamped down on foreign exchange outlays, however, BJC was left with a $2 million foreign exchange debt from the State Materials Bureau and an insistence by Beijing that remaining vehicles be

[50] "Cash Shortage Forces AMC to Review Cherokee Production in China," *China Business and Trade,* Apr. 23, 1986, p. 3.

[51] Visit by OTA staff to Beijing Jeep Corp., Jan. 28, 1986.

[52] Some observers believe that the original contract was poorly conceived and that AMC should take much of the blame for this. Subsequent problems they believe stem as much from inadequate financial planning and unrealistic capitalization as they do from any problem inherent in doing business in China. (Steven R. Hendryx, "The China Trade: Making the Deal Work," *Harvard Business Review,* July-August 1986, pp. 75-84.) The venture's experience to date suggests that timetables calling for 80 percent local content by 1988 and 10,000 exported vehicles in 1990 were unrealistic. Also, many foreign observers point out that AMC's initial cash contribution of $8 million was very small in relation to its goal of building an export-quality jeep in China. ("Problems at Two Joint Ventures—Fundamental Problems Plague AMC Joint Venture/If Things Go On Like This, There'll Never be a Chinese Detroit," *The China Business Review,* July-August 1986, pp. 34-35. The second joint venture referred to in this article is that of Shanghai-Volkswagen Automotive Company Ltd. producing Santana sedans.)

Photo credit Er/c O Basques

The Beijing Automotive Works produces two types of jeeps in parallel assembly lines. The BJ-212 pictured on the right is a Soviet-designed jeep that has been produced since the 1950s. The Cherokee Jeep on the left is a product of the Beijing Jeep Corp. Ltd., a joint venture formed with American Motors Corp.

bought only with Chinese currency. Production of Cherokees dropped to seven vehicles a day, about one-half the output rate hoped for. The original 1986 production target of 1,000 was thus lowered to less than 2,000.

This joint venture came very close to failing, primarily because of these foreign exchange problems, with AMC threatening to walk away from the deal. However, the joint venture is too large and symbolically important for either side to let it fail. The importance was underscored by the extensive discussions of AMC with the China National Automotive Industrial Corp.,[53] the State Economic Commission, and the State Planning Commission on the joint venture's problems. Some feel that the much-publicized difficulties of this joint venture in the international press helped AMC obtain this much-needed assistance from the highest levels. Recent reports indicate that many of the problems have been solved.

McDonnell Douglas MD-82 Commercial Aircraft Coproduction

China is one of the few countries in Asia to have developed its own combat aircraft." The Chinese developed the Shenyang J-8 *Fin back* fighter, which made use of technology acquired from the manufacture under license of Soviet aircraft such as the MiG-21. The Chinese F-8-

[53] The government has recently replaced the China National Automotive Industrial Corp. (CNAIC) with a federation which will provide China's more than 2,000 automobile and motorcycle manufacturing enterprises with consulting services and guidance in order to help coordinate the automobile industry, The reason for the demise of CNAIC, which started in 1982 with high hopes for automobile production coordination, was that its excessive power stifled the initiative of individual enterprises. (*China Business and Trade*, vol. *VI* 11, Issue 17, Mar.23,1987, p. 4.)

[54] The Beijing Jeep Corp. Ltd. recently held an exhibition on its three-year anniversary. The joint venture has so far produced 1,782 Cherokee Jeeps with domestic content reportedly accounting for one-sixth of the jeeps total cost. Dividends were shared by AMC and the Chinese for the first time in 1986. The Chinese and American managers agreed to reinvest $101.25 million in the expansion of production during the country's Seventh Five-Year period (1986-1990). ("Joint Venture on Jeeps Marks Anniversary," *XINHUA*, Jan. 15, 1987.)

[55] The Chinese have announced plans to display four of their aircraft at the 1987 Paris Air Show which starts June 12,1987 in LeBourget, France. This is China first aircraft presentation at this biennial salon. The four aircraft are the Nanchang A-5 and Xian FT-7 fighters, the Harbin Y-12 twin-turboprop utility transport, and the Northwestern Polytechnical University D4RD remotely piloted vehicle. ("Chinese Plan to Display Aircraft at Paris Air Show," *Aviation Week and Space Technology*, Jan.19,1987, p. 21,)

2 is a Mach 2.2, delta-wing, air-superiority fighter derived from the J-8 fighter.[5G]

China also laboriously (and expensively) built two prototype airliners in the Boeing 707 category, designated as the Y-10 or, as some termed it the "708. '[57] This airliner was extensively reverse engineered from the Boeing 707s bought by the Chinese. The engines of the Y-10 were of U.S. manufacture. The first Y-10 was used for structural tests, and the second was for actual flying tests for airworthiness. The second plane began flight testing in September 1980 and flew successfully for a total of about 300 hours.[58] One major problem with the plane was the integrity of its fuel tanks—the Chinese were accustomed to the Soviet style of aircraft building, which uses bladders or tanks for the fuel, not the U.S. style, which uses "wet wings" (the aircraft wing itself is a fuel tank). Such problems and doubts about obtaining international acceptance led to a decision not to manufacture the Y-10, but to join instead with McDonnell Douglas.

In April 1985, McDonnell Douglas and Shanghai Aviation Industrial Corp. (SAIC) signed an agreement providing for the coproduction of 25 MD-82 twinjet transports, with an option for 15 more. The agreement took 10 years to finalize. The Chinese had earlier produced landing-gear door subassemblies for McDonnell Douglas commercial airliners. McDonnell Douglas was satisfied with the quality of the work on the over 200 doors assembled and decided to go forward with a proposal to coproduce 25 MD-82 commercial airliners in Shanghai with the Chinese.'[g] The Civil Aviation Administration of China (CAAC), the umbrella Chinese organization that oversees all aspects of aviation, has agreed to acquire the 25 MD-82s. The five other MD-82s have already been put into service by regional carriers in Shanghai and Shenyang.

Thirty-eight engineers and specialists from the United States are staying at the McDonnell Douglas coproduction facility in Shanghai, run by the SAIC. They stay from 2 months to up to 2 years. The contract also specifies that approximately 220 Chinese will travel to the United States for training, most of them in planning, engineering, and assembly. Of these 220, approximately 90 percent will be engineers and 10 percent technicians. In 1987 they intend to coproduce 2 planes. The post 1987 timetable is not definite, but they hope to assemble four planes in 1988, seven in 1989, eight in 1990, and four in 1991.

The McDonnell Douglas coproduction agreement is complex, with 500 pages (in both English and Chinese) five parts covering:

1. licensing details
2. delivery of aircraft to CAAC and after-sales service,
3. offtrade (countertrade) agreements,
4. new joint development of aircraft, and
5. discussion of a new joint management system.

The total deal covers a period of about 10 years.

A major step for the Chinese is now completed with the signing of the "Memorandum of Agreement for Technical Cooperation in the Field of Civil Aviation" between the FAA and the CAAC.[G1] This agreement, along with its Annex 1, certifies FAA airworthiness to the MD-82s being assembled in Shanghai and is essentially an extension of the airworthiness certificate given to the MD-80 series of aircraft manufactured in McDonnell Douglas' Long

[56] The U.S. Air Force and the People's Republic of China signed a $501 million contract in October 1986 to upgrade the F-8 fighter with U.S. made avionics equipment. A draft request for proposals has been issued by the Air Force and a formal RFP will go out in early March 1987 with a contract award planned for August. Delivery of the first 50 kits and five spares is scheduled for 1991. The kits will include new radars, inertial navigation equipment, head-up displays, air data computers, and a new data bus. ("Chinese F-8-2 Fighter Configured for All-Weather Day/Night Missions," *Aviation Week and Space Technology,* Jan. 19, 1987, pp. 42-43.)

[57] See, for example, E. E. Bauer, *China Takes Off: Technology Transfer and Modernization,* University of Washington Press, 1986, concerning several interesting technology transfer histories.

[58] Visit by OTA staff to the Shanghai Aviation Industrial Corp. plant, Shanghai, Feb. 4, 1986.

[g] Shanghai site visit by OTA staff, Feb. 4, 1986.

[G] Visit by OTA staff to the Shanghai Aviation Industrial Corp. plant, Shanghai, February 4, 1986.

[G1] Memorandum of Agreement for Technical Cooperation in the Field of Civil Aviation between the United States of America Department of Transportation, Federal Aviation Administration and the People's Republic of China, Civil Aviation Administration of China," signed Mar. 14, 1986 and "Annex 1 to the Memorandum of Agreement" signed Mar. 15, 1986.

Beach facilities. With this certification the MD-82s assembled in China can be flown or sold anywhere in the world. McDonnell Douglas actually monitors the Chinese work in assembling the SKD (semi-knock- down) units to make sure that the completed aircraft are in compliance with FAA requirements. FAA inspectors from Long Beach also go to China approximately every 3 months to check for compliance in May 1986, Annexes 2, 3, and 4 were drafted and sent to the Chinese. These annexes deal with controlling air traffic, maintaining airworthiness, and developing an air traffic control system plan. The Chinese have expressed an interest in these but do not want to commit foreign exchange to them at this time.

The MD-82 production line started as planned on April 1, 1986, with the first plane completed in June 1987, 1 month ahead of schedule.[63] This plane will be test-flown to see that it is airworthy and operates to FAA specifications, with delivery in July. Subsequent planes will then be essentially replicas of this first one.

China's aircraft industry is developing new types of 100-seat jet planes in cooperation with Messerschmitt-Bolkow-Blohm (MBB) of West Germany and McDonnell Douglas. This cooperative arrangement was signed in April 1985. China has sent over '200 senior specialists from its aircraft industry to West Germany and the United States to help design and produce the new aircraft.[64]

One reason for so much interest by foreign firms is that the potential market for aircraft in China is enormous. Unlike other countries in the region, China contains a home market for aircraft that, by itself, is large enough to justify at least the development of aircraft sized for regional markets. In this respect, China can be compared only with the United States and the Soviet Union.[65]

Satellite Telecommunications

Background

According to a recent Department of Commerce Industry Sector Analysis for Telecommunications in China, "China recognizes that telecommunications is one of two or three industries upon which the fate of its entire modernization rests. The principal focus is on rapid improvement of what can only be described as an appalling telephone system. '[66] Only 1 person in every 200 has a phone, placing China among the lowest six countries in the world in phone density. Long waits for connections, poor line quality, and lack of service are continual problems. Much of the equipment dates back to the 1930s and 1940s. Chinese international telecommunications capacity has been developing at a rate of 30 percent a year (albeit from a small base), mostly through increasing communications by satellite. China can produce several types of equipment, including ground stations (particularly C-band) and telephone transmission lines, but these are generally not technically sophisticated.

Satellite telecommunications is a very appropriate high-technology sector for China. China's large population, spread over vast land masses with extreme variations in climate and terrain, makes this an ideal technology- better even than microwave transmission, in most cases. Fiber optics would be a contender only on high-volume trunk lines between major cities or for military uses requiring a high degree of security. The Chinese realize that telecommunications is an extremely important part of their national infrastructure, and many of their ambitious development plans are closely tied to it. They also realize that there is military and propaganda value to increased telecommuni-

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[63] "'Chinese MD-82 Procedures Under Review, " *Aviation Week and Space Technology,* May 25, 1987, p. 29.

"See Bruce A. Smith, "Chinese Join Wings, Fuselage of First Coproduced MD-82, " *Aviation Week and Space Technology,* Dec. 15, 1986. pp. 41-43 and "First Chinese-Assembled MD-82 Nears Completion in SAIC [Shanghai Aviation Industrial Corp.] Facilities, " *AviationWeek and Space Technology,* June 1, 1987, pp. 34-35.

[64] "[Chinese] Aircraft Industry Cooperating with U. S., FRG," *Xinhua, Nov. 21, 1985,* reported in JPRS-CEA-85-112, Dec. 20, 1985.

[65] Pierre Condom, "The Far East—Today's Customer " Japan, of course, despite being a small country, also has strong reasons for developing its own aircraft.

[66] "'Telecommunications in China— Industry Sector Analysis," U.S. Department of Commerce, Washington, D. C., 1985.

cations capabilities. However, with limited resources, telecommunications development has come and will probably continue to come after agriculture, transportation, and energy development.

China has three options for achieving satellite telecommunications capability: It can lease the capacity on existing satellites, buy satellites from other countries, or develop its own capabilities. China is actually pursuing all three options. INTELSAT (International Telecommunications Satellite Organization) has provided transponder capacity to China, and this was expanded with the purchase by China in 1986 of two transponders from the satellite at 66 degrees East longitude. One of the transponders is used for educational programming, and the other for news and cultural programming.[57] China has also investigated the purchase of satellites, as discussed below. Purchase or lease of a system for complete coverage of the entire country would be prohibitively expensive, however, considering China's great needs.[58]

China has significant expertise in both scientific satellites and rockets (see table 6 for a chronology), but its communication satellites in particular are far behind the best Western technology.[59] Technology transfer is probably the best compromise. China can buy several satellites and associated technology from the United States or Europe, and it can use this to greatly speed up its own development.

Satellite Telecommunications Technology Transfer

China requested foreign proposals for substantial development of its satellite telecommunications capabilities in the late 1970s and again for 1984-85. In the earlier case, the respondents to the request for proposal (RFP) were Hughes Aircraft, GE, and RCA-Astroelectronics of the United States, MBB from West Germany, and British Aerospace Dynamics.

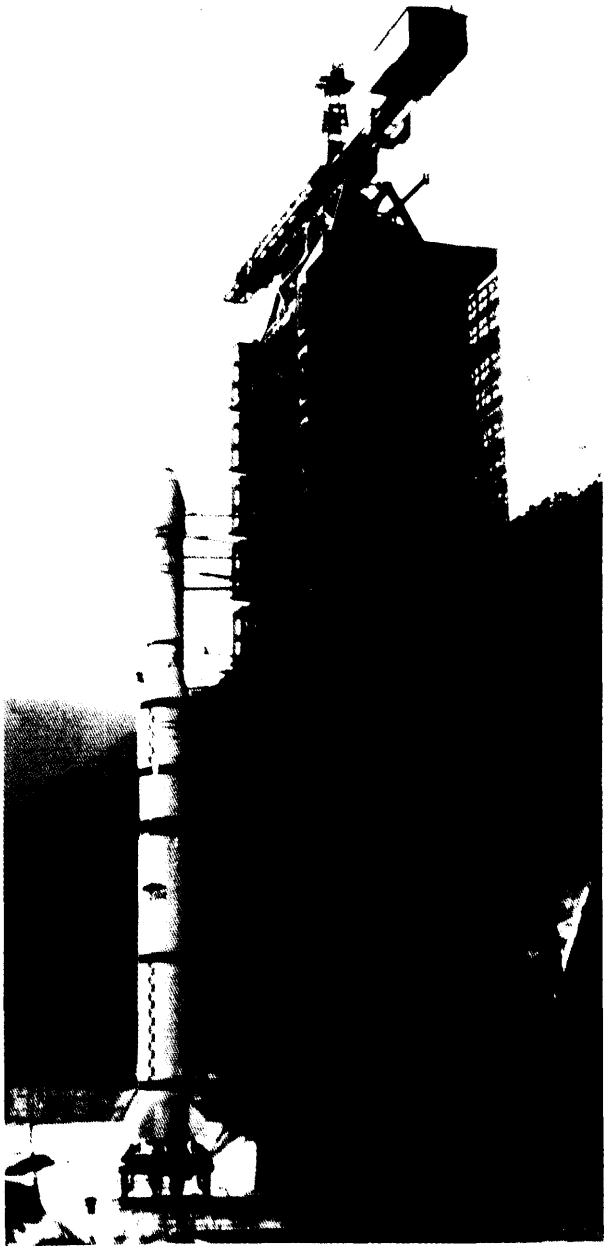

Photo crecfIt China **Greaf kVa// /rxfustry Corp**

The main thrust of the Chinese drive for commercial launch business is the Long March 3, shown above at the Xichang launch site. This vehicle is essentially a Long March 2 with the addition of a new cryogenic third stage which boosts the payload into a geostationary transfer orbit. The Long March 3 has been launched three times with the latter two being successful.

[57] Radhakrishna Rae, "China's Space Plan," *Satellite Communications,* February 1987, pp. 25-27.

[58] Leasing of one communications satellite transponder costs about $30 million per year. This does not include ground equipment. Depending on the type, central ground stations cost from 0.5 to 4.0 million dollars apiece. Buying an entire satellite communications system (which would have several transponders) could cost 120 to 150 million dollars with the satellite lasting 9 to 14 years. The U.S. civilian sector presently has 150 to 200 active transponders. INTELSAT has about 330 to 340 transponders available for use and is presently operating at about 50 percent of capacity.

[59] China's particular needs are in increasing communications satellite power and longevity and in improved satellite stabilization and control.

Table 6.—Satellite Telecommunications Development in China: A Chronology of Important Events

1956 Chinese Astronautics industry development begins.

1960 USSR technicians depart, thus ending technical assistance in production of liquid fuel rockets,

1965 Beginning of research and design of first satellite and carrier rockets.

1968 China Academy of Space Technology formed to coordinate space program.

1970 *Chirrasat 1.* April 24, 173 kg. China becomes fifth country to develop launch capability and launch its own satellite, Tracking, telemetry, and command network of seven stations i n place. Satellite circled the Earth every 114 minutes, broadcast "The East is Red. "

1971 *Chinasat 2.* March 3.221 kg. Experimental-scientific.

1972 RCA Globcom erects first satellite earth station in Shanghai.

1974 *Long March* 2—launch failure.

1975 *Chinasat 3,* July 26. 1750 kg. Scientific satellite.
Chlnasat 4, November 26. 1750 kg. Reconnaissance satellite. Returned to Earth December 2, China is third country to master satelllte return technology. *Long March* 2 problem corrected and all subsequent launches with this rocket are successful.
Chinasat 5. December 16. 1750 kg. Meteorological satellite.

1976 *Chinasat 6, 7.*
China becomes member of Intelsat. Leases 60 half-way International telecommunications circuits

1977 China Academy of Sciences organizes Space Science & Technology Center for space research,

1978 *Chinasat 8.* January 26. Conducted scientific experiments.
Begin negotiations with U.S. companies for import of direct broadcast satellite, Joint tests with France and Germany on European satellite. Joint tests with U.S. (RCA) on Marisat. First Chinese aerospace delegation to the U.S.—NASA Invitation.

1979 NASA and AIAA visits to China, Cryogenic fuels development revealed, China only third country to use cryogenic third-stage rocket. Deng Xiaoping visits Johnson Space Flight Center in Houston.

1980 China begins astronaut training (later abandoned). Satellite purchase postponed on grounds of "economic readjustment "

1981 *Chinasat 9, 10, 11.* China (CAST) begins discussions with NASA for science and technology exchanges.

1982 *Chinasat 12.* September 9. Scientific experiment.

1983 *Chinasat 13.* August 19, Scientific satellite.
China-Italy joint tests with Italian *Sirius* satellite. U.S. Government issues more liberal guidelines for licensing of technology exports to China. *Landsat* ground station finally approved.

1984 *Chinasat 14.* January 29. First successful launch with *Long March* 3 (CZ-3). Gas generator burnout prevents proper payload positioning. First liftoff from new spaceport in Sichuan Province.
Chinasat 15. April 8, Successful launching of communications (test) satellite on CZ-3, Geosynchronous equatorial orbit.
Chinasat 16. September 12.
United States sends "presidential" aerospace trade mission to China. China and Germany sign agreement for space technology cooperation Including joint development and manufacture. Canada's Spar Aerospace sells China ground station package valued at over $24 million (Canadian). In August, RFP for Direct Broadcast Satellite (DBS) issued

1985 *Chinasaf 17.* October 21, Resource survey.
China Dai/y on June 13 announces that China is ready to market space products and services. At Stockholm International Aeronautical Federation Congress, China describes launch failures, provides launcher details.
China opens new space launch complex to potential customers. People to People, NASA, AIAA groups of US aerospace technicians visit China.
On July 15, China postpones RFP for DBS.
August 1. China begins 3 months of free trial on Intel sat satellite for educational T.V.

1986 *Chinasat 18.* February 1. CZ-3 launch of "operational" commercial satellite, Geosynchronous orbit.
Several Western companies make launch reservations with the Great Wall Industries Corp. which markets Chinese launch services,

SOURCE Off Ice of Technology Assessment 1987

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In the later case the respondents were RCA-Astroelectronics (now GE Aerospace-Astrospace Division), Matra of France, and MBB teamed with Ford Aerospace (United States). In neither case did the Chinese sign a contract.

The amount of technology transfer offered by the foreign companies was an important bargaining point in both cases. The Chinese reportedly were quite skillful in playing off the competing companies against one another. As it turned out, the Chinese received a great deal of technological information, essentially for free, from these two aborted satellite telecommunications RFPs. Some feel that the first round immensely helped the Chinese and led to their space successes in the early 1980s.[70] Most people feel, however, that the Chinese bargained in good faith: a lack of foreign exchange and bureaucratic infighting over the type of satellite system China should have were the real problems."

Eventually, China resolved the systems issue with the selection of the low-power C-band instead of the higher power Ku-band, which had been the subject of the RFP.[72] 73 The conflict had resulted largely from the different communications needs of several Chinese ministries and the military .74 The complexity of the bureaucratic structure involved in the selection, production, and application of space communications technology is shown on the organization chart of figure 6. This complexity typifies much of the Chinese bureaucracy, and is largely responsible for the delays in decisionmaking.

Chinese Satellite Expertise

China launched its first geosynchronous satellite in 1984 and a second in February 1986, demonstrating an ability to move rapidly in areas of particular interest. However, in most aspects of satellite telecommunications technology, the Chinese are 20 years behind the United States and Western Europe." These satellites have worked, but they are heavy (considering their low power) and will probably be short-lived. In addition, the Chinese have, until recently, had little use of the satellites, since the ground-based infrastructure was largely nonexistent.

The Chinese have a great deal of the theoretical, or ''academic, expertise required for successful development of sophisticated satellite telecommunications equipment. But, with the exception of ground antennas, they have not had the practical experience of designing, building, and operating viable, efficient systems. Satellite attitude control and

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'('Satellite telecommunications demonstrates the Chinese capability to advance through informal technology transfer. The Chinese developed a great deal of satellite and launch capability on their own and through study of technical literature. Although development cannot be achieved across-the-board through such methods, it is interesting that the Chinese were able to move ahead in these areas despite the overshadowing of scientific effort by the Cultural Revolution. Part of the push in this field came from military desires, of course.

"'An unsuccessful early bid, however, does not prevent a subsequent successful bid in a related area. For example, France's Matra was not successful in its proposal to China for a telecommunications satellite system. However, the Chinese were interested in the satellite control center portion of their proposal and out of this came an agreement for supply of data processing centers at two Chinese ground stations valued at $8-10 million. ("France to Supply China with Data Processors, " *Aviation Week and Space Technology,* July 21, 1986, p. 25.) Matra hoped to sign the final contract in October 1986 with deliveries beginning in 1987. The processing centers will be based on Digital Equipment Corp. VAX computers, which were specified by China. The contract was signed in December 1986 for $7.8 million (''Matra Will Supply Data Processing Equipment to China, " *Aviation Week and Space Technology,* Dec. 8, 1986, p. 27. The DEC Model 8500 was originally specified, but the Chinese have now specified the improved technology Model 8700, partly because the 8500 is being phased out in 1987 by Digital Equipment Corp. A request based on the changeover to the 8700 computer has been filed with COCOM with approval expected in the next several months. ("New Computers Selected for Chinese Stations, " *Aviation Week and Space Technology,* May 11, 1987, p. 33.

"C-band operates at a frequency of 6 Gigahertz (G Hz) uplink from the sender to the satellite and 4 GHz downlink from the satellite to the earth station. Ku-band operates at 14 GHz uplink and 12 GHz downlink (1 GHz =91 billion cycles per second). See the OTA Case Study contractor report "Satellite Telecommunications Technology Transfer to China" by China Business Development Group, Alexandria, Virginia, July 1986 (Appendix 3, Vol. I I), for an extensive discussion of the relative strengths and weaknesses of the two systems.

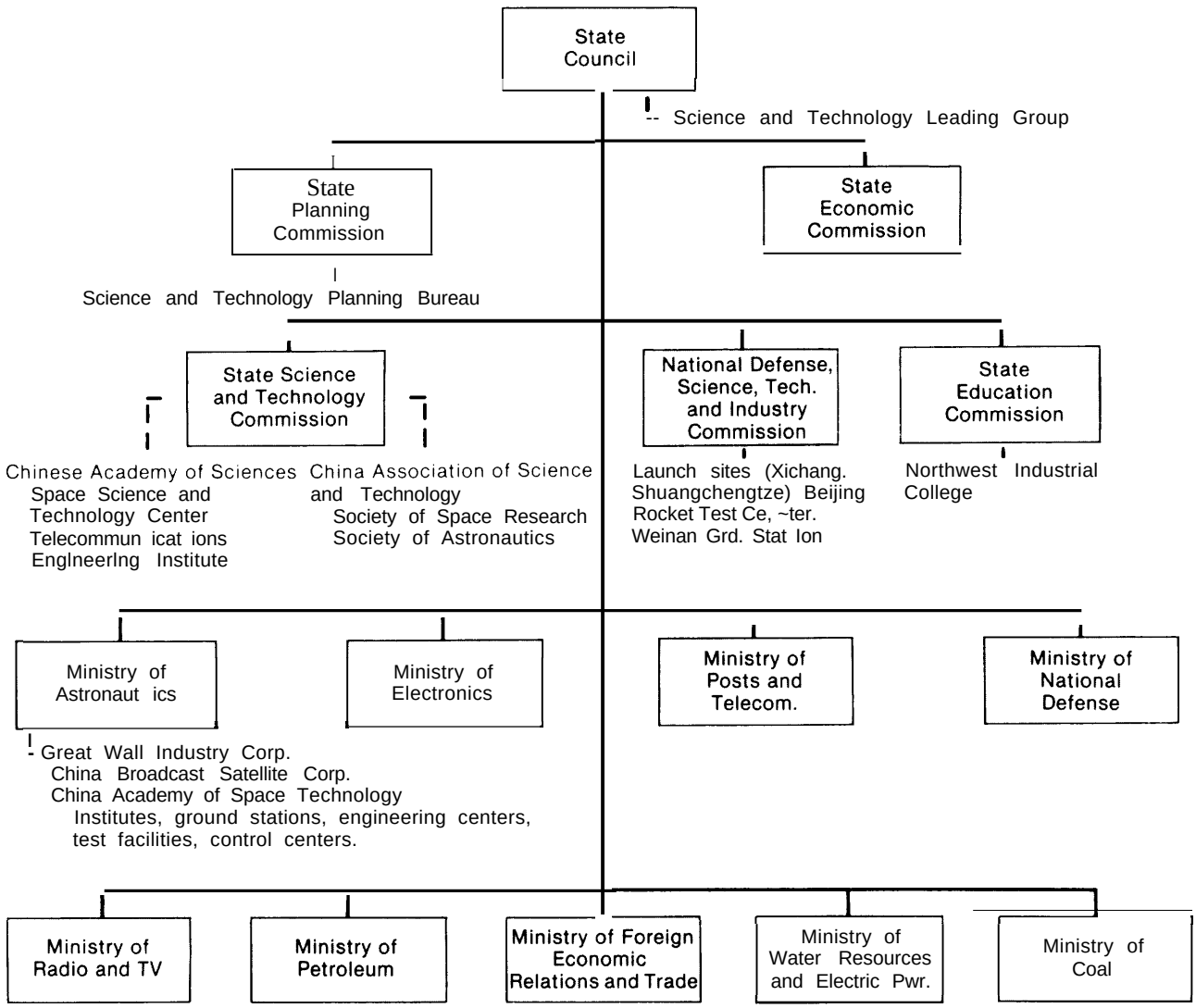
[73]It is unknown, at this point, whether they will issue a 3rd RFP or decide to proceed on their own.

"Primarily the Ministry of Astronautics, Ministry of Electronics, Ministry of Radio and Television, and the State Education Commission. For the interested reader, an extensive discussion of this matter is contained in the OTA Case Study contractor report *'Satellite Telecommunications Technology Transfer to China, " July 1986 (app. 3, vol. I I of this report).

"'Ibid.

Figure 6.—China: Satellite Telecommunications Technology Transfer

Chinese agencies responsible for selection, production, and application of space communications technology



SOURCES National Counc(I for U S -China Trade, *A v(al~on Week & Space Techr?o/ogy,* U S Embassy, Bel)lng, AIAA reports, *Nature,* November 21 1985

stabilization are presently the two specific satellite technology areas of major concern to the Chinese. In a more general sense, lack of technology infrastructure hinders China's satellite telecommunications development. The space-based component and telecommunications equipment manufacturers that provide a large, varied technical support in the United States and Europe do not exist in China.

China is now offering, on the international market, satellite launch services to geosynchronous orbit using its Long March 3 vehicle. China will also alter its Long March 2 rocket (usually used for low-earth orbit (LEO) launches) by stretching the tanks and adding four liquid rocket boosters. The new version, designated the CZ-2-4L, will lift 1,900 kg into geosynchronous orbit with the help of a PAM-D2 (payload assist module) upper stage. It is hoped to be ready by the late 1980s.[77]

Impact on the United States

Concerns have been expressed that transferring satellite telecommunications technology to China will assist the development of a competitor and the military capability of a potentially hostile country. Neither fear seems likely to be realized. Development of Chinese satellite telecommunications will not pose a threat to sales of U.S. firms for at least 10-15 years, since Chinese technology will not be good enough at any price until then. Any satellite telecommunications will improve the capabilities of the Chinese military to some extent, but the technology transfer aspects are not directly very worrisome. Most export control concerns related to this technology stem from miniaturization technology and increased digital processing and computer capabilities of the Chinese, which are likely to come from other sources as well.

Launch services, however, if subsidized by the Chinese and proven reliable, could well cut into Shuttle or *Ariane* launch sales.[77] Several customers have recently announced that they are planning to launch their satellites on China's Long March rockets, largely because of the unavailability of other slots and the relatively low prices for launches by China.[78] Other potential contenders for international launch services include the Soviet Union, which has already offered its Proton rocket to launch *Inmarsat* satellites, and Japan, which may be in the commercial launch business in the early 1990s.[79]

The Chinese space program could eventually become a significant factor in satellite launch services. The U.S. Department of Transportation estimates that commercial customers will want to launch about 20-25 commercial payloads per year in the late 1980s and that U.S. companies could capture 50 percent or more of that market.[80] It is estimated, however, that the Chinese could have the capability to launch 6-12 geosynchronous satellites a year by the early 1990s, of which only two or three launches would be for their own domestic needs. Officials of the China Great Wall Industry Corp. (CGWIC), the marketing arm of China's Ministry of Astronautics, have approached 39 companies in 19 nations seeking

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[77] "International Notes," *Space Business News,* July 14, 1986, p. 1, See also "PRC: Modified 'Long March' Launcher," *FBIS: Science and Technology Perspectives,* vol. 2, No. 6, Apr. 30, 1987, p. 7-8 and Craig Covault, "New Chinese Heavy Rocket Spurs Effort To Win Commercial Launch Contracts, *Aviation Week and Space Technology,* May 4, 1987, p. 22-23,

[78] See for example, "Chinese Launch Services Executives Guarantee They Can Beat Any Price, *Satellite News, vol.* 10, No. 17, Apr. 27, 1987, p. 1. Launch insurance, an important consideration nowadays, is also offered by the Chinese. See "PRC Firm [People's Insurance Company of China] to Insure Launch of U.S. Satellite," *XINHUA*, Feb. 14, 1987 and "Chinese Make Inroads on Commercial Launch Market," *Aviation Week and Space Technology,* Mar. 9, 1987, p. 134.

[79] China has won launch reservations for satellites of Pan Am Pacific Satellite Corp. and Dominion Video Satellite ("China Wins Launch Reservations for Three More U.S. Satellites," *Aviation Week and Space Technology, Nov. 24, 1986,* p. 20.) Western Union and Swedish Space Corp. are other customers of the Long March vehicle. See Liu Jianjun, "Launching Satellites for Foreign Firms," *Beijing Review,* Jan. 26, 1987, p. 30. In April 1987, China signed its first long-term agreement with a U. S. company to market commercial booster launch services. The trade service company selected by Great Wall Industry Corp. is Becker and Associates of McLean, Virginia. See Gus Bochanis, "Chinese Launch Services to Open Local Office," *Washington Technology,* May 14, 1987, p. 6.

[80] "Some Rockets Still Work," *The Economist,* Aug. 16, 1986, p. 57, See also: Natasha Wei, "Launch Wars–With the World Space Industry in Disarray, China Hopes for a Shot at the Big Time," *The China Business Review,* September-October 1986, pp. 12-15.

[81] Phillip M. Boffey, "Science to Carry on in Space, NASA Says," *New York Times,* Aug. 19, 1986.

launch service customers."[d] CGYWC also exhibited at the Paris Air Show, June 12-21,1987.

China has been extending itself worldwide in its space efforts. China, Japan, and the United States recently held a joint meeting on space studies in Beijing, during June 1987, called the Pacific Basin International Symposium on Advances in Space Science and its Applications. This was the first time that China has invited a large group of foreign experts on space development from several countries. The forum was backed by the Chinese State Science and Technology Commission and was jointly sponsored by private organizations of the three countries, namely, the Japanese Rocket Society, the American Astronautical Society, and the Chinese Society of Astronautics. Agenda items included: 1. satellite telecommunications and development of remote sensing technology in the Pacific area, 2. space station research in the Pacific area, and 3. development of the next generation of rockets for launching satellites."

Future prospects for China in space could include cooperating with the United States, Europe, or Japan in several types of space technology.[83] China and France's Matra are presently evaluating the feasibility of offering commercial microgravity flight opportunities using recoverable reentry capsules launched by Long March 2 and 3 vehicles.[84] Chinese space officials have also talked in general terms of building an orbiting space station in the late 1990s and of a shuttle sometime later, but budget imperatives have held back development outlays.[85] Nonetheless, the Chinese have also announced that they have begun choosing a team of astronauts for future Chinese space flights, although they did not give a date for these flights. The Chinese said that their scientists had developed life support systems and the biggest centrifuge in Europe or Asia to prepare astronauts for the stresses of space flight.[8G] Several observers believe, however, despite the impressive accomplishments of the Chinese space program, that launching manned Chinese rockets is presently well beyond their ken.

Computers and Electronics

China's electronics industry has six major product areas: television, radio, and recording equipment; computers; radar and communication equipment; electronic components; professional and industrial electronics instrumentation and equipment; and military electronics." The industry is characterized by multiple ministerial-level organizations with an interest in the research, production, and application aspects of electronics technology, components, or equipment. Also of critical importance is a series of similar research and production units under the control of provincial and municipal authorities. At times, the mere presence of these numerous organizations has made for intense rivalry and competition because each of the respective ministries and localities has desired to have its own infrastructure for meeting its electronics needs.

There are over 2,600 factories in the country's electronics industry, along with over 130 research institutes and 6 dedicated universities focused on electronics technology. The Ministry of Electronics Industry (ME I) is the most important body. The extent of direct

[d]Craig Covault, "New Chinese Heavy Rocket Spurs Effort to Win Commercial Launch Contracts," *Aviation Week and Space Technology,* May *4, 1987,* pp. *22-23.*

[82]"*Sources* Say PRC to Host Space Studies Forum," *KYODO,* Tokyo, Japan from FBIS-Japan, Aug. 5, 1986.

[83]"International Notes–The Chinese and British Agree to an Exchange of Satellite Technicians," *Space Business News,* Dec. *15, 1986,* p. 1, "International Notes–China and Japan Plan to Discuss Cooperating in Space Technology in Coming Months," *Space Business News,* Aug. 11, 1986, p. 1. Some feel, however, that Japan will be very careful in tying in with the Chinese in these technology areas. This is because Japanese space technology is now coming into its own after being hobbled for several years by a technical agreement with the United States on launcher development.

[84]"Chinese Will Launch French Payloand," *Aviation Week and Space Technology,* May 4, 1987, p. 23.

[85]John F. Burns, "China's Proud Space Program–It's Modest, But Reliable," *The New York Times,* May 19, 1986, p. D 10. Also see "Chinese Make Inroads on Commercial Launch Market," *Aviation Week and Space Technology,* Mar. 9,1987, p. 134.

[86]"China Says it Plans Manned Space Flight 'Before *Long',*" *New York Times,* Sept. 2, 1986, reporting on an article appearing in *The People Daily,* Aug. 31, 1986.

[87]See Denis Fred Simon and Detlef Rehn: *"Technological Innovation in China Electronics Industry: The Case of Shanghai,"* study funded by the Volkswagen Foundation, FRG (to be published by Ballinger Publishers, Cambridge, MA).

ME I control over these facilities varies as a result of the recent divestment decision in 1985 and the degree to which local authorities are involved in overseeing the operation of specific units.'[88] As presently structured, the MEI is divided into four main departments: broadcasting (television and communication), radar and navigation, electronic devices and components, and computers. The computer department is the former State Administration of Computer Industry, which was incorporated into the ME I structure during the May 1982 bureaucratic reform.

A major organizational reform occurred in the computer industry in late 1986 with the establishment of the "Great Wall Computer Group Conglomerate. "8[9] This reform decreased the previously dominant role that MEI had played in computer R&D and production. The formation of this conglomerate, which is known in Chinese as a"jituan, is part of the general decentralization of authority in ME I as well as the effort to create better horizontal linkages among units associated with different facets of production. The GWCGC is composed of 58 existing computer production units, 4 R&D institutes and 5 universities—all drawn from ME I, the CAS, and the Beijing municipal government. The group will undertake all phases of research, manufacturing, sales and service, and training. It will operate as an integrated entity in an effort to foster coordination and minimize administrative interference from the local or central government. The core of the group will be the China Computer Development Corporation, which will be composed of 6 smaller computer companies. A similar type of organizational effort has taken place in Shanghai with the formation of the Yangtze River Computer Group Conglomerate.

Heretofore, each department under MEI controlled a series of manufacturing and research facilities. For example, under the department responsible for computers, there was a fully articulated research and development and industrial structure containing 130 enterprises and 26 research units.[89] A select number of key enterprises are still under the direct control of ME I, including those that are mainly military oriented, though most of their project money comes from the National Defense Science, Technology, and Industry Commission or other military-related organizations. In other cases, the principle of "dual leadership' is followed; i.e., enterprises are jointly administered by central and local authorities. (This does not include those enterprises that are collectively owned and controlled.) According to one Chinese official, there can be as many as 10 different organizational forms involving different mixtures of local and central control. Similar types of organizational arrangements exist under the other ministries mentioned above, such as the Ministry of Space Industry (MSI), which has a number of branch factories and research institutes located in cities such as Shanghai. Understanding these organizational principles goes a long way toward clarifying why decisionmaking in China can be so complex and why it is so difficult to carry out successful innovation.

Of the major changes in policy and organization that have been introduced to overcome these difficulties since the early 1980s, the most prominent has been the creation of the "State Council Leading Group for the Revitalization of the Electronics Industry. " This group, headed by Vice-Premier Li Peng, is designed to ameliorate the coordination problems that have dominated China's efforts to develop its electronics industry. It established the frameworkgl for the development of China's electronics industry during the Seventh Five-Year Plan (1986-90) and beyond, and included the following goals:

- The overall goal of the industry is expanded application of electronics technology in or-

[88]For details of this divestment effort see *China Daily*, Aug. 2, 1985.

[89]"New Computer Giant Eyes Home Market, *Beijing Review*, Jan. 19, 1987, pp. 5-6.

[90]See Denis Fred Simon "China's Evolving Computer Industry: The Role of Foreign Technology Transfers, June 1986 (app. 2, vol. II).

[91]See "The Strategy for the Development of China's Electronics and Information Industries" and Li Peng: "The Electronics and Information Industries Have to Serve the Construction of the Four Modernizatons," *Jingji Ribao* (Economic Daily), Jan. 14, 1985, and Xinhua, Jan. 11, 1985, *FBIS—China*, Jan. 15, 1985, pp. K25-27.

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Beijing No. 3 Computer Factory, which started manufacture ng microcomputers ı n 1981 Photo shows technicians assembling and de bugg! ng microcomputers.

der to better serve the development of the national economy and society. The popularization of microcomputers, for example, is to be stressed along with software, especially Chinese character programs;

- The acquisition and assimilation of foreign technology are to be stressed as a means of closing the prevailing gap between China and the rest of the world. Joint ventures and other forms of cooperation are to be encouraged. The aim of these measures is to complement indigenous R&D and manufacturing programs in order to "speed up the development of China's electronics industry in order to attain advanced world levels sooner and thereby increase our capacity for self-reliance;
- Greater attention should be paid to creating a fully articulated and integrated electronics industry, capable of supplying needed components and manufacturing equipment as well as final products. Within this context, the main goal is "to achieve economical, large-scale mass production with good quality and low cost. Special attention will be given to large-scale integrated circuits; the short-term goal will be "to master selected, suitable, and advanced LSI circuits;'
- Efforts should be made to establish an effective balance between centralization and decentralization with respect to the management of the electronics industry. Electronics products that require large investment, long production time, and high technology (e.g. LSI) must be produced under unified state planning and unified arrangements in order to avoid blind development and waste of time, manpower, and materials.

The Chinese have recently had some major achievements in their computer industry, as shown in table 7. However, present problems in the Chinese computer and electronics industry include lack of experience in the field, technology not up to international standards, and too little use of Chinese products. To meet their plans for national economic development, the Chinese have pushed hard in the last few years to buildup their electronics industry. However, they are not satisfied with their efforts, since they have imported much technology at considerable cost and their products, especially computers, are still not up to international standards.[92] For example, mini and mainframe computer sales to China have been substantial as shown in table 8. With appropriate foreign technology transfer, approximately 70 percent of the products of China's electronics industry could, by the year 2000, achieve the sophistication of today's products in the industrialized countries.

United States involvement in the Chinese computer and electronics market has been sig-

[92] "Electronics Poised for Big Advance," *China Daily*, Feb. 4, 1986.

Table 7.–Major Achievements in China's Computer Industry, 1977-85

1977 Development of China;s first microcomputer (DJS-050).

1979 Development of HDS-9 (5 MIPS) by CAS Institute of Computer Technology.
!levelopment of DJS-052 microprocessor (eight bit, one chip).

1983 Development of China's first supercomputer (" Yinhe" ["Galaxy"], 100 MIPS) by the S&T University for National Defense in Changsha.
Development of the 0520 microcomputer (IBM PC compatible) by the MEI Institute No. 6 and production by Beijing Wire Communications Factory.
Development of the "757" 10 MIPS parallel computer by CAS Institute of Computer Technology.
Development of a 16-bit desk-top computer (77-II) by the Lishan Microcomputer Corporation.

1984 Development of the 16-bit TQ-0671 microcomputer system by the Tianjin Computer Institute (CPI: MC 68,000),

1985 Development of NCI-AP 2701 floatina ~oint arrav Drocessor bv MEI North China Institute of Computer Technology.
Development of NCI-2780 super-min~omputer (32' bit) by Nort'h China Institute of Computer Technology (Clone ~f DEC VAX 11/780).
Development of 8030 computer by East China Institute of Computer Technology (compatible with IBM 370/138).
Development of YH-X1 super-minicomputer by the S&T University for National Defense in Changsha.

SOURCE Off Ice of Technology Assessment, 1987

Table 8.—U.S. Computer and Related Equipment Sales to China (in thousands of dollars)

Item	1981	1982	1983	1984	1985
Analog and hybrid computers . . .	163	5,041	1,715	2,082	6,767
Digital computers	5,168	11,337	11,324	25,265	80,062
Digital central processing units	5,179	2,169	10,816	32,494	35!411
Random access auxiliary storage . . .	1,052	1,049	1,849	1,519	7,399
Serial access auxiliary storage	140	430	680	1,995	5,204
Terminals	699	1,108	2,241	2,261	3,900
Printers	645	626	1,063	1,814	3,454
Communications and peripherals	268	1,644	2,301	8,006	9,175
Parts	3,763	8,376	11,913	20,476	31,710
Microprocessor integrated circuits.	104	25	4	50	47
Printed circuit boards	258	58	557	1,407	2,245
Cathode ray tubes	8	91	22	179	417

SOURCE Office of Chinese Affairs, U S Department of Commerce, 1986

nificant. Noteworthy is that in most categories of computer and related equipment sales to China, U.S. sales from the early 1980s to the present have steadily increased. The experiences of three U.S. firms-IBM, Wang, and Foxboro–which represent different approaches and goals in technology transfer to China, are presented below.

IBM China

IBM's approach to the Chinese market up until now has emphasized sales, not technology transfer.[93] This strategy may have to change soon, however, since the Chinese have become less willing to import microcomputers directly without any explicit technology transfer element. Each year since 1980, IBM has been able to sell 20-25 mainframe systems to China. In addition, several thousand IBM personal microcomputers have made their way into China, some through direct sales, but a large number through the "gray market. " IBM has also set up a training facility in China to support its sales-past, present, and future.[94]

[93]From Denis Fred Simon, "China's Evolving Computer Industry: The Role of Foreign Technology Transfers, " contractor report prepared for OTA, June 25, 1986, pp. 55-56,

[94]"Among some of the U.S. computer firms that have focused on training are the following: a) IBM, which set up a training institute in Beijing as part of its sales of the IBM 5550 and other machines; b) Wang Laboratories, which setup a joint development center with the Hubei Radio Factory and a service center in Beijing; c) INTEL, which is working with the Computer Bureau of the ME I on establishment of a training center for 500-700 persons in Beijing; and d) Sperry, which is working with the China Computer Technical Services Corporation to train Chinese operators on Sperry equipment.

In many respects, IBM's success in China has had much to do with the fact that Chinese computer officials have considered IBM products (along with the Digital Equipment Corp. 's VAX series) to be one of the standards upon which to develop their own indigenous computer industry.

In 1984, IBM China was established. This gave IBM a formal Chinese presence and signalled the Chinese Government that IBM was making a long-term commitment to China. IBM China introduced to China the Model 5550, a large microcomputer that was well received not only because of its ability to handle Chinese characters efficiently, but also because its processing capabilities are far above any Chinese mass-produced machine. In 1985, IBM donated 100 of the machines to Beijing University, Qinghua University, Fudan University, and Shanghai Jiaotong University and began training classes for 40 teachers and students in operating the computers. Chinese officials would like IBM to enter into a joint venture in Guangzhou to manufacture the 5550 in China. The idea of entering into such a joint venture, however, runs counter to IBM general approach to international marketing. Nonetheless, negotiations are continuing at this time.

Wang Joint Venture

Another U.S. computer firm that has been increasingly successful in China is Wang Laboratories, Inc.[95] Wang began doing business in China as early as 1972, though it did not really become significant until 1978-79. According to the *China Daily,* Wang has sold more than 200 small and medium-sized computers in China, most of which have been handled through its sales agreement with Instrimpex. In 1985 the company's revenues from China-related business reached more than $17 million.[9G] Along with direct sales, Wang setup a small service center in Beijing in early 1984. Several months later it joined forces with the Hubei Radio Factory in Wuhan to establish a joint development center for cooperative activities in office automation, software development, and personnel training. Wang's underlying approach to China has been a strategy emphasizing sales and production of small machines, with the hope that these sales would lead to purchases of larger machines around which all of the smaller machines could be connected and networked. Its major competitive advantage in China has been its Chinese-character operating system, known as the VS (idiographic VS) system.

In 1980 Wang began negotiating with China's ME I about establishing a joint venture in China. Three proposals emerged from these discussions:

1. a joint venture with the Shanghai Computer Corporation in Shanghai;
2. a joint venture with the Xiamen Development Corporation in Fujian; and
3. a joint venture with the Beijing 738 Wire Communication Factory in Beijing.

Initially, the aim was to introduce a CKD operation for its VS system in Beijing, a CKD operation for the Wang Office Assistant in Shanghai, and a CKD operation for the IPC (idiographic professional computer) system in Xiamen. Wang was to provide the machinery and related equipment as well as cash in on setting up the production lines. The Chinese would provide the manpower, some capital investment, the buildings, and other infrastructure.

In each of the three proposed cases, Wang's major aim was to replicate its existing facilities in the United States or elsewhere. Wang's orientation in setting up joint ventures in China was to stress consistency with its proven operations. For example, in general, Wang would not bring secondhand equipment into China; nor did it anticipate introducing any drastic changes in its mode of operation. Its hope was to use capabilities at its production sites in Ireland, Scotland, Puerto Rico, Australia, Mexico, and Taiwan to assist with the startup of its China ventures. Wang expressed

[95] Taken from the OTA contractor case study "China's Evolving Computer Industry: The Role of Foreign Technology Transfers, " prepared by Denis Fred Simon, June 25, 1986, pp. 57-61.
[96] "Wang Starts Computer Sales Drive, *China Daily,* Feb. 21, 1986.

its willingness to provide four key forms of technology transfer: manufacturing know-how, engineering and managerial know-how, software diagnostics, and after-sales service and maintenance techniques. Moreover, Wang stressed to Chinese officials that the equipment intended for use in China was equal to that being used in the Wang facilities in Taiwan. This fact prevented a major "technology transfer issue" from emerging in the negotiations–though the issue of the value of the technology did present a stumbling block at various points in the discussions.

A number of other issues also emerged during the course of negotiations between the two sides. First, the quantity and cost of training was a major concern to the Chinese. Wang made a special effort to define the number of people that would receive training, the tasks and areas of training, and the costs. In keeping with its policy of consistency, it offered China no more and no fewer training slots than it had given to other countries. China wanted as much training as possible.

Second, the question of foreign exchange remittance remained unsettled. It was agreed that after the third year, each venture would have an export requirement of up to 25 percent of the output. Heretofore, China's aim had been to have foreign firms hold large quantities of foreign exchange as an incentive for them to do more local sourcing and train local firms to be effective suppliers. And, while Wang prefers local sourcing and local employees, it is also concerned with four key considerations:

1. quality to meet worldwide standards, especially since the products would be using the Wang trademark;
2. overall cost competitiveness;
3. ability to meet delivery schedules; and
4. ability to meet volume requirements.

Overall, Wang's main concerns with engaging in manufacturing operations in China revolved around China's lack of familiarity with large-scale, mass production operations. Concerns existed about whether operations would ever get large enough to generate sufficient economies of scale to be profitable. Second, it was felt that local parochialism, combined with bureaucratic infighting, might continue to pre elude the emergence of broad perspectives on marketing approaches. Third, Wang officials feared that China's current manufacturing techniques and philosophies might interfere with meeting quality requirements. Moreover, while the potential return on Wang's equity investment in China was of direct concern, the most pressing issue was and continues to be the cost of doing business in China until the venture matures. Under these circumstances Wang's initial strategy was to keep its ventures small while minimizing unnecessary exposure and using as few expatriates as possible to prevent a drain on the joint venture's resources.

Since initial discussion began, the three proposed projects have been restructured, owing to a variety of factors on both sides. For 1986, Wang started up its first joint venture in Shanghai. Instead of producing the Office Assistant at this site, however, the IPC is being produced. The change was necessitated because the performance of the IPC has gone up and the price has gone down, thus reducing the attraction of the earlier product. The venture has required extensive renovation of an existing facility in Shanghai. The decision to proceed first with the Shanghai venture in China was not without its problems because the ME I felt somewhat concerned about its ability to control events in that municipality. The bureaucratic rivalry between MEI and Shanghai was not something that could be easily dissipated. Nonetheless, in the interest of time, and after taking existing technical capabilities into consideration, ME I acquiesced.

Foxboro Joint Venture

The Foxboro Company of Foxboro, Massachusetts, a world leader in process control technology,[97] knew that China had extensive process control needs and thus could represent a

[97] Process control technology generally involves regulation of industrial process temperatures, pressures, flow rates, etc. to maximize efficient production and maintain quality of the product, This is accomplished by connecting sensors (which measure the state of the system) to computers (which are preprogrammed or use adaptive optimal control algorithms) which then feedback to properly adjust the process.

large market for its products.'" Foxboro officials felt that an effective strategy for penetrating the Chinese market would require a long-term commitment to operations in China and a willingness to transfer its technology. From the Foxboro perspective, cooperation with China in the production of process control equipment in China would be part of a larger corporate strategy. Having visibility and a reliable presence in China, it was thought, would facilitate sales to China from Foxboro directly, from Foxboro's other overseas affiliates, and from the vendors of large process industry equipment who would incorporate Foxboro controls into larger systems. This strategy has had some success. Quite apart from the question of the profitability of the joint venture in China, sales to China from Foxboro's European operations, for instance, have been worth US$10 million in recent years.

The convergence of Chinese and American interests led to the establishment of one of the first joint ventures under China's new joint venture law, Shanghai-Foxboro Company Limited (SFCL), in April 1982.[99] The partners in the joint venture are the Foxboro Company and the Shanghai Instrumentation Company (SIC), a company under the Shanghai Instrumentation and Electronics Bureau of the Shanghai City government. The joint venture, the first involving the transfer of high technology, has attracted much attention, and was chosen as a site for President Reagan to visit during his 1984 trip to China.

The Foxboro-China connection began in 1975 when a team from Foxboro's Singapore and British affiliates presented a technical seminar in China that led to sales. '[00] In 1978 a Chinese delegation composed of representatives of the Shanghai Instrumentation and Electronics Bureau (S IEB), the Bureau of the Instrumentation Industry of the Ministry of Machine Building, and the then Ministry of Foreign Trade visited Foxboro headquarters in Massachusetts. Three exploratory visits to China by Foxboro personnel followed in the 1979-81 period.l'" Negotiations during this period resulted in the signing of preliminary agreements in support of a joint venture. A contract establishing the joint venture was signed in 1982 with the SIC, but it also had to be approved in Beijing. '"' Subsequently, as problems arose, there was uncertainty as to which Chinese party had responsibility.

Foxboro credits its affiliate in Singapore with the early vision and initiative to involve Foxboro in China. But the SFCL case is also one where the Chinese took a great deal of initiative early in the process. The Bureau of the Instrumentation Industry of the Ministry of Machine Building knew that China had process control needs that could only be met in the short run with foreign help. In addition to going to Foxboro, the Chinese also visited other companies in the United States and Japan (Honeywell, Bailey, Fisher Control, YEW, Yamataki-Honeywell). According to the Chinese management of SFCL, the Japanese were interested only in selling products and were not willing to transfer technology.

Foxboro apparently was chosen as a partner for the following reasons: First, the Chinese believed that Foxboro would be willing to transfer technology that was up to world standards. This had been the company practice in its other international operations. Second, Foxboro gave evidence of being interested in a long-term arrangement. This was again consistent with company practices elsewhere. And third, the Chinese believed that they would have in Foxboro not only a reliable source of technology, which they needed, but also a company with considerable technology transfer experience, which was indeed the case.

The Foxboro technology transfer position is that it is willing to transfer its advanced tech-

""Unless otherwise indicated, the information in this section is based upon interview s conducted in Shanghai and at Foxboro headquarters in Foxboro, Massachusetts by OTA staff.

[99]See Yao Jianguo, "High-Tech Success Against the odds,'" *Beijing Review*, No.46, Nov.17, 1986, pp. 17-19.

[100]*Intertrade*, June 1984, p. 46-47.

'("These seminars and visits, as mentioned earlier in the General Electric locomotive case study, can he a very effective means of informal technology. transfer which, in certain cases, has the potential of leading to more formal agreements and cent racts.

""Ibid.

nology if three conditions are met: (1) there is a market for the leading edge technology; (z) its transfer is economically feasible and realistic; and (3) the joint venture is able to receive and assimilate it. With regard to the latter, the key indicator for Foxboro is the availability y of manpower who not only can understand the principles of the technology, but, more importantly, have the know-how to ensure that the technical infrastructure for the technology-product testing and quality control, installation, and servicing is established and functioning.

Other important aspects of this technology transfer experience were site visits and training. There had been approximately 100 trips to Foxboro, involving 40 individuals, as of January 1986. In addition, there had been some 40,000 person-hours of training at the Shanghai facility.1°3

The joint venture is now considered relatively successful.1°4 However, during its first 6 months, there were many disappointments. The Chinese in particular believed that progress was not fast enough and kept asking, "When are you going to start making computers?" The Foxboro position was (and is) that the Chinese should "learn to walk before learning to run. " Thus, Foxboro insisted that the technology transfer start with simple tasks such as the soldering of circuit boards.

A number of important factors pertain to the assimilation of this technology. One is the availability of technical manpower. SFCL employs 328 people (up from 287 at the beginning of the joint venture), of whom 120 are reported to be engineers. This is an exceptionally high proportion of technical manpower for a Chinese enterprise. This relative abundance is a measure of the commitment of the Government to the joint venture and to the importance of the process industry. Nevertheless, the Chinese management of SFCL believes that the lack of trained personnel is one of the more important limiting factors on the company. The U.S. management does not seem to be as concerned about this constraint as it is about others.

A second factor is the Chinese supply system and the local availability of inputs for manufacturing. In the Foxboro view, localization is proceeding too slowly. The mentality of solving supply problems through vertical integration, a legacy of the Soviet-style economy, is deeply entrenched and biases solutions to the supply problem in the wrong direction. In addition, the Chinese supplier industries are not seeking the right technologies. The Chinese continue to resist the kind of specialization that would lead firms to seek product niches and search for the right technologies to achieve some sort of comparative advantage.

Another type of assimilation problem is the difference in language and culture. The language problem was attacked early with the preparation of an English-Chinese process control glossary. The time and effort spent in compiling this glossary has been most worthwhile from the Foxboro perspective. There are now standardized meanings for the technical terms associated with the technology, and these have made possible the avoidance of much confusion. The cultural differences may be harder to deal with, especially the risk aversion which the American managers perceive among the Chinese at the middle and lower ranks.

According to Foxboro, there were also export control problems at the outset, which the Chinese partners resented. The problem with the U.S. Government was largely an educational one; much effort was required to inform the Government of what was anticipated in Foxboro's operations in China. The Government had concerns about the computer embedded in the process control equipment and about networking capabilities that might be transferred. Some of the components used in the system were also an issue, and there were licensing delays until Foxboro was able to demonstrate that the computer in the system was technically "dedicated" to process control use.

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[103] *Intertrade*, June 1984, p. 47.

[104] Its business reached $7.5 million in 1986, a 37 percent increase over 1985. It has been in operation for four years, and in that time the company has sold 140 sets of automatic-control apparatus and meters to power-generating stations and petrochemical and metallurgical plants in China. It plans to put three new products into production in 1987. ("Electrical Joint Venture with U.S. Reports Growth, " *Xinhua*, Jan. 31, 1987.)

The liberalization of U.S. export controls for sales to China in 1983 facilitated the introduction of digital technology to SFCL.

The relative success of SFCL is due to a number of factors. Foxboro is a well-run company with a highly regarded product and considerable technology transfer experience. Its technology is in great demand in China and has a strategic importance for Chinese modernization. The initiative for cooperation with Foxboro came from a powerful ministry, and the joint venture seems to enjoy high-level political support, as indicated, for instance, by SFCL'S ability to recruit a high proportion of educated technical manpower. Top Chinese managers of SFCL were involved with the project from the beginning, and Foxboro's establishment of the special China team seems to have been important.

From the Foxboro perspective, one of the key questions for the future of technology transfer is whether the Chinese will become more imaginative in problem solving, more creative, and less risk averse. The Chinese still focus too much on the more advanced technology. Foxboro has introduced the Fox 300, a digital machine, into China but has not made it the focus of its technology transfer activities. Instead, the Foxboro efforts have centered on the transfer and assimilation of the Spec 200, an analog machine. Foxboro believes that the Chinese should concentrate on mastering the technology of the Spec 200, which is quite suitable for their needs, but the Chinese are still fascinated with the 300.

The Role of the Small-to-Medium-Size Firm

Heretofore, it has appeared that most firms involved in the Chinese market have been large in terms of overall personnel, earnings, and sales. The costs of doing business in China, including long negotiations, frequent trips to China, and the hosting of numerous Chinese delegations to the United States, is prohibitive for many small companies. Nonetheless, analysis of the American business presence in China reveals the participation of an appreciable number of small-to-medium-size firms (firms with less than US$1OO million in annual sales). While few of these smaller firms have made direct equity investments in China, they have been able to engage in a broad range of activities in China, including technology transfer, services, direct sales, and training.

In a survey commissioned by OTA, it was found that among the smaller U.S. firms involved in the China market, most tend to be driven by short-term prospects and immediate sales opportunities; only among larger firms was the long-term perspective part of a strategic orientation toward the Chinese market.l"' Interestingly, however, many of the smaller firms involved in China have also had a significant number of other international business relationships, thus suggesting that "going international" was not new to them. Moreover, despite the difficulties associated with doing business in China, the smaller companies seemed prepared to expand their level of activity wherever possible.

Smaller firms seem to have many advantages for doing business in China. First, their size provides them with greater flexibility to respond to China's changing economic and technology needs. These firms tend to have a greater ability to pursue a market niche strategy in China, carving out a very specialized place in the midst of increasingly strong competition from both other U.S. firms and foreign companies. Second, within these firms themselves, it is often easier to reach a decision on a Chinese business proposal. And third, because of their relatively smaller scale, these firms are willing to handle a series of smaller sales and related business transactions. According to the survey, because of these factors, a number of respondents indicated that over time small firms may have a better chance of succeeding in China than their larger competitors.

"" Survey on Transfer of Technical and Scientific Information and/or Sales to the People's Republic of China, " administered for OTA by the Midwest China Center during November 1986 (app. 9, vol. II).

The most significant problems encountered by small firms had to do with the length of the negotiation process and the process by which their contacts with China were initiated. Most firms, large and small, tended to underestimate the time needed to complete a negotiation. Because of their size and personnel constraints, smaller firms tend to encounter significant opportunity costs when they have to send one or two of their key technical or managerial personnel to China for extended periods. They also felt that they were at a disadvantage because their size usually precluded the opening of a permanent office in China to represent the company and market its products. Only 35 percent of the small firms had some sort of office or representation in China, in contrast to 64 percent of the large firms.

The business people surveyed felt that export control procedures did affect their ability to compete with firms from other nations. One large firm has four full-time professionals and five secretaries working on licensing regulations while another uses a total of eight people–all of which adds to the cost of the product. When asked whether U.S. Government export control procedures had substantially affected their business with China, approximately one-quarter of the respondents said yes, one-half said no, and the remainder said that export controls were not applicable to their line of business with China. Suggestions for improvement of export controls included regulatory personnel with the proper technical background. At present many are not able to understand a complex technology and lack the insight to judge its relevance to military applications. In addition, many take a rigid approach to interpreting the rules regarding technology.

Many firms commented about their need for more and better information about China and the Chinese market both before and after they began business activities in China. In particular, they stressed the need for additional information about decision making in China. Generally, they felt dissatisfied with the quality of the information and support being provided by U.S. Government agencies as well as by the respective State agencies responsible for international business promotion. Trade shows were cited as a more useful mechanism for obtaining needed information, as were private consultants, though locating appropriate consultants was difficult.

Among the small-to-medium-size firms, there does not seem to be a particular pattern emerging with respect to their industrial or technological orientation. Both high-technology and standard technology firms are involved in China. For example, in a sample of such firms conducted by the Office of Domestic Operations of the U.S. and Foreign Commercial Service, Department of Commerce, the industries covered included everything from computer software, advanced laboratory analysis equipment, and cardiac monitoring equipment to providing coal analysis, ice cream production know-how, and the transfer of hog confinement techniques and related equipment.

GOVERNMENT AND INSTITUTIONAL TECHNOLOGY TRANSFER

The U.S. Government-Supported Programs

Right after the establishment of diplomatic relations in 1979, President Carter and Deng Xiaoping signed the landmark document "Agreement on Cooperation in science and technology' in Washington, D.C. This accord is the major bilateral Science and Technology program between the United States and China and provides the umbrella under which subsequent scientific, technological, and educational exchanges have occurred. It covers a wide range of activities, including educational ex-

[106] *A Relationship Restored: Trends in U. S,-China Educational Exchanges, 1978-1984* (Washington, DC: National Academy Press, 1986), p. 62.

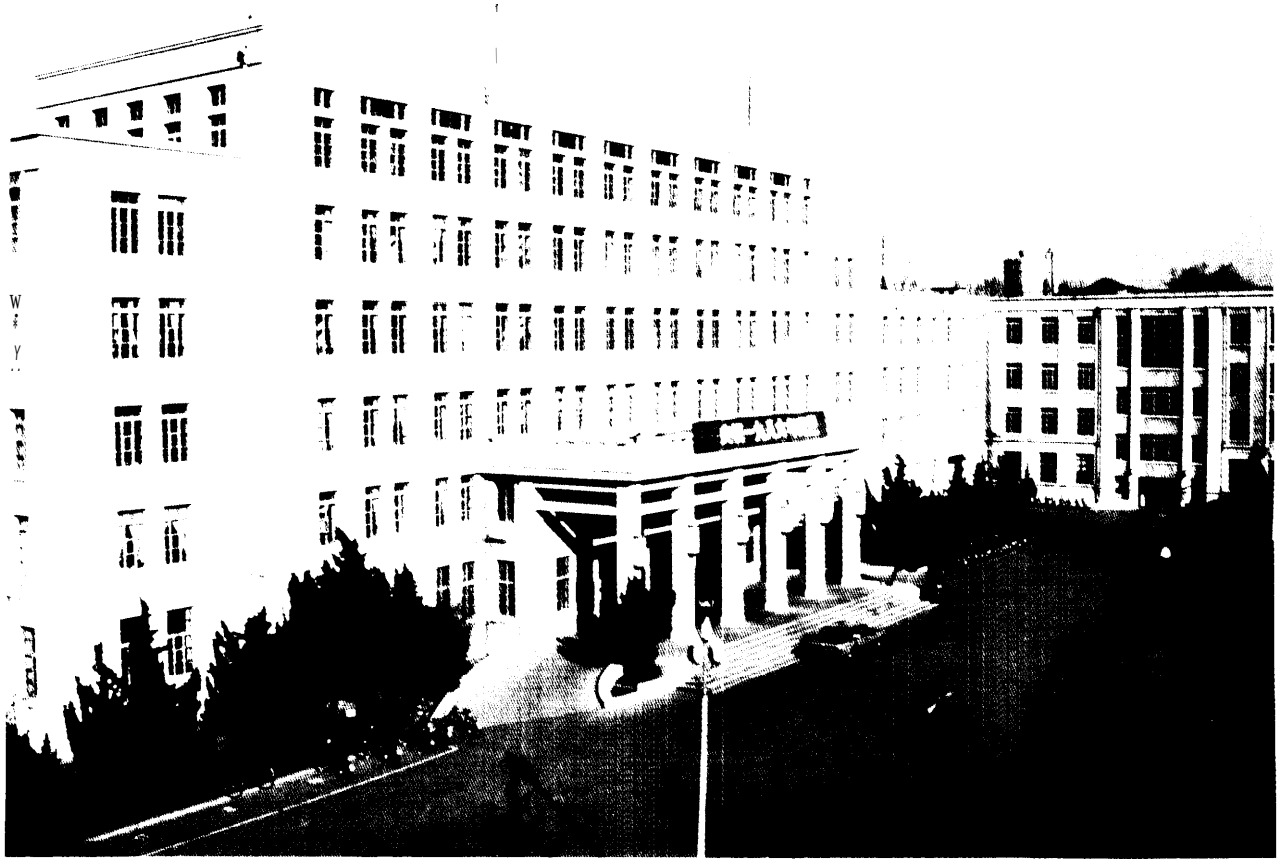

Photo credit Erfc O Basques

The Dal Ian Management Institute (The National Center for Industrial Science and Technology Management Development) located at the Dal Ian Institute of Technology was established in accordance with the US-PRC Science and Technology Protocols, It is jointly sponsored by the State Economic Commission, the State Science and Technology Commission and the Mi nl nstry of Education on the Chinese side and by the Department of Commerce on the U.S. side. This highly successful management training program started in 1980.

change, space technology, high-energy physics, earthquake studies, and telecommunications. The earliest agreements started in 1978-79, with new ones being added periodically. The active agreements and some pending ones as of June 1986 are listed in Appendix B.

There are two overarching U.S.-China commissions that have fundamental responsibility for establishing the basis for U.S.-China economic cooperation. The U.S. Treasury Department is represented on the Joint Economic Commission, whereas the Department of Commerce is the U.S. representative on the Joint Commission for Commerce and Trade. Both commissions have interests in technology transfer arrangements.

Other programs in China are the Fulbright Program and the activities of the National Science Foundation. The Committee on Scholarly Communication with the People's Republic of China (CSCPRC) has also been active in this arena since its founding in 1966 under the joint sponsorship of the American Council of Learned Societies, the National Academy of Sciences (NAS), and the Social Science Research Council. The CSCPRC is designated to administer the National Program for Advanced Research and Study in China. In addition to this national

program they have also run the reciprocal “Distinguished Scholar Exchange Program” since 1979.

Bilateral Agreements

The number of bilateral accords in science, technology, or education between Chinese and U.S. Government agencies grew from 2 to 26 between 1978 and 1986. It was felt that giving major government agencies in each country a stake in improved U.S.-China relations would help institutionalize the Sine-American relationship more rapidly. Appendix B shows that the agreements cover abroad range of scientific areas, including: agriculture, space technology, high-energy physics, medicine and public health, earthquake studies, aeronautics, management, nuclear safety, transportation, and telecommunications. Activities under most of these agreements are funded under existing agency budgets, not through special appropriations. Thus these agreements have led to varying degrees of activity, depending on agency priorities.

As of 1985, some of the most intensive activity was under the aegis of the protocols on atmospheric science and technology, marine and fishery science and technology, the earth sciences, earthquake studies, and management of industrial science and technology (under which the Dalian Management Center was set up). Interactions under the 1979 “Understanding on Agricultural Exchange’ were extensive until November 1983, when activities were suspended because China did not import the quantity of U.S. grain called for in a long-term agree ment. 1°7 Activities under this exchange have recently resumed, however.

Under the auspices of the United States-China Accord on Industrial and Technological Cooperation, the Department of Commerce and China’s Ministry of Foreign Economic Relations and Trade have developed a series of work programs that target U.S. Government trade and investment promotion activities and U.S. private sector interests on priority development projects. Work programs exist in aerospace, electronics and telecommunications, machine building, metallurgy, and building materials.

Student Exchange

Included in the U.S.-China science and technology agreement was the previous “Understanding on Educational Exchanges, ” signed in October 1978, which provided for the exchange of undergraduate students, graduate students, and visiting scholars to undertake research and study in each country.

During the 1985-86 academic year, about 17,000 Chinese students and professors were enrolled in U.S. universities, mostly in graduate programs of science and engineering.[108] Nationwide, Chinese students were the 11th largest group of foreign students in the United States during the 1984-85 school year, behind Taiwan, Malaysia, Nigeria, Iran, South Korea, Canada, India, Japan, Venezuela, and Hong Kong. [109]

Most of the Chinese students coming to the United States under the revived U. S.-China educational exchange program have been concentrated heavily in science and other technical disciplines. Over two-thirds of those sponsored by the Government were in the physical, life, health, or computer sciences, mathematics, and engineering.

About one-half of all Chinese students and scholars sent abroad come to the United States. The rapid buildup in the numbers of students and scholars coming to the United States is said to have made the exchanges an important element in China’s effort at modernization. How effectively these students’

[107] 1 bid,, p. 64.

[108] Chinese Embassy, Washington, DC, 1986.

[109] Institute of International Education in New York, figures quoted in the *Philadelphia Inquirer*, Andrew May Kuth, “Chinese Students Soak Up Technology to Take Back Home, ’ July 4, 1986, p. 1B.

[110] The number of U.S. students and scholars going to China under the exchanges has been smaller and in different academic fields. An estimated 3500 Americans participated in exchanges from 1978 through 1984 with a majority pursuing short-term language study. Of those who performed research, two-thirds were in the social sciences and humanities.

[111] *A Relationship Restored: Trendsin U.S.-China Educational Exchanges, 1978-1984* (Washington, DC: National Academy Press, 1986), p. 62.

skills are used when they return to China is open to debate.[112] Most would agree, however, that Chinese students regard their studies in the United States favorably.[113]

Statistics on Chinese students in the United States are very uncertain but about one-third of the students have been financed by relatives who live outside of China. However, China may have decided to foreclose this approach.'" The majority of the students are funded by grants from the Chinese Government. Increasingly, the Chinese Government funds students for only the first year abroad and expects them to find financial aid to complete their training.[115] The U.S. Government does not allow foreign students into the country unless they can prove that they have adequate funds. In addition, acceptance of a nonimmigrant exchange visitor visa may, in certain circumstances, subject the holder to a 2-year foreign repatriation requirement upon termination of status. 116 The Chinese Government official position is that only those students who accept grants from the Chinese Government are required to return. 'l' The Chinese students generally do want to return. In the few cases where they sought to stay, however, the Chinese have exerted tremendous diplomatic pressure.1'[8]

Private Programs

U.S. company support for technology transfer through training has been demonstrated in several instances. One example with great future potential is the Telecommunications Training Institute, where training of developing country telecommunications specialists is performed on U.S. company premises. Of a different nature is a large university-industry collaboration between China and the Georgia Institute of Technology called China/Tech. This is a Chinese-American joint venture between Technology Exchange Corp., a private company in Atlanta, and the Technology Clearinghouse of China, a Chinese corporation wholly owned by and operated under the guidance of CAST (Chinese Association for Science and Technology). China./Tech will provide a wide range of consulting services to U.S. companies that are interested in setting up new ventures or in licensing technology to China. The entire Georgia Tech staff is available for consulting services, and the 1.4 million Chinese scientists and engineers who are members of CAST will keep China/Tech apprised of China's modernization efforts.'"

[112] See for example, Leo A. Orleans, "Chinese Students and Technology Transfer, *Journal of Northeast Asian Studies*, vol. IV, No. 4, winter 1985, p. 3 ff.

[113] 'This establishment of " 'personal ties' could be influential in future U.S.-China economic relations. Chinese students trained in the United States are absorbing preferences for U.S. technology and equipment which may help perpetuate the apparent Chinese preference for U.S. technology.

[114] Leo A. Orleans, personal communication, June 1987.

[115] Ibid.

[116] *Foreign Nationals in the United States–Information Guide—1986* Edition, Price Waterhouse Center for Transnational Taxation, New York, pp. 62-63.

[117] ""The Chinese say that they have sent more than 30,000 students overseas at state expense since 1978. So far about half of them have completed their courses and returned to China. However, of those who went at their own expense, 40 percent of all students abroad, only a small number returned. (" Study Abroad: No Panic, " *Beijing Review*, vol. 30, No. 2, Jan. 12,1987, pp. 6-7,)

[118] *Philadelphia Inquirer,* op. cit.

[119] Otis Port, "Georgia Tech Has China On ts Mind, " *Business Week*, Mar. 31, 1986, p. 70H.

CONCLUSION

The Chinese have targeted the energy, transportation, and communications technology sectors as priority areas in their most recent 5-year plan. Large-scale technology transfer from industrialized countries is essential for China's continued economic development. Areas of foreign expertise likely to be in great est demand thus include conventional and nuclear electric power production, automobile technology, rail technology, telephone switching systems, fiber optics, and computers. Management expertise is also a critical need for the Chinese.

The investment climate in China remains unattractive for many U.S. companies, and any changes will come slowly. However, as the Chinese reforms proceed and new benchmarks are established, the investment climate will probably improve. This is because the Chinese realize that the degree to which China accomplishes its modernization goals will depend on the importation and application of advanced technologies throughout the economy. Prospects for joint ventures may improve since the foreign investment law of October 11, 1986 was codified with 16 sets of detailed implementing regulations covering specific investor concerns in March 1987. Also, despite specific problems of their own (usually involving proprietary rights or foreign exchange), licensing agreements will continue to be a common mode of technology transfer for foreign companies, particularly since the Chinese have apparently agreed to honor patent conventions. If the patience and perseverance of U.S. firms can be matched by Chinese pragmatism, U.S. ventures in the Chinese market can truly become those of “equality and mutual benefit. ”

APPENDIX A: PROVISIONS OF THE STATE COUNCIL OF THE PEOPLE'S REPUBLIC OF CHINA FOR THE ENCOURAGEMENT OF FOREIGN INVESTMENT (PROMULGATED ON OCTOBER 11, 1986)

Article 1. These provisions are hereby formulated in order to improve the investment environment, facilitate the absorption of foreign investment, introduce advanced technology, improve product quality, expand exports in order to generate foreign exchange, and develop the national economy.

Article 2. The State encourages foreign companies, enterprises, and other economic entities or individuals (hereinafter referred to as "foreign investors") to establish Chinese-foreign equity joint ventures, Chinese-foreign cooperative ventures and wholly foreign-owned enterprises (hereinafter referred to as "enterprises with foreign investment") within the territory of China,

The State grants special preferences to the enterprises with foreign investment listed below:

- production enterprises whose products are mainly for export, which have a foreign exchange surplus after deducting from their total annual foreign exchange revenues the annual foreign exchange expenditures incurred in production and operation and the foreign exchange needed for the remittance abroad of the profits earned by foreign investors (hereinafter referred to as "export enterprises"); and
- production enterprises possessing advanced technology supplied by foreign investors which are engaged in developing new products, and upgrading and replacing products in order to increase foreign exchange generated by exports or for import substitution (hereinafter referred to as "technologically advanced enterprises' ').

Article 3. Export enterprises and technologically advanced enterprises shall be exempt from payment to the State of all subsidies to staff and workers, except for the payment of or allocation of funds for labor insurance, welfare costs, and housing subsidies for Chinese staff and workers in accordance with the provisions of the State.

Article 4. The site use fees for export enterprises and technologically advanced enterprises, except for those located in busy urban sectors of large cities, shall be computed and charged according to the following standards:

- five to twenty RMB yuan per square metre per year in areas where the development fee and the site use fee are computed and charged together, and
- not more than three RMB yuan per square metre per year in site areas where the development fee is computed and charged on a one-time basis or areas which are developed by the above-mentioned enterprises themselves.

Exemptions for specified periods of time from the fees provided in the foregoing provision may be granted at the discretion of local people's governments.

Article 5. Export enterprises and technologically advanced enterprises shall be given priority in obtaining water, electricity and transportation services, and communication facilities needed for their production and operation. Fees shall be computed and charged in accordance with the standards for local state enterprises,

Article 6. Export enterprises and technologically advanced enterprises, after examination by the Bank of China, shall be given priority in receiving loans for short-term revolving funds needed for production and distribution, as well as for other needed credit.

Article 7. When foreign investors in export enterprises and technologically advanced enterprises remit abroad profits distributed to them by such enterprises, the amount remitted shall be exempt from income tax.

Article 8. After the expiration of the period for the reduction of exemption of enterprise income tax in accordance with the provisions of the State, export enterprises whose value of export products in that year amounts to 70 percent or more of the value of their products for that year, may pay enterprise income tax at one-half the rate of the present tax.

Export enterprises in the special economic zones and in the economic and technological development zones and other export enterprises that already pay enterprise income tax at a tax rate of 15 percent and that comply with the foregoing conditions, shall pay enterprise income tax at a rate of 10 percent.

Article 9. After the expiration of the period of reduction or exemption of enterprise income tax in accordance with the provisions of the State, tech-

nologically advanced enterprises may extend for 3 years the payment of enterprise income tax at a rate reduced by one half.

Article 10. Foreign investors who reinvest the profits distributed to them by their enterprises in order to establish or expand export enterprises or technologically advanced enterprises for a period of operation of not less than **5 years,** after application to and approval by the tax authorities, shall be refunded the total amount of enterprise income tax already paid on the reinvested portion. If the investment is withdrawn before the period of operation reaches **5 years,** the amount of enterprise income tax refunded shall be repaid.

Article 11. Export products of enterprises with foreign investment, except crude oil, refined oil, and other products subject to special State provisions, shall be exempt from the consolidated industrial and commercial tax.

Article 12. Enterprises with foreign investment may arrange the export of their products directly or may also export by consignment to agents in accordance with State provisions. For products that require an export license, in accordance with the annual export plan of the enterprise, an application for an export license maybe made every six months.

Article 13. Machinery and equipment, vehicles used in production, raw materials, fuel, bulk parts, spare parts, machine component parts and fittings (including imports restricted by the State), which enterprises with foreign investment need to import in order to carry out their export contracts do not require further applications for examination and approval and are exempt from the requirement for import licenses. The customs department shall exercise supervision and control, and shall inspect and release such imports on the basis of the enterprise contract or the export contract.

The imported materials and items mentioned above are restricted to use by the enterprise and may not be sold on the domestic market. If they are used in products to be sold domestically, import procedures shall be handled in accordance with provisions and the taxes shall be made up according to the governing sections.

Article 14. Under the supervision of the foreign exchange control departments, enterprises with foreign investment may mutually adjust their foreign exchange surpluses and deficiencies among each other.

The Bank of China and other banks designated by the People's Bank of China may provide cash security services and may grant loans in Renminbi to enterprises with foreign investment.

Article 15. The people's governments at all levels and relevant departments in charge shall guarantee the right of autonomy of enterprises with foreign investment and shall support enterprises with foreign investment in managing themselves in accordance with international advanced scientific methods.

With the scope of their approved contracts, enterprises with foreign investment have the right to determine by themselves production and operation plans, to raise funds, to use funds, to purchase production materials, and to sell products; and to determine by themselves the wage levels, the forms of wages and bonuses, and the allowance system.

Enterprises with foreign investment may, in accordance with their production and operation requirements, determine by themselves their organizational structure and personnel system, employ or dismiss senior management personnel, and increase or dismiss staff and workers. They may recruit and employ technical personnel, managerial personnel, and workers in their locality. The unit to which such employed personnel belong shall provide its support and shall permit their transfer. Staff and workers who violate the rules and regulations, and thereby cause certain bad consequences may, in accordance with the seriousness of the case, be given differing sanctions, up to that of discharge. Enterprises with foreign investment that recruit, employ, dismiss, or discharge staff and workers, shall file a report with the local labour and personnel department.

Article 16. All districts and departments must implement the "Circular of the State Council Concerning Firmly Curbing the Indiscriminate Levy of Charges on Enterprises. " The people's governments at the provincial level shall formulate specific methods and strengthen supervision and administration.

Enterprises with foreign investment that encounter unreasonable charges may refuse to pay and may also appeal to the local economic committees up to the State Economic Commission.

Article 17. The people's governments at all levels and relevant departments in charge shall strengthen the co-ordination of their work, improve efficiency in handling matters and shall promptly examine and approve matters reported by enterprises with foreign investment that require response and resolution. The agreement, contract and articles of

association of an enterprise with foreign investment shall be examined and approved by the departments in charge under the State Council. The examination and approval authority must within three months from the date of receipt of all documents decide to approve or not to approve them.

Article 18. Export enterprises and technologically advanced enterprises mentioned in these provisions shall be confirmed jointly as such by the foreign economic relations and trade departments where such enterprises are located and the relevant departments in accordance with the enterprise contract, and certification shall be issued.

If the actual results of the annual exports of an export enterprise are unable to realize the goal of the surplus in the foreign exchange balance that is stipulated in the enterprise contract, the taxes and fees which have already been reduced or exempted in the previous year shall be made up in the following year.

Article 19. Except where these provisions expressly provide that they are to be applicable to export enterprises or technologically advanced enterprises, other articles shall be applicable to all enterprises with foreign investment.

These provisions apply from the date of implementation to those enterprises with foreign investment that have obtained approval for establishment before the date of implementation of these provisions and that qualify for the preferential terms of these provisions.

Article 20. For enterprises invested in and established by companies, enterprises, and other economic organizations or individuals from Hong Kong, Macao, or Taiwan, matters shall be handled by reference to these provisions.

Article 21. The Ministry of Foreign Economic Relations and Trade shall be responsible for interpreting these provisions.

Article 22. These provisions shall go into effect on the date of issue.

SOURCE: *Beijing Review*, No. 43, Oct. 27, 1986.

APPENDIX B: PROTOCOLS AND MEMORANDA OF UNDERSTANDING UNDER THE U. S.-PRC AGREEMENT ON COOPERATION IN SCIENCE AND TECHNOLOGY

1. Agreement:	Understanding on Exchange of Students and Scholars
Date signed:	October 1978, Exchange Letter of January 1979
Date extended:	Unlimited
U.S. agency:	USIA, DOE, NSF, NAS, NEH
Chinese unit:	MOE, CASS, SSTC
2. Agreement:	Understanding on Agricultural Exchange
Date signed:	November 1978
Date extended:	Unlimited
U.S. agency:	USDA, USGS, and DOI/Fish and Wildlife Service
Chinese unit:	Ministry of Agriculture, Animal Husbandry, and Fisheries
3. Agreement:	Understanding on Space Technology (overall protocol on Space Science Application and Technology currently under negotiation)
Date signed:	January 31, 1979
Date extended:	Unlimited
U.S. agency:	NASA
Chinese unit:	Chinese Academy of Space Technology (under the Ministry of Astronautics) and CAS
4. Agreement:	Implementing Accord on Cooperation in the Field of High Energy Physics
Date signed:	January 31, 1979
Date extended:	February 1984
U.S. agency:	February 1989
Annexes and dates:	Annex June 12, 1979, Joint Committee Reports 1979-1980, 1980-1981, 1982-1983
U.S. agency:	DOE
Chinese unit:	CAS (formerly signed with SSTC)
5. Agreement:	Protocol on Cooperation in the Field of Metrology and Standards
Date signed:	May 8, 1979

Date extended: May 8, 1984
Date expired: May 8, 1989
Annexes and dates: Annex (1) May 8, 1979; Annex (2), May 5, 1981 (supersedes Annex (l). (Annexes do not apply to extension.)
U.S. agency: DOC (National Bureau of Standards)
Chinese unit: State Bureau of Metrology and State Bureau of Standardization

6, Agreement: Protocol on Cooperation in the Field of Atmospheric Science and Technology
Date signed: May 8, 1979
Date extended: May 1984
Date expires: May 1989
Annexes and dates: Annex (l), May 1979; Annex (2), May 1979; Annex (3), September 1980; Annex (4), September 1980; Annex (5), November 1981; Annex (6), November 1981
U.S. agency: NOAA, NSF, NASA, USDA
Chinese unit: State Meteorological Administration

7. Agreement: Protocol on the Field of Marine and Fishery Science and Technology
Date signed: May 8, 1979
Date extended: May 1984
Date expires: May 1989
Annexes and dates: Annex (l), May 1979; Annex (2), Working Group Meeting 1980; Annex (3), Working Group Meeting 1982; Annex (4), Working Group Meeting 1984
U.S. agency: NOAA, NSF
Chinese unit: National Bureau of Oceanography and Ministry of Agriculture, Animal Husbandry and Fisheries

8, Agreement: Protocol on Cooperation in the Sciences and Technology of Medicine and Public Health
Date signed: June 22, 1979
Date extended: Extension under negotiation
Date expired: June 22, 1984
Annexes and dates: Annex (l), November 1980; Annex (2), November 1980; Annex (3), January 1982
U.S. agency: HHS (NIH)
Chinese unit: Ministry of Public Health

9. Agreement: Protocol on Cooperation in Hydroelectric Power and Related Water Resource Management
Date signed: August 28, 1979
Date extended: Expired; no plans for extension
Date expired: August 28, 1984
Annexes and dates: Annex (l), March 1980; Annex (2), September 1982
U.S. agency: DOC, DOI (Bureau of Reclamation, Corps of Engineers, Tennessee Valley Authority)
Chinese unit: Chinese Ministry of Water Resources and Electric Power

10. Agreement: Protocol for Scientific and Technical Cooperation in the Earth Sciences
Date signed: January 24, 1980
Date extended: January 24, 1985
Date expires: January 24, 1990
Annexes and dates: Annex (l), Patents, November 1981; Annex (2); Annex (3); Annex (4), Copyrights; Annex (5); Annex (6) Working Group Meeting 1984
U.S. agency: DOI (USGS) and NSF
Chinese unit: Chinese Academy of Geological Sciences

11. Agreement: Protocol for Scientific and Technical Cooperation in Earthquake Studies
Date signed: January 24, 1980
Date extended: January 24, 1985
Date expires: January 23, 1990
Annexes and dates: Annexes (l-8)
U.S. agency: USGS and NSF
Chinese unit: Chinese State Seismological Bureau

12. Agreement: Protocol for Scientific and Technical Cooperation in the Field of Environmental Protection
Date signed: February 5, 1980
Date extended: February 1985
Date expires: February 1989
Annexes and dates: Annexes (l-3)
U.S. agency: Environmental Protection Agency
Chinese unit: Office of the Environmental Protection Leading Group

13. Agreement: Protocol on Cooperation in the Basic Sciences
Date signed: December 10, 1980
Date expired: December 1985
Annexes and dates: Annex (l), Patents and Copyrights, March 1981
U.S. agency: NSF
Chinese unit: CAS and CASS

14. Agreement_,: Protocol on Cooperation in the Field of Building Construction and Urban Planning Science and Technology
Date signed: October 17, 1981
Date expires: October 1986
Annexes and dates: Annex (1)
U.S. agency: Department of Housing and Urban Development
Chinese unit: Ministry of Urban and Rural Construction and Environmental Protection

15. Agreement: Protocol on Cooperation in Nuclear Safety Matters
Date signed: October 17, 1981
Date expires: October 1986
U.S. agency: NRC
Chinese unit: National Nuclear Safety Administration (formerly SSTC)

16. Agreement: Protocol on Scientific and Technical Cooperation in the Study of Surface Water Hydrology
Date signed: October 17, 1981
Date expires: October 1986
Annexes and dates: Annexes (l-4), 1983; Annexes (5-6), 1985
U.S. agency: DOI ([JSGS)
Chinese unit: Bureau of Hydrology (under the Ministry of Water Conservancy)

17. Agreement: Cooperation in the Fields of Nuclear Physics and Controlled Magnetic Fusion Research
Date signed: May 11, 1983
Date expires: May 1988
Annexes and dates: Annexes (l-5), 1985
U.S. agency: DOE
Chinese unit: SSTC

18. Agreement: Cooperation in Aeronautical Science and Technology
Date signed: May 11, 1983
Date expires: May 1988
Annexes and dates: Annex (l), Copyrights, April 5, 1985; Annex (2), April 5, 1985
U.S. agency: NASA
Chinese unit: Chinese Aeronautical Establishment (under the Ministry of Aeronautics)

19. Agreement: Protocol on Cooperation in Science and Technology of Transportation
Date signed: May 11, 1983
Date expires: May 1988
U.S. agency: Department of Transportation
Chinese unit: Ministry of Communications

20. Agreement: Protocol on Cooperation in the Field of Scientific and Technical Information
Date signed: May 8, 1979
Date extended: April 30, 2984

Date expires: April 1989
Annexes and dates: Annex (l); Annex (2-4), February 8, 1982
U.S. agency: DOC (NTIS)
Chinese unit: ISTIC (under SSTC

21. Agreement: Cooperation in the Field of Management of Industrial Science and Technology
Date signed: May 1979
Date extended: April 1984
Date expires: April 1989
U.S. agency: DOC
Chinese unit: State Economic Commission, SSTC, MOE

22. Agreement: Protocol on Cooperation in Statistics
Date signed: July 24, 1984
Date expires: July 1989
U.S. agency: DOC (Bureau of the Census)
Chinese unit: State Statistical Bureau

23. Agreement: Memorandum of Understanding on Cooperation in the Basic Biomedical Sciences
Date signed: May 11, 1983
Date expires: May 1988
U.S. agency: NIH
Chinese unit: CAS

24. Agreement: Protocol for Scientific and Technical Cooperation in Surveying and Mapping Studies
Date signed: April 16, 1985
Annexe~ and dates: Annex (l), 1985
U.S. agency: USGS/Defense Mapping Agency
Chinese unit: National Bureau of Surveying and Mapping (under SSTC)

25. Agreement: Protocol on Cooperation in the Field of Fossil Energy Research and Development
Date signed: April 16, 1985
Annexes and dates: Annex (l), 1985
U.S. agency: DOE
Chinese unit: Ministry of Coal Industry

Under negotiation:

1. Agreement: Landsat Ground Station Memorandum of Understanding
U.S. agency: DOC (NOAA/NESDIS)
Chinese unit: CAS

2. Agreement: Telecommunications
U.S. agency: DOC
Chinese unit: Ministry of Post and Telecommunications

3. Agreement: Health Memorandum of Understanding between the Center for Disease Control and the China National Center for Preventive Medicine
U.S. agency: HHS (PHS and CDC)
Chinese unit: China National Center for Preventive Medicine

ABBREVIATION KEY. *U.S. agencies:* CDC Centers for Disease Control; DOC Department of Commerce; DOE Department of Energy, DOI Department of the Interior, HHS Department of Health and Human Services, NAS National Academy of Sciences; NASA National Aeronautics and Space Administration; NBS National Bureau of Standards; NEH National Endowment for the Humanities; NESDIS National Environmental Satellite Data and Information Service; NIH National Institutes of Health: NOAA National Oceanic and Atmospheric Administration; NRC Nuclear Regulatory Commission, NSF National Science Foundation; NTIS National Technical Information Service; PHS Public Health Service, USDAU S Department of Agriculture, USGS U S Geological Survey, USIA U S. Information Agency.
Chinese units CAS Chinese Academy of Sciences, CASS Chinese Academy of Social Sciences: ISTIC Institute of Science and Technology Information of China, MOE Ministry of Education: SSTC State Science and Technology Commission

SOURCE;. *A Relationship Restored. Trends m U S.. China Educational Exchange. 1978-1984,* National Academy Press, Washington, DC, 1986