CHINA'S EVOLVING COMPUTER INDUSTRY:

THE ROLE OF FOREIGN TECHNOLOGY TRANSFERS

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A. Introduction

> "In the 1950s we began to develop computers through copying; since then, there has always been a tendency to emphasize hardware over software, mainframes over peripherals and components, research and design over technology and production, applicative experiments over practical results. Thus, for a long time, computers produced in our country have been known to be unreliable, unsupported, not easy to use, and not easy to repair. Moreover, we have too many varieties of computers which are largely identical with only a few minor differences. In addition, our computers are not produced in batches and development is rather slow. As facts have proven, this is not a good strategy for developing computers."[1]
> (Remarks of a researcher from the Institute of Computer Technology, Chinese Academy of Sciences)

Since the announcement of the four modernization program in the mid-1970s, China has paid special attention to the development of its computer industry. In the March 1978 S&T plan, for example, computers were one of the eight priority areas singled out by the leadership. The main impetus for pushing ahead in the computer area derives from a blend of scientific, industrial, and defense-related imperatives. Chinese leaders hope to move China into the so-called "age of informatics" by encouraging the widespread utilization of computers in all sectors of the economy and society. This effort, which has undergone a number of twists and turns since 1978, has high level support among both the political as well as the scientific community. And, in some

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[1]Wang Xinggang, "Ideas on Developing Computers in Our Country," Ziran Bianzhengfa Tongxun, Number 6, 1982, pp.3-5 translated in JPRS 83064, March 14, 1983, pp.1-5.

areas, it has already begun to yield appreciable results. In contrast to the previous focus on mainly scientific calculations, computers are being used today in bookkeeping, inventory control, production control, product design, medical diagnosis, and traffic management.

This report provides a series of assessments regarding China's strategy and objectives for computer development. It examines the specific role played by acquisition of foreign computers and related know-how by the PRC, stressing what the likely impact of recent and future computer imports in China will be. A list of selected imports and other forms of foreign participation is provided in the appendix. The information contained in the report is based on an extensive review of Chinese and English language sources on computer development; b)interviews with US computer firms engaged in China-related business; and c)a series of field trips to China, one in July 1985 to Shanghai and a second to Beijing in January 1986. In the case of the former, interviews and site visits concentrated on Shanghai's role as a local computer and electronics base in China's overall development. In the case of the latter, meetings were held with government officials in the State Council, Ministry of Electronics Industry, and various other "centrally-led" organizations to ascertain Beijing's goals and intentions regarding national computer development.

B. Overall Perspective

Chinese leaders will continue to attach great importance to the expanded development and more effective application of computers. The PRC push in the computer area bears a number of similarities with the French effort of the 1970s. Nora and Minc, in their seminal work entitled The Computerization of Society, highlight the features of a national plan in France designed to minimize dependence on foreign sources of technology and equipment while harnessing computers to stimulate economic and social change.[2] Similarly, the PRC's primary aim is to establish a strong indigenous-based computer capability. The leadership, from Premier Zhao Ziyang on down, sees increased computerization as a necessary prerequisite to attaining desired advances in scientific research, industrial productivity, national communications, and defense capabilities, especially regarding strategic weapons programs. This high level of support is manifested in increased investment and related funding for indigenous computer R&D programs, modernization of key manufacturing facilities, and training programs in all segments of the education system.

As of the end of 1985, China had approximately 300,000 computers in place.[3] Mainframes and minicomputers accounted for

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[2]Simon Nora and Alain Minc, The Computerization of Society (Cambridge: MIT Press, 1980).

[3]This total includes single-board and 8-bit computers as well as mainframes, mini-, and microcomputers.

about 7,000 or so of this total.[4] Between 1983 and 1985, the number of microcomputers increased by almost 600%, growing from about 40,000 to over 250,000 during this short span of time. The dominant field of use was in computation in research and engineering, accounting for 60% of the user rate. In contrast, by early 1984 there were well over 2 million microcomputers in use in the US, with the dominant users (as measured by relative spending) being the banking, insurance, and business services industries.[5]

Since the implementation of the so-called "open door policy," the most remarkable feature of China's computerization experience has been the rapid growth of imported computers, especially microcomputers.[6] One estimate suggests that such imports grew from 4,500 in 1983 to 105,000 in 1984! Only about 5.0% of these imports, however, were acquired as final product units; the majority were brought into China via Hong Kong as assembly kits due to the structure of China's import duties at the time and Western controls/delays on the export of the technology embodied

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[4]This figure comes from Li Xianglin, director of the office of the Leading Group for Electronics under the State Council. See "Computers Brave All Walks of Nation's Life," China Daily, June 6, 1986.

[5]Tom Forester, ed., The Information Revolution (Cambridge: MIT Press, 1985).

[6]Interestingly, the use and import of computers appears to be geographically dispersed throughout the country--though it does appear that the key coastal areas have been able to respond to import opportunities more rapidly because of foreign exchange availability.

in many of these machines.[7] In large part, it is the immediate dissatisfaction with the growing dependence on imports combined with concerns about excessive expenditures of foreign exchange that have driven the push to build up indigenous R&D and manufacturing capacity.

Current development efforts must also be seen against the backdrop of China's pre-1978 experience with computer R&D and production. The history of computer development has been characterized by uneven performance, with serious problems of machine compatibility and software generalizability. The Chinese produced their first electron-tube computer (103) in 1958; the first transistorized computers (109B, 441B, 121, and X-2) appeared in the mid-1960s. The onset of the Cultural Revolution, however, dealt a severe setback to computer development at a time when the West was just starting to catapult ahead. Nonetheless, by the early 1970s, the first series of computers with integrated circuit technology appeared (111, 112, 150, and 655). These achievements were attained by a small, selected group of specialists working, in many cases, without the benefit of a strong R&D support network.

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[7]According to officials at MOFERT, in January 1985, a new set of import duties went into effect. For machines above the 32-bit word length, duties range from 10-12%; the rate for spare parts for these machines runs 7.5-10%. For machines below the 32-bit level, duties ranges from 50-70%; the duty on spare parts for these machines is between 30-40%.

The milestone in China's computer development occurred in 1973 with the introduced of the first serialized machines, the DJS-100 series. Modelled after the NOVA computer developed in the US, the DJS-100 series expanded to include a number of different models capable of meeting the needs of a variety of users. In general, these machines were much slower than their Western counterparts and lacked much of the software to support widespread use. About the same time, the DJS-200 series also appeared, modelled after the IBM-360 series. While a number of machines were produced, they never really attained the levels of performance associated with the IBM. While some of these machines were hand tailored to meet the needs of special end-users, such as the PRC defense sector, they never entered large-scale serial production. In essence, the most serious Chinese deficiency is that they have been able to produce many one or two of a kind machines, most of which are of the stand-alone variety, but have never been able to move ahead into the stage of large-scale production due to specific technical shortcomings and a host of political problems. (See Chart 3)

The objective of developing a technologically advanced computer industry is to be supported, in large part, by the concerted effort being made to improve the quality of China's domestic semiconductor and electronic components industry,[8]

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[8]See "State Council Urges Priority for Electronics," Xinhua, January 11, 1985 translated in FBIS-PRC, January 11, 1985, p.K25. See also Wang Yangyuan, "On the Technical Targets China's

including several large programs to perfect large-scale integrated circuits in both the memory and logic areas.[9] There are 17 major enterprises in China engaged in research and production of integrated circuits.[10] Low yields and poor reliability have been major problems plaguing China's IC industry. At present, almost all the manufacturers of key computers in China rely extensively on imported chips, etc.[11] Recognizing that backwardness in microelectronics has been a major obstacle to further computer development, enhancement of existing capabilities is now a high priority element of the country's overall computer development strategy.[12]

Integrated Circuits Should Reach in the 1990s," Jisuanji Shijie, #9, May 8, 1984, p.3 translated in JPRS-CST-85-017, June 11, 1985, pp.90-92.

[9]Computers are also an important ingredient in the development of microelectronics in China. For example, an intelligent analysis and design system for integrated circuits was recently developed by the Institute of Automation and the Institute of Metallurgy under the CAS. With the help of a computer, the technology of artificial intelligence, pattern recognition, and IC design can be combined to analyze complex circuitry, and design and verify layouts. China Daily, March 19, 1986.

[10]"Microelectronics Industry Makes Big Connections," China Daily, April 7, 1986.

[11]Even among the memory chips and microprocessors that are domestically produced, the majority are modelled after existing foreign models. A new single-board microcomputer (TWS 0600) developed at the Tianjin Institute of Computer Technology, for example, uses the Motorola MC6800 (with some modifications) as its central processing unit.

[12]In late 1985, China's first 3-micron 16-K static RAM circuit was produced by the Institute of Microelectronics at Qinghua University. SRAMs are key elements is microcomputers and automated equipment. China Daily, October 26, 1985, p.3.

C. Structure and Organization

Organizationally, the computer industry is dominated by the Ministry of Electronics Industry, which supervises 8 research institutes, 130 manufacturing facilities for computers (83) and peripherals (47), and 13 application units, with a total of 107,000 workers and staff--out of which approximately 16,300 are researchers, technicians and engineers. The MEI has direct administrative control over 17 of the manufacturing units, while

Selected IC R&D and Production Units in China

Name	Location
Dongguang #878 Factory	Beijing
Beijing #2 Semiconductor Factory	Beijing
Beijing #3 Semiconductor Factory	Beijing
Electronics Factory #871	Shaoxing
Lishan Microelectronics Factory	Xian
Shanghai Component Factory #5	Shanghai
Shanghai Radio Factory #14	Shanghai
Shanghai Radio Factory #19	Shanghai
Jiangnan Semiconductor Factory	Wuxi
Tianguang Semiconductor Factory	Gansu
Changzhou Semiconductor Factory	Changzhou
CAS #109 Factory	Beijing
Institute of Metallurgy, CAS	Shanghai
Institute of Semiconductors, CAS	Beijing
Institute of Microelectronics Qinghua University	Beijing
Institute of Microelectronics Fudan University	Shanghai

the remaining ones are under some form of local and/or central control.[13] Within the MEI, direct responsibility for management of computer-related matters belongs to the department of the computer industry, which is the former State Administration for the Computer Industry. (See Chart 1) SACI was originally established in 1979 to unify the management of R&D, production, and marketing of computers on a nationwide scale. It was incorporated into the MEI as part of the May 1982 bureaucratic reforms. The director of the computer department is Liao Yuming.

Along with MEI, several other ministries play a key role in computer development and application. The two most important are the Ministry of Space Industry (space and weapons programs) and the Ministry of Machine-Building Industry (industrial applications). In addition, there are 5 specialized computer institutes within the Chinese Academy of Sciences (e.g. Institute for Computing Technology in Beijing, Institute of Computer Applications in Chengdu, etc.). Their major focus is on basic design, computer architecture and software development. Several of China's major universities also play an important role in computer development, including Qinghua, Beijing, Fudan, and Shanghai Jiaotong.

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[13]Out of the total number of facilities, 19 fall into the category of "large and medium," while 111 fall into the "small" category.

Sitting above these various organizations is the State Council "special leading group for electronics" headed by Vice-Premier Li Peng--which has overall responsibility for developing and coordinating China's national computer strategy. This leading group, which was re-organized in 1984 after a somewhat inauspicious start under the direction of Vice-Premier Wan Li, relies on inputs from key ministerial representatives from the civilian and military sectors as well as an advisory group of about 10-15 computer specialists from leading universities and research institutes around the country.[14] While the leading group does not have a specific budget for project purposes, it works directly with the State Planning Commission to ensure that sufficient funds are available for key projects. Its emergence is highly significant because of its mandate to provide overall policy guidance and cross-ministerial coordination in an industry where both have been severely lacking in the past.

Along with the State Council "leading group," the State Science and Technology Commission, the State Education Commission, and the State Economic Commission also have substantive responsibilities for helping to formulate China's informatics policy and manage the country's computer development. (See Chart 2) These national level organizations are complemented by a series of provincial and municipal commissions and corporations

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[14]Denis Simon and Detlef Rehn, "Understanding China's Electronics Industry," China Business Review, March/April 1986.

for management of local computer development and applications. Three cities stand out in this regard: Beijing, Tianjin, and Shanghai. Shanghai municipality, for example, has its own "local level" leading group for electronics and computers.[15] In addition, in 1984 the Shanghai Computer Corporation was created as a separate entity under the aegis of the Shanghai Economic Commission to manage computer manufacturing, R&D, software development and applications in the city's various industrial and commercial facilities.[16]

A number of organizations are involved in the business of managing the PRC's computer imports. One primary organization is the China National Electronics Import and Export Corporation (CEIEC), which is an independent corporation operating within the Ministry of Electronics Industry. The CEIEC has a number of branches throughout the country, e.g. in Shanghai--though its principle role is to act on behalf of MEI and other central ministries. The Ministry of Foreign Economic Relations and Trade, operating through the China National Technology Import Corporation, Instrimpex, and China National Machinery Import-Export Corporation also plays an important role--though its level

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[15]A number of ministries also have introduced their own "leading groups" for computer technology, applications, and standards. For example, the Ministry of Railways formed such as group in mid-1983 as part of its efforts to better coordinate and provide guidance for computer utilization. Jisuanji Shijie, #13, July 5, 1983, p.1.

[16]Renmin Ribao, June 29, 1984, p.3.

of activity had diminished in some respects due to trade decentralization and the emergence of import/export firms under the respective functional ministries. Various organizations are involved in importing computers and related equipment for the Chinese military, including the Northern Industries Corporation (NORINCO), Poly-Technologies, Milky Way Company in HK, Xinshidai Corporation, Poly-Technologies, and Great Wall Corporation. For example, NORINCO is now in the process of preparing a plan to import a computer-aided design and manufacturing center for heavy truck development. The Oriental Scientific Instruments Corporation acts on behalf of the Chinese Academy of Sciences as its primary computer import arm.

Interactions among computer users as well as the R&D community involved with computers has been facilitated by the creation of the Chinese Computer Federation in March 1985. Prior to this date, the CCF was a professional society under the Chinese Institute of Electronics.[17] The aim of the CCF is to develop computer science and technology in China, promote the application of computers, and to stimulate the growth of the local computer industry. The CCF has 11 professional committees, eight professional groups, seven working committees, and an office to handle day-today affairs. As of January 1986 there were over

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[17]See Dianzi Jisuanji Dongtai, #6, 1981, p.64 translated in JPRS 78836, August 26, 1981, pp.1-4.

15,000 members. The CCF has relations with the computer societies of 28 provinces, cities, and municipalities.

D. China's Strategy for Computer Development

China's strategy for developing its computer industry has been an evolving one, heavily influenced by a combination of domestic political as well as technological and economic factors.[1] In addition, considerations of self-reliance and technological dependence have also played a role in the definition of an overall strategy, though it must be acknowledged that great uncertainty has existed in the past and will continue to exist in the future regarding the balance between foreign imports and indigenous efforts. In early 1982, the Chinese leadership articulated a blueprint for computer development which would catapult China by 1990 to the same technological levels achieved in the advanced developed countries in the early 1980s.[18] This was a very ambitious target given the fact that China's computer design and manufacturing capabilities have been considered by most foreign experts to be 7-10 years behind those of the US and Japan. Total computer output was designed to triple by 1990, reaching an annual production capacity of 1,800 large and medium computers and 40,000 micro and single board computers. The role of foreign technology,

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[18]The description of these goals was provided by Li Rui, former general manager of the department of computer industry under the MEI. See "Computers in China," Summary of World Broadcasts/Far East (FE/W1201/A/13), November 10, 1982, pp.13-14.

although assigned an important place in the strategy, was clearly viewed with a large dose of caution. According to one former MEI official, "our consistent policy is too rely on ourselves, and at the same time learn from the advanced technology of foreign countries. ...if we blindly import[ed] computers, we would have to spend billions of dollars before widespread use of computers in China was achieved."[19]

In both 1983 and 1984, major nation-wide conferences were held to further map out the appropriate course for computer development. At the 1983 meeting, a decision was made to give greater emphasis to micro and minicomputers, reflecting the increased appreciation of the potential role of computers in industrial management and production, engineering design, etc.[20] The strongest imperative for progressing ahead in computers, however, began to appear in late 1983 as discussions about the "new global technological revolution" began to sweep China. At a January 1984 symposium sponsored by the China Research Society on the Future, Huan Xiang cited computers and knowledge-intensive industry as the keys to China's ability to catch up with the West.

> "Some new rising industrial countries... are beginning to devote attention to arming themselves with the application of computers. Brazil in South America is doing so. India is also promoting computers as a major component of its national construction planning. South Korea has

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[19] Summary of World Broadcasts/Far East (FE/W1201/A/13), p.14.

[20] "Conference on Computer Development Ends," FBIS PRC, August 13, 1983, K.15.

> also worked out a 10-year development plan for the computer. The computer is developing fast in Singapore. ...Taiwan--a part of China--has concentrated funds on developing microelectronic technology and has founded the Xinzhu Science Area. Hong Kong industrial circles have suggested the founding of a development center for computer technology. **They are all devoting major efforts to developing technology-intensive industries and are engaged in rearranging their economies. This trend cannot but arose our concern and attention.**[21]

At the February 1984 conference, the essential elements of the current computer development strategy began to take shape. Focusing on the last 2 years of the Sixth Five Year Plan, Jiang Zemin, former Minister of the MEI (and currently Mayor of Shanghai), stated the following objectives:

1. "...we will concentrate our efforts on building a technological basis for the microcomputer industry and raise our ability to produce complete equipment. We will energetically develop the production of 8-bit computers, 16-bit computers, and a general system for microcomputers to form several assembly and adjustment lines for microcomputer sets."

2. "...we will energetically raise the percentage of China-made components and parts used for manufacturing microcomputers and focus our attention on making China-made circuit boards."

3. "We will pay close attention to the construction of three computer industrial bases of north China, south China, and east China and to forming combined service bodies for computer research and production to create favorable conditions for rapidly developing the computer industry in the Seventh 5-Year Plan period."

4. "To develop the electronics industry, we should centralize financial and material resources, pay special attention to key points, ...expand foreign economic exchanges, introduce advanced

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[21]Huan Xiang, "Catch Up with the Industrially Advanced Countries," Guangming Ribao, March 2, 1984, p.4 translated in JPRS-CST-85-013, May 1, 1985, pp.10-12.

technology, and strive to raise our ability to stand on our own feet to blaze a new trail in the electronics industry."[22]

For the rest of the decade (1986-1990), China's strategy for developing its computer industry will continue to contain many, if not all, of the points spelled out in 1984. For the most part, China's primary focus is on the linking together of electronics and informatics development. The centrality of this thrust was established in January 1985 in a speech made by Vice-Premier Li Peng.[23] According to Li, the "emphasis of development of the electronics industry will be shifted onto the course of developing microelectronics technology as the foundation and computer and telecommunications equipment as the main body."[24] Li's speech is significant because it reflects the realization among the leadership of two key points: 1)that there is an integral link between the electronics, informatics and communications industries--the latter two which cannot develop without significant progress in the case of the former; and 2)that there must be a greater degree of synergy between indigenous programs

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[22]"Minister Jiang Zemin on China's Developing Electronics Computer Industry," Zhongguo Xinwen She, February 21, 1984 translated in FBIS PRC, February 28, 1984, pp.K8-9.

[23]Li Peng, "Electronics and Information Industries Should Serve the Four Modernizations," Xinhua, January 13, 1985 translated in FBIS-PRC, January 15, 1985, pp.K20-24.

[24]FBIS-PRC, January 15, 1985, p.K.25.

and foreign imports.[25] These themes were repeated again by MEI head Li Tieying, in his announcement of the development goals for China's electronics industry in the 7th Five Year Plan.[26]

In terms of specific types of computers, development of microcomputers, which are regarded as the most suitable in terms of prevailing production capabilities and potential applications, will continue to be emphasized. Technologically, the Chinese have been able to develop and produce 8-bit and single board computers, many of which have been modelled upon existing Western machines. They have also been able to develop and manufacture on a limited basis 16-bit microcomputers; here again many of these machines resemble Western equivalents such as the IBM-PC/XT. (In the area of imports, the Chinese have shifted away from purchase of almsot all 8-bit machines and many types of 16-bit computers since they are now able to produce varieties of both machines on their own.)

The development of mainframe computers (and super computers), which experienced serious problems in the past, is now entering a recovery stage in terms of the overall strategic orientation of

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[25]For an earlier commentary on this latter point see Ge Zhangi, "A Discussion of the Countermeasures of the World's New Technological Revolution and the Foreign Trade of China's Electronics Industry," Guoji Maoyi Wenti, Sept-Oct 1984, pp.6-10 translated in JPRS-CEA-85-004, January 16, 1985, pp.48-55.

[26]Li Tieying, "Continue the Reform, Speed Up the Development, and Actively Invigorate the Electronics Industry," Zhongguo Dianzi Bao, January 21, 1986, p.1. See also Zhongguo Dianzi Bao, December 31, 1985, p.2.

the industry.[27] This is best exemplified by the attention being given to the 757 computer (10 mips) designed and produced by the Chinese Academy of Sciences and the Galaxy (100 mips) designed and produced by the National Defense S&T University in Changsha, Hunan.[28] A decision was made in late 1985 to designate Beijing, which was chosen over several other cities, including Shanghai, as a special site for mainframe computer development. According to the EDP China Report, an R&D-production complex will be established, built around the following key institutions: The Beijing Wire Communications Factory, the North China Computer Research Institute, the CAS Institute of Computer Technology,

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[27]For an analysis of China's use of computer-aided design techniques to develop large computers see Liu Shenquan, "Use of Computer Aided Design in the Development of a Large Computer," Jisuanji Yanjiu Yu Fazhan (Computer Research and Development), Number 6, March 1983, pp.1-7 translated in JPRS-CST-85-010, April 17, 1985, pp.48-57. Among the limiting factors cited by Liu in the use of advanced CAD techniques in China are poor quality peripherals, the small capacity of magnetic disks, absence of plotters and graphic input devices, and lack of interactive systems.

[28]Based on information obtained in Beijing in January 1986, it appears that at least two (2) Galaxy machines have been built, one that is being used by the Ministry of Petroleum Industry and one that is still in Changsha being used by the PRC defense community.
There also is some evidence to indicate that three other machines have been developed as part of the Galaxy project: 1)Galaxy F1--which is a digital computer for simulation; 2)Galaxy X1--which is a super minicomputer; and 3)Galaxy Yx-21--which is a digital bionic computer (fangsheng jisuanji). Significantly, it was asserted that approximately 90-95% of the integrated circuits and related components used to build the Galaxy were imported from abroad. Similarly, the 757 computer, which initially used a magnetic core disk for memory storage and relied solely on domestic components, is now being re-built using imported integrated circuits for both logic and memory functions. As a result of these improvements, the operational speed of the 757 will be increased from 10 to 30 mips.

Beijing University, Qinghua University, Beijing Computer Industry Corporation, and the Beijing Information Engineering College.[29] The basic orientation in terms of design--which has been dictated by considerations of standardization, software compatibility, and networking needs, will be to emulate Western models produced by such prominent firms as DEC, IBM, and Control Data Corporation. This will ensure that domestic built machines can effectively interface with many, if not most, of the computers that have been imported over the last several years.

Nonetheless, while mainframe development will be given additional capital investment and support, it appears likely that the stress on development of microcomputers will continue during the rest of the 1980s, with increasing emphasis placed on domestic production of both components and complete machines.(Table 2) There is also some evidence of a growing interest in minicomputers because of their price-performance ratio compared to large mainframes. One driving force behind the concentration on microcomputers, and more recently minicomputers, is the shift away from stand alone machines towards more networking both within and between organizations as well as the growing emphasis on application of computers in industrial, management, and office

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[29] "Beijing Area Chosen to Manufacture Mainframe and Medium-Scale Computers," EDP China Report, Volume 4, November 30, 1985, p.18.

settings.[30] In this regard, China hopes to gradually, though steadily, approach the current breadth of Western uses as well as quality levels and processing capabilities by the 1990s.[31]

Computer Applications in China

(By the nature of the end-user)

Sector	% of Units
Industry/Transport	61.2%
Science/Education	17.0%
Commerce/Finance	3.4%
Culture/Health	3.4%
Agriculture	2.5%
Other	12.5%

Source: Commercial Section, US Embassy, Beijing, China, 1986.

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[30]In mid-1095, the State Economic Commission inaugurated a program in cooperation with the Chinese Enterprise Management Association to run a series of training courses on computer use for managers and factory directors in 3,000 key industrial firms. "Managers and Directors of 3000 Large and Medium-Sized Enterprises Will Be Trained for Computer Knowledge in June," Jingji Ribao, March 1, 1985, p.1.

[31]For an overview of microcomputers in the West see the special issue of Science, February 28, 1986, pp.935-978. In order ensure quality levels, MEI will require local microcomputer manufacturers to apply for permits before they can produce machines. Each factory must undergo an inspection and pass a certain technical level to qualify for a permit. Each permit will be good for three years. To be considered for a permit, the factory must have a quality control management system, it must be able to certify a MTBF on components of more than 1000 hours, and it must offer maintenance, service and application assistance. EDP China Report, March 15, 1986, ppp.144-145.

Application of Mini & Mainframe Computers in China

Application	% of Units
Artificial Intelligence/CAD	33.2%
Scientific Calculations	20.6%
Data Processing	27.7%
Process Controls	18.5%

Source: Commercial Section, US Embassy, Beijing, China, 1986.

Tianjin is key one city where the current national strategy has been implemented successfully, albeit partially and quite gradually in some cases, and where overall computer development and application appears to have responded well to the directives coming out of Beijing. The rise of the local computer industry has been spearheaded by the R&D work of the Tianjin Institute of Applied Computer Technology, which played an important role in the development of the DJS-153 minicomputer and the Tianjin #2 Radio Factory.[32] With its over 6000 person workforce in the computer industry, Tianjin has been able to popularize the use of microcomputers throughout all facets of industry by responding to end-user needs.[33] For example, in early 1984 the Tianjin Institute successfully trial manufactured the DJS-155-1 digital

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[32]Yang Mingbiao, "Cooperation Between Electronic Computer Institute and Radio Plant #2 on Microcomputer Development and Applications," Tianjin Ribao, November 29, 1983, p.1 translated in JPRS-CST-85-013, May 1, 1985, p.65.

[33]"Tianjin's Popularization of Microcomputers Gains Successes with 632 Sets Used in More than 30 Fields of Industrial Management," Tianjin Ribao, January 10, 1984, p.1 translated in JPRS-CST-85-013, May 1, 1985, pp.60-61.

computer, a ruggedized and improved version of the DJS-153. Because it possesses anti-shock characteristics, it is suitable for installation on ships, in vehicles, etc. In addition, city leaders have been able to use the advances of the industry to overcome local hesitation and lack of knowledge about the use of computers.[34] One major success in this area was the successful application of a microcomputer to the distributor system of the Tianjin #2 Cotton Mill.[35]

E. Constraints and Progress in Computer Development and Application

The major constraints in establishing an advanced Chinese computer industry fall into four categories: 1)manufacturing capabilities; 2) peripheral equipment; 3) technical personnel; and 4) software.[36] Techniques for mass production of final products

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[34]Developments in Tianjin have benefitted from the strong support of the local S&T and economic commissions as well as from exposure to foreign machines and technology. In this latter regard, the Tianjin Institute of Computer Technology utilized Japanese designs as well as the Motorola 68000 microprocessor to develop the TWS 0600 single-board microcomputer. Tianjin Ribao, January 12, 1984, p.1 translated in JPRS-CST-85-013, May 1, 1985, p.79.

[35]"Successful Test Run of a Microcomputerized Distributor," Tianjin Ribao, December 25, 1983, p.2 translated in JPRS-CST 85-013, May 1, 1985, pp.68-69.

[36]Financial constraints are also a problem, though not as serious as in other fields. During the Sixth Five Year Plan, the central government invested 5.0 billion yuan in the computer industry, which constituted 0.9% of the central government's total investment in fixed assets. Approximately US$ 1.0 billion went for computer imports during this same period. China Daily, April

as well as computer computers are severely lacking in China. Even though advanced components are being developed in the laboratory, many factories lack the necessary production equipment and managerial know-how to produce these items in sufficient quantities and at necessary reliability levels. A good example of how these shortcomings can affect the development of a specific machine involves the case of the DJS-186, a 16-bit minicomputer similar to DEC's PDP-11 series. The DJS-186, whose development began in 1978, experienced numerous problems because the delivery of domestic-made ICs did not materialize and imports had to be used instead and continued uncertainty over which factory was going to take over manufacture of the prototype.[37]

Relatedly, the Chinese remain unable to meet the growing needs of computer users in most facets of peripherals, mainly because they are lacking in both technology and manufacturing capabilities. This is particularly true regarding items such as disk drives, printers, and monitors. For example, while places such as Taiwan and South Korea have been able to push forward on monitor development because of their achievements in black & white/color televisions, China has not been able to rely on such a technological foundation to move ahead in this area.

10, 1986, p.2.

[37]S. Jacobson and Jon Sigurdson, Technological Trends and Challenges in Electronics (Lund, Sweden: Research Policy Institute, 1983), pp.249-289.

In terms of personnel, while the Chinese have set out to train a substantially increased number of computer scientists, engineers, and programmers, the fact remains that they still do not have a broad base pool of experts to support a full-fledged national effort throughout the country.[38] As of the beginning of 1985, there were 89,800 person employed in China's computer industry, 15,300 of which can be described as "technical workers;" by mid-1986 that total number grew to over 107,000.[39]

Training is an important aspect of China's computer development drive. A good example of one of China's better computer science programs is the one at Nanjing University.[40] Initially part of the mathematics department when it was established in 1958, it formally became a department in 1978. There are 54 faculty members in the department: 2 full professors, 7 assistant professors, 37 lecturers, and 8 teaching assistants. As of the early 1980s, there were approximately 600+ undergraduates, 20 postgraduates, and 8 advanced students in the

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[38]According to one official at Beijing University, the ratio of software and hardware personnel is 1:4 while in most advanced nations it is 3:1. Chen Yifan, Urgent Need to Train Qualified Personnel for the Computer Industry," Guangming Ribao, March 3, 1984, p.2 translated in JPRS-CST-85-016, May 23, 1985, pp.23-24.

[39]The distribution of the technical workforce is also a problem; over 28,000 of China's computer experts are in Beijing. This number is similar for Shanghai, leaving the rest of China with a severe shortage. China Daily, January 18, 1986, p.2.

[40]Wen Youxin, "Report on Nanjing University's Computer Science Department," Gaojiao Zhanxian, No.4, April 1982, pp.25-26 translated in JPRS 82183, November 8, 1982, pp.57-60.

department. In addition, over 800 students from other parts of the university were given training through courses in computer science offered by the department. All together, about 35 courses of instruction are offered. The department has also been steadily involved in national computer development efforts, having completed 13 national and local level projects, eight of which "have filled gaps in China" and six of which have won awards. Through work on these projects, it has formed cooperative relationships with a number of key production units, including the Shanghai #13 Radio Factory, the Changzhou #2 Radio Plant, and the Nanjing #734 Plant. Faculty and students from Nanjing University have been sent abroad to study computer science.

Programs such as the Computer Science Department at Nanjing University have sprung up through out China's higher education system. The US$200 million education loan given to China by the World Bank in 1982 has helped facilitate the purchase of equipment and the introduction of higher level courses dealing with computer programming, languages, etc. These advanced programs are complemented by a broad based effort to introduce China's younger students at the elementary and high school levels to the role of computers.[41] In both respects, the Chinese have gone far beyond the Soviet Union so far in trying to spread computer literacy

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[41]Some of these programs are being supported by the local science and technology association. See FBIS-PRC, February 28, 1984, p.P1.

throughout the country.[42] Yet, while education programs, including ones such as the computer education project supported by the World Bank and the Beijing Computerland Institute, are a step in the right direction, Chinese officials acknowledge that they still remain inadequate in terms of meeting current and projected future needs for a wide range of computer literate technicians. According to one estimate by an official from the MEI's State Computer Administration, at least 100,000 trained specialists are needed in research and production, while an additional 500,000 will be needed as computer operators by the 1990s.[43]

With respect to computer software, substantial progress does appear to have been made in the development of Chinese character input systems as well as software.[44] So far, four primary computer input systems exist for use of Chinese characters: 1)cang jie system (developed in Taiwan and Hong Kong): characters are entered by pressing 1 to 5 English language letters; 2)three corner system (developed at Wang Labs): all characters are reduced

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[42]See "Soviets Launch Computer Literacy Drive," Science, January 10, 1986, pp.109-110. Th article reports that high school students in the USSR are being taught computer basics without machines; the Soviet Union has yet to develop and mass produce a serviceable domestic personal computer.

[43]China Daily, April 10, 1986, p.2.

[44]In the case of the former, there are somewhere around 400 different systems in China for inputing Chinese characters. Two interesting approaches using "pinyin" were recently developed by researchers at the Science and Technology Bureau of Nanyang Prefecture in Henan and the Guangzhou Institute of Electronics Technology in Guangdong respectively. China Daily, July 11, 1984.

to roughly 100 radicals and are entered by typing in codes for each part of the entire character; 3)pinyin system: English letters are used for romanized characters; and 4)dragon system: which is based on telegraphic code numbers that are contained on a large keyboard. PRC computer specialists have developed a number of similar and complementary systems for working with Chinese characters.

In mid-1985, for example, a computerized Chinese-language information storage system was introduced by the Beijing Teachers University. It can automatically process any Chinese language information into corresponding key word and phrase data banks, print out lists of word usage frequency, edit, and compile word entry indexes. A national university computer software center was established in Beijing through the Ministry of Education in early 1984 to offer technical services to various local and national level organizations.[45] A few months later in the same year a national software industry association was also established to share information on research projects in the software area.[46]

Relatedly, in late 1983 China's first CAD system for exterior car body design was produced through the joint effort of the Shanghai Tractor and Automobile Research Institute and the

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[45]"Education Ministry Holds Software Conference," FBIS-PRC, March 20, 1984, pp.K17-18.

[46]"Software Industry Association Established," Xinhua, September 6, 1984, p.K18-19.

Institute of Mathematics at Fudan University.[47] And, in early 1986, China's first comprehensive software package called "The Software Package for Modern Digital Signal Processing," was introduced by the Northern Jiaotong University in Xian in conjunction with five other institutes in Beijing, Shanghai, and Xian.[48] The package covers a total of 42 programmes ranging from measurement statistics to modern spectral analysis.

The city of Shanghai clearly has ambitions to become a leader in the development of software and to enter the world market as a key source of computer software.[49] Shanghai Jiaotong University has been particularly adept at introducing all types of new and improved software into the Chinese market.[50] Shanghai's strategy is to rely on a)its abundant labor force, b)its strong S&T and education base, and c) the availability of transport and communication capabilities to produce a low cost package of software.[51] And consistent with this objective, the Software AG

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[47]"China's First CAD System for Car Body," Jiefang Ribao, October 20, 1983, p.2 translated in JPRS-CST-85-038, November 5, 1985, p.68.

[48]"Software and Money Aid Science," China Daily, April 11, 1986.

[49]Madelline Ross, "Shanghai's Push Into High Technology," China Business Review, March/April 1985, pp.36-39.

[50]See Shanghai Academy of Social Sciences, ed., Shanghai Jingji Fazhan Zhanlue Wenti (Shanghai: Academy of Social Sciences Publishing House, 19840, pp.133-142.

[51]See "There Are Bright Prospects for Shanghai's Software Exports," Shijie Jingji Daobao, May 23, 1983, p.10.

Inc of Tokyo has been negotiating with the Shanghai Institute of Computer Technology to work with a Chinese counterpart on software development and exports.[52]

However, as in the past, the problem of "generalizability" continues to be widespread as a significant percentage of the software being developed still tends to be machine-specific. In the past, software development was considered to be the "achilles heel" of Chinese computer development. Today, the introduction of several central government standards for software development[53] as well as the appearance of various organizations such as the China Software Corporation and the China Computer Users Association will help remedy a large number of these problems.[54] The latter organization, which was formed in March 1983, has numerous branches throughout the country.[55]

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[52]Japan Economic Journal, July 31, 1984, p.15.

[53]As of early 1985 there were between 100-400 Chinese input systems under development in China. The State Council has set up a special committee to "boil down the massive, often disparate work into a unified system for industrial production." China Daily, Business Weekly, January 29, 1985, p.2. See also China Daily, May 23, 1985.

[54]A good example of Chinese progress was the recent development of HCDOS, a Chinese-English operating system that runs on the IBM 5550. The 5550 is a multi-function microcomputer that can handle Chinese character inputs. (The Chinese would like to eventually manufacture in Guangzhou under the Huanan (East China) Computer Corporation.) The operating system was developed by the Institute of Computer Applications Research at Hunan University and a computer company in Changsha. All of the original software for the IBM PC and the 5550 can still operate using HCDOS.

[55]See FBIS-PRC, March 29, 1983, p.K7.

In spite of the proliferation of computers, under-utilization remains a serious and widespread problem. The investment made in the development of application systems is unproportional to that made in the development or import of basic systems. According to an EDP China report, "...users are usually only willing to pay for hardware and hand out money almost grudgingly for software. The importance of researching and designing application systems is not yet widely recognized." [56] The problem is particularly acute regarding domestic made machines. In fact, many questions remain about the future of existing lines of domestic computers, such as the DJS-100 series because of the realization that many of these machines do not meet international standards in terms of quality, type of operation, and/or software compatibility.[57]

According to sources in Beijing, 32,000 microcomputers were manufactured in 1985, while there were still 40,000 stocked in warehouses with no customers in sight.[58] In addition, officials in the computer industry have suggested that in Beijing municipality, for example, the utilization rate of installed microcomputers is only 26%, while the national average is in the

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[56] EDP China Report, Volume 4, June 17, 1986, p.242.

[57] As suggested earlier, the DJS-200 has already officially been discontinued as of 1981-82.

[58] "Computers Facing Glut in Market," China Daily, January 11, 1986, p.3. One source suggests that the number of stockpiled microcomputers has decreased to 18,000 by January 1986. China Daily, April 10, 1986, p.2.

range of 15-20%.[59] The problem of poor utilization has its roots in personnel shortages, though other key factors include organizational rivalry and intense bureaucratic jealousy,[60] poor maintenance, limited software availability, and poor after-sales service.[61] One estimate suggests that the Chinese will waste between US$20-$85 million over the next three years because of improper use and maintenance of imported computers.[62] In some cases, enterprises have been "ordered" to have a computer without having the personnel to operate it or any idea about how to best

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[59]According to one source, a survey of 14,000 microcomputers in place in Beijing revealed that most are used less than three hours of day. "Beijing Has Future as Computer Capital," China Daily, January 18, 1986, p.2.

[60]See the case of the wrangling among the Kaifeng Computer Center, the local telephone bureau, and the Kaifeng #3 Hospital in Henan province to appreciate the extent to which organizational rivalry plays a role in China. China Daily, April 7, 1984, p.3.

[61]There are approximately only 10,000 people involved in computer services in China. The creation of the China Computer Services Corporation in 1984 to handle 6 main functions: systems integration, technical training, data processing services, database supply, software development, and specialized services and consultation, is a positive step toward improving computer usage, though the numbers of people and their skill levels remain inadequate. Chen Liwei, "The Position and Role of Computer Services in the Computer Industry," Dianzi Xuebao, #5, September 1984, pp.65-67 translated in JPRS-CST-85-009, April 9, 1985, pp.57-61.

[62]Sam Howe, "China's High Tech Troubles," New York Times, May 5, 1985, p.F9.

put the machine to use.[63] These problems hold true to both domestic made and foreign imported computers.[64]

Political problems can also be pervasive in the computer industry. At the Hunan Provincial Computer Center, eight persons had to be dismissed from their posts because they lacked the skills to handle their particular assignments.[65] The Hunan center is one of the key links in China's national computer network; its responsibilities include collecting, processing, storage, and exchange of economic information within and outside the province.[66] Through a "network of personal connections," high level cadres used their positions to secure jobs for their relatives and children. The center became known as "a home for the lazy."[67] At one point, of the 39 children of leading cadres above the rank of department directors, more than 60% (24 persons) knew little or nothing about computers. After numerous problems,

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[63]"Problem of Idle Computers," China Daily, April 3, 1985.

[64]For a rather critical assessment of China's computer industry see Cary Lu, "China's Emerging Micro Industry," High Technology, March 1985, pp.69-70. Lu cites lack of access and understanding of software, a dearth of qualified personnel, high costs, language problems, etc. as factors that have slowed down computer development and application.

[65]"Hunan Set to Curb Irregular Recruiting," China Daily, April 5, 1984.

[66]The center was completed in 1982. See FBIS-PRC, July 22, 1982, p.P6.

[67]China Daily, May 11, 1984, p.3.

the situation was brought to the attention of the provincial party committee for resolution.

Even though the above-mentioned utilization problems are pervasive, the fact remains that use of computers has spread throughout the economy and society. According to an official from the MEI, there were about 100 types of uses for computers in 1980 (with most computers being used for calculations), while as of mid-1985 there were 15,000 uses.[68] The Chinese have even gone so far as to establish a computer dating service! In many cases, computers have been introduced in the form of industrial control systems, such as in the Ministry of Machine-Building Industry (MMBI), where work on automation has rapidly proceeded forward over the last two years. There is a computer research center in the MMBI that has as its principle function the expanded introduction of CAD/CAM technologies--though some of its efforts are being held back by the lack of specialized components from MEI to support its development efforts.[69]

Most important, the drive to introduce computers into industry and society has stimulated expanded interactions among

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[68]"Computer Production Must Follow Demand," China Daily, April 10, 1986, p.2.

[69]In some cases, because of the nature of prevailing export controls, the Chinese have been able to purchase the hardware for CAD work, but have been blocked from buying the accompanying software--a situation which has, on the one hand, fostered poor utilization of imported equipment, but on the other hand, has stimulated indigenous software development efforts.

computer manufacturers and potential end-users. Given the gap that has often existed between developers and users in China, this trend could be highly significant. For example, the Shaoguan Radio Factory in Guangdong, which is a leading manufacturer of 8-bit and 16-bit microcomputers in South China, has transferred a number of its engineers and skilled workers to form an outreach/sales team for the promotion of microcomputer use.[70] In addition, the factory has instituted user training classes, a lecture series, etc.

China also has plans to boost development efforts in robotics--which is still in its infancy in comparison with similar efforts in Japan and the US.[71] The Seventh 5 Year Plan contains provisions for the manufacture of industrial robots for paint spraying, point and arc welding, and cargo carrying.[72] As of the end of 1985, China had more than 100 industrial robots and 1000 mechanical hands in place.[73] Among China's 20 robot research institutes and development centers, the Institute of Automation of the CAS in Shenyang will be the site of a major robotics research and development center.

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[70] Nanfang Ribao, March 4, 1984, p.2 translated in JPRS-CST-85-014, May 2, 1985, pp.40-41.

[71] Zhang Chunfen, "Development of Industrial Robots for the Aviation Industry," Hangkong Zhizao Gongcheng, #5, May 1, 1985, pp.2-4 translated in JPRS-CST-86-001, January 17, 1986, pp.60-63.

[72] "Robots Set To Receive Boost in Development," China Daily, February 1, 1986, p.1.

[73] China Daily, November 13, 1985.

Among the successful examples of effective application of computers are the following: a)establishment of a computer based flood warning system under the Ministry of Ministry of Water Conservancy and Electric Power; b)formation of a computer center under the People's Bank to manage financial transactions; c)application of computer controls to boiler operation in thermal power stations in Guizhou province; d)safety analysis in power plants; e)social science data storage and analysis in the Chinese Academy of Social Sciences; f)establishment of a computer center at the Daqing Oilfield to handle prospecting information and research work; and g)computer-aided architectural design, especially concerning earthquake-proof construction.[74] Significantly, the Communist Party has also gotten caught up in China's computer revolution; the provincial party office in Shaanxi, with the help of the Lishan Microelectronics Company, has introduced a computer system for general management tasks. Thus, while problems abound, China has gone much further than, for

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[74]Along with industry-oriented applications, the first computer station in rural China was set up in mid-1984 outside of Beijing. The computer station, which is run by a local township in Beijing municipality, is responsible for calculating the temperatures needed for growth of all sorts of plants, figuring out appropriate planting densities, determining adequate water allocations for irrigation purposes, and calculating fertilizer needs and applications. It will also perform accounting tasks for the rural industry and a host of other scientific calculations regarding the amount of light and humidity needed by plants in local greenhouses.

example, the USSR in allowing the roots of the new information society to take hold.[75]

One area where some rather interesting work has already been done deals with the attempt to establish a nationwide economic and S&T information network linked through the China National Science and Technology Center in Beijing.[76] A number of the key coastal cities (10) along with the Institute for Scientific and Technical Information (ISTIC) under the SSTC are the key organizations involved.[77] The Chinese are attempting to draw upon Western data bases as well as create their own data retrieval systems.[78] Progress, however, has been impeded by China's poor communications infrastructure, which have added a large element of insecurity and unreliability into the process of data transfer and computer communication. By early 1985, for example, there were only 0.5 telephones per every 100 persons in China. Recent improvements in

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[75]Loren Graham, "Science and Computers in Soviet Society," in Erik Hoffmann, ed., The Soviet Union in the 1980s (New York: Academy of Political Science, 19840, pp.124-134. The Chinese have gone so far as to establish a computer leasing and financing service to promote interest in computers. In 1984, the China Bank of Industry and Commerce in Shanghai opened a leasing agency for those enterprises and government agencies that do not have sufficient funds to purchase computers.

[76]"Information Center Construction Starts," China Daily, September 24, 1984, p.3.

[77]According to Wang Tingjiong, director of ISTIC, there are more than 60,000 people engaged in information collection, dissemination, and services. China Daily, April 2, 1986.

[78]"Nationwide Information Network Planned," China Daily, January 24, 1984, p.1.

communications, obtained primarily through technology and equipment imports, may help alleviate some of these problems in the near future. For the present, however, the existence of local area networks as well as distributed processing remains the exception rather than the rule.[79]

Summarizing, the problems of computer development and use in China are being attacked from a multitude of directions. Component manufacture is being given highest priority as the Chinese seek to minimize their dependence on foreign sources for both components and final products, especially in the microcomputer area. Nonetheless, the emphasis on acquisition of computer manufacturing technology will persist, with a growing emphasis on minicomputers. Greater centralized control seems to be emerging as the need for standardization and quality control has been recognized. Application problems remain and there is an insufficient number of qualified personnel on both the development and applications side. Thus, while substantial progress has been, it remains unlikely, with some exceptions, that China will meet its goal of attaining overall by 1990, Western technological and utilization levels of the 1980s in the field of computers.

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[79]One important exception in this regard was China's ability to create a workable computer network throughout portions of the country to store and process data for the 1982 national census. "Counting to a Billion," Datamation, March 1983, pp.183-185. Another exception is the LAN that has been planned for the Ministry of Electronics Industry. See Fan Xitian, et.al., "The MEI Organizational Management Network System," Dianzi Jishu Yingyong, #2, February 25, 1985, pp.6-8.

F. Role of Foreign Computer Imports and Technology

> "Since importing was emphasized in the 1980s, China's computer industry has suffered a great blow. Importing is a correct policy, but how to organize imports properly has not been resolved very well. Any unit can now arrange for its own imports, but what is being imported is mostly equipment, not technology. This is not only wasteful, it also hits domestic industrial production and scientific research work hard. Computer plants are now worried about their own production, since the more they produce the more they loose money... In contrast, they make a lot of money by selling imported machines either with a changed outside appearance or by selling them as soon as they are imported... There is a policy problem here."[80]

In the attempt to modernize their computer industry as rapidly as possible, the Chinese have continued to emphasize the import of technology and computers from abroad. Reliance on foreign ideas and know is nothing new as far as China's computer development is concerned.[81] Beginning with the initial start-up of the industry in the 1950s, China relied on Soviet technical specification to launch its own domestic development program and, as indicated earlier, utilized IBM designs to initiate the DJS-200

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[80]"How to Develop China's Computer Industry," Guangming Ribao, April 2, 1984, p.2 translated in JPRS-CST-85-016, May 23, 1985, pp.19-20.

[81]Two things, however, should be remembered in this context. First, electronics has been intimately caught up in the symbolic aspects of China's political debates over the last several years, and therefore, by implication, computer development has been highly politicized. Second, willingness to use foreign technology to advance indigenous computer development has not meant total acceptance. In many cases, local adaptations were introduced, e.g. as part of the policy of sinicization, which in many cases did little to enhance performance and frequently created operational and compatibility problems.

series in the 1970s. In addition, foreign technical literature and data regarding computers and electronics has continued to flow into China throughout the last two decades--continuing even during the Cultural Revolution.[82] Moreover, during visits to any number of Chinese universities and research institutes, it quickly becomes apparent that there is no dearth of information or journals regarding computer development in the West. Were it not for the availability of these published materials, as well as China's increased access to Western hardware since 1978, it is likely that computer developnment would have been even further delayed and even distorted.

According to comments by Chinese officials in the MEI, foreign computer companies that introduce sophisticated technology and management skills, will be allowed a share of China's domestic market.[83] This policy was introduced, in all likelihood, because proportional to overall equipment imports, very little computer-related technology in disembodied form has flowed into the PRC over the last several years. Within China, in some cases, a tension has arisen between those who are potential end-users and want access to a computer immediately and those who believe that excessive imports should be controlled so that domestic technological capabilities can be allowed to develop. This

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[82]Personal communication in Chongqing, March 1985.

[83]"Computer Market Opening to Foreign Manufacturers," China Daily, September 7, 1984, p.1. See also "Market for Computers Opened to Foreigners," China Daily, September 6, 1984.

debate, which is reflected in the above comments by a computer engineer at the Tianjin Computer Factory, has been particularly acute with respect to microcomputers. Between 1981-1985, excessive imports of foreign microcomputers basically undermined the effort to create a viable domestic base.[84] More specifically, so-called "development efforts" were actually limited to assembly of imported SKD (semi-knock down) and CKD (completely knocked down) kits.[85] This brought in large amounts of revenue to those doing the assembly operations because of the great demand for foreign made personal computers, but did little to stimulate indigenous technological progress.[86]

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[84]In 1981, 36% of all microcomputers sold in China were domestically made. Due to the policy of tightening up in mid-1984, that number jumped to 56% in 1985. Of course, the term "made in China" is somewhat ambiguous, since assembly of foreign computers can be included in this category. Nonetheless, it does reflect a growing tendency towards encouragement of local computer products. China Daily, April 10, 1986, p.2.

[85]Assembly of imported computer kits became financially feasible because the duties on imported components were less than the duty on imported computers. Also, both Fujian and Guangdong had initially been exempted from needing to acquire an import license, thus making its easier for persons in both these provinces to broker what came to be called "instant knock-down" computers from Hong Kong, etc.

[86]In some cases, however, indigenous programs for microcomputer development did move forward. For example, the Jinzhou Electronic Computer Factory, Qinghua University, and the 2nd Branch of the Beijing Institute of Technology jointly developed and manufactured the DJS-142, a mini, all-purpose digital computer. The machine can be configured with floppy disk or with a 5-to-20 MB hard disk storage system. While not up to technological levels in the industrialized nations, this machine represents China's continuing effort to develop its own hardware. According to Chinese sources, its operating system supports COBOL as well as BASIC computer languages.

As a result, computers are on the list of 45 items requiring an import license issued by the Ministry of Foreign Economic Relations and Trade.[87] In some respects, Chinese officials in the computer industry see China's development alternatives as lying somewhere between the "self-reliance-oriented" approaches of Brazil and India and the import and imitation-oriented strategy of South Korea and Taiwan.[88] In the case of the former, strong protectionist policies were imposed as a means to moderate foreign competition and pressures foreign firms to provide technology in return for greater market access. In the case of the latter, foreign models have been used for imitation and copying; firms in these two sites have seen linkages with foreign firms as a way to get into the computer industry rather than as a threat to indigenous development.[89] Based on discussions in China and a number of recent articles in the Chinese press, there appears to be a growing trend towards greater "selectivity" and elements of "protectionism" in terms of computer imports, especially in the microcomputer area. This movement does suggest that in some respects the Chinese may be orienting themselves more towards the India/Brazil approach--even in spite of the fact that both

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[87] "Ministry Adds 15 Items to Import Licensing List," China Daily, March 5, 1986, p.3.

[88] See Francis Rushing and Carol G. Brown, eds., National Policies for Developing High Technology Industries: International Comparisons (Boulder: Westview Press, 1986).

[89] Even if China pursues the path of imitation and copying, it will require a substantial improvement in its microelectronics capabilities as well as further progress in the use of computer aided design and manufacturing techniques.

countries have experienced problems because of their strict controls.[90] This tightening up over imports, however, while addressing fundamental concerns among the leadership about technological dependency, still takes place in an environment where people tend to denigrate the quality of Chinese-made machines.[91]

China's computer specialists hope that the appearance of the Great Wall 0520 microcomputer can represent the first step in building a more credible domestic computer industry.[92] Basically an IBM-PC/XT clone using US, Japanese, and South Korean components, the Great Wall is produced at three factories in China, the premier one being the Beijing Wire Communications Factory (along with factories in Sichuan and Shandong provinces) which accounted for half of total production and has a capacity to manufacture 10,000 a year. The 0520 series includes three models in order to respond to specialized user needs in engineering design, scientific research, and factory management.[93] The Great

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[90]The tradeoffs are discussed in Rushing and Brown, eds., National Policies for Developing High Technology Industries.

[91]In order to improve the competitive position of domestic made machines, the Chinese recently dropped the prices of indigenously-manufactured models--which heretofore had been considerably more expensive than imported machines (even including import duties) in terms of their price/performance ratio.

[92]"Great Wall Towers Over Domestic Sales," China Daily, Business Weekly, April 2, 1986, p.2.

[93]The MEI has established a "0520 Microcomputer Task Force" to handle sales as well as maintenance, service, and the publishing of materials. The group will work with the China

Wall 0520A uses the Intel 8088 16-bit microprocessor, has a storage of 512 kilobytes and a high resolution color display of 640x200.

It also features a Chinese character disk operating system and is readily supported by a wide variety of Chinese character and IBM software, a factor that makes it more attractive then previous machines.[94] Moreover, to encourage its acceptance in China, the SACI of MEI established an 0520 computer software development consortium; it has signed contracts with over 20 units for over 50 software-related tasks.[95] The main difference from the IBM/PC/XT is that the main board has two serial ports and one parallel port, thus giving the 0520 improved performance characteristics.[96] According to the manager of the computer

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Computer Technology Service Corporation, which will handle training and general sales. The members of the group include the Beijing Wire Communications Factory, the Shanghai Computer Corporation, the Fujian Computer Corporation, the Huabei Terminal Equipment Company, the Suzhou Computer Plant, the 6th Bureau of the MEI and Qinghua University as well as such peripheral manufacturers as the Jiannan Machinery Plant and the Nanjing Wire Communications Plant. Jisuanji Shijie, #7, April 8, 1984, p.1.

[94]China has introduced the Great Wall into the US in the hopes of eventually exporting these machines into the US market. However, while the press in China hailed the success of the Great Wall microcomputer at a recent US computer show, many questions remain about the extent of real compatibility with the IBM machines.

[95]"0520 Microcomputer Software Takes the Path of Joint Development," Jisuanji Shijie, #9, May 8, 1984, p.1.

[96]"Briefing on the ChangCheng 0520 Microcomputer," Dianzi Jishu Yingyong, January 25, 1985, pp.12-14 translated in JPRS-CST-85-027, August 22, 1985, pp.99-105.

division of the Beijing plant, close to 5,000 machines were sold in 1985 and demand is expected to reach 20,000 in 1986. The average cost per machine is 25,000 yuan, which is about 2/3 the price of an imported IBM personal computer.[97]

The concern about the slow progress in indigenous computer development has meant that the PRC has no real alternative in the short-term but to rely on technology transfer as a means to stimulate more rapid and sustained domestic progress. China's key focus, however, is on the acquisition of foreign computer design and manufacturing know-how rather than on the purchase of a large number of foreign-produced machines. Technology acquisition--as opposed to equipment acquisition--is being strongly encouraged because it is viewed as an intermediate step on the way to avoiding long-term dependence on external sources for foreign computers and eventually foreign technology. A good example of a project consistent with Chinese objectives involves the import of a disk drive production line from France in mid-1984 by the Jiannan Electronic Equipment Factory in Hunan.[98] (The line which was the first peripheral production line imported in China, has the capacity of to produce 500 Model ZPC-204 hard disk drives and 3000 ZPC-3 floppy disk drives.) Another involves the 10 year,

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[97]"Ministry Cuts Prices of PRC-made Computers," Xinhua, June 28, 1984 translated in JPRS-CST-85-012, April 23, 1985, p.64. Prior to mid-1984, the price of the Great Wall was 36,000 yuan.

[98]"MEI's Computer Bureau Sets Up First Modernized Disk Drive Production Line," Jisuanji Shijie, #11, June 8, 1984, p.1.

US$12 million licensing agreement between the Gould Corporation and the Tianjin Automation & Instrumentation Factory concluded in late 1984 for assembly and manufacture of dedicated industrial computers called programme controllers.[99] Under the agreement Gould will provide technical training to include instruction in manufacturing techniques, testing operations, quality control processes, and equipment maintenance.

Even in the area of large mainframe development, where appreciable numbers of imports are likely to continue for a while, it is clear that the Chinese are continuing to use Western designs as part of their overall design efforts. R&D programs at MEI's two leading research institutes, the Huabei Computer Research Institute in Beijing and the Huadong Computer Research Institute in Shanghai, are already engaged in following this strategy in terms of their own development efforts. According to one MEI official, "computer technology development should be guided by the principle of standardization, serialization, and universalization. The chosen models should use successful varieties available elsewhere in the world for reference and should absorb matured experience."

This perspective is quite consistent with Chinese practice since the 1970s, when the IBM 360 series was used as a model for

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[99] "Chinese and US in Computer Deal," China Daily, July 12, 1984, p.2.

the Chinese DJS-200 series--though as indicated the performance of these machines never attained IBM levels due to architecture and software problems. In order to gain access to technology, the Chinese have signed a number of joint venture-type agreements with firms such as IBM, Burroughs, and Hewlett Packard.[100] China's expectation is that its relationship with these foreign firms will evolve away from just sales and distribution, and eventually include provisions to manufacture computers and related components.[101] In fact, given the recent concerns about excessive imports and the newly added duties on such imports, foreign firms will increasingly find themselves faced with no viable alternative but manufacturing-oriented joint ventures or licensing of their technology if they want to sell microcomputers (16-bit) into the Chinese market.

Sending students, scholars, and technical experts abroad for formal training is a major part of China's strategy for building a modern computer industry. Persons are being sent to places such as MIT, Carnegie-Mellon, Cal Tech, Stanford, etc. to learn the

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[100]At this time, IBM appears to be the most active among the US firms who are trying to expand their computer sales in China. IBM has made the most extensive commitment to the Chinese market, with 13 authorized dealers throughout the country as of the end of 1985.

[101]According to one Chinese commentator at the CAS, "it is difficult to solve the problem of compatibility with foreign computers. Thus, one good way of producing compatible computers is by entering into joint ventures with foreign countries." Wang Xinggang, "Ideas on Developing Computers in Our Country," Ziran Bianzhengfa Tongxun (Journal of the Dialectics of Nature), Number 6, 1982, pp.3-5.

latest thinking in the West about computer design and architecture. In addition, groups of Chinese engineers are being sent overseas for training as part of the equipment purchase agreement.[102] Unlike Taiwan, most of these visitors have returned or will return to China. In some cases, individuals have come with very specific objectives in mind, e.g. computer memory development or a software enhancement--making its highly likely that when they return to China they will be able to easily apply their newly garnered information--a situation that stands in sharp contrast to the cases of other students/scholars who come to the US with somewhat more vague goals. Over the long term, it is this group of visiting scholars in the computer field that will form the technological backbone of the industry.

The desire to focus attention on indigenous development does not mean that China has lost interest in importing foreign computers. (See Table 1) Over the next 3-5 years, the demands of economic and military modernization will necessitate continued import of computers, especially, as indicated, in the mini and mainframe range. US sales of computers and related automated data processing equipment rose from US$50 million in 1983, to US$101 million in 1984 and US$187 million in 1985. (According to the

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[102]For example, 45 engineers were sent by the Ministry of Water Resources and Electric Power to complete a three month training course on the VAX 11/750 at Digital Equipment Corporation. The training was conducted in Chinese and administered through Sun Associates, a Chinese-American company active in China trade. China Daily, July 3, 1985, p.2.

Department of Commerce, US-China trade totalled US$7.1 billion in 1985; computer-related sales as a % of total US exports to China accounted for only about 5.4% of total US sales to the PRC) (See Table 2) A visit through a variety of industrial and research facilities reveals a plethora of foreign made computers, and while US-made machines appear prevalent, the stock of computers includes an appreciable number from Taiwan (Multitech) as well as others (some US made) that clearly were clandestinely brought into the country via Hong Kong prior to the relaxation of US export controls and COCOM controls.

China's problem, however, is that even as gains expanded access to more sophsiticated equipment and higher levels of technology, it continues to be plagued by ineffeciency and ineffectiveness when it comes to the assimilation of foreign technology and know-how. Reverse-engineering with respect to computers is a difficult process, especially if a country lacks the capabilities to manufacture the needed components at required levels of quality and reliability on a consistent and continuous basis. And, even if these Chinese can secure needed components from abroad, there is little evidence heretofore, except perhaps for the Galaxy, that they have been able to take that critical step into the world of design, adaptation and innovation on their own. As one Chinese author recently stated in addressing China's penchant for buying equipment and ignoring technology, "let us change as soon as possible the formula of 'the first machine being

imported, the second machine being imported, and the third machine also being imported' into one of 'the first machine being imported, the second machine being made by China, and the third machine being exported."[103] For China, this will be more easily said than done until the 1990s.

G. Foreign Competition in the China Computer Market (Table 6)

Competition for an increased share of China's computer market is likely to grow in the immediate future as US firms will encounter stiff competition from Japan (Fujitsu, NEC and Hitachi), West Germany (Siemens and Nixdorf), and France (Sofrecom). France (Sems Company), for example, gained lots of political capital when it installed China's first imported computer production line in September 1983 in Guangzhou for manufacture of the "Suola-16 minicomputer.[104] Close business-government cooperation in the case of the Japanese and West Europeans will foster their competitive positions in the Chinese market.

Of these three, however, it should come as no surprise that the Japanese have been and will continue to be the most aggressive

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103"Guangming Ribao Discusses Overreliance on Imported Technology," Zhongguo Xinwen She, July 4, 1985 translated in JPRS-CEA-85-072, August 9, 1985, p.9.

104"Installation of Sino-French Computer Production Line Noted," Guangzhou Ribao, October 30, 1982, p.1 translated in JPRS 82905, February 18, 1983, p.31.

and difficult competitors.[105] It is already clear that during the mid-to-late 1970s, Hitachi benefitted (and US firms such as IBM suffered) from the more rapid normalization of relations between China and Japan. The so-called "China strategies" of Japan's computer companies have and will continue to stress training, cooperative software development, special financing packages, and service in order to obtain a competitive advantage.[106]

Firms such as NEC, Fujitsu and Hitachi have already made substantial strides in developing potential product loyalty through their high profile market position as well as the creation of special training and software centers in China and Japan.[107]

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[105]This is not to suggest that other countries will lag far behind. France, in particular, has been aggressively pursuing computer-related sales in China. Along with the Jiannan project mentioned earlier, they have also sold a production line for manufacture of the "Suola-16" minicomputer to the Huanan (South China) Computer Corporation in Guangzhou. The project, which was funded by both local and central government authorities, involves the coming together of a number of key computer production units under MEI in the Guangzhou area.

[106]Some US firms have chosen to market their computers and related products through their Japanese subsidiaries. For example, Honeywell and its Japanese affiliate (Yamatake-Honeywell), recently signed an agreement for process control technology that includes training in Japan, the US and China. IBM, through its Japanese marketing agent in Japan (Kanematsu Gosho Ltd), is also relying on its Japanese links to penetrate the Chinese market. Kanematsu is one of 13 IBM agents in China. It will concentrate its activities in southern China, particularly in the Shenzhen economic zone. China Daily, February 19, 1985.

[107]For example, a Sino-Japanese Software Center was established in 1982 between NEC and the China Computer Technical Service Corporation of the MEI. The center provides machine time for computer users and accepts computational tasks, designs software systems, and demonstrates various computer products. Jisuanji Shijie, #5, March 5, 1982. NEC also negotiated an

An agreement for joint development of software signed in mid-1983 between the Japan Software Industry Association and the China Science and Technology Exchange Center of the SSTC will also help facilitate the marketing and sale of Japanese computer products.[108] Japanese firms also have been quick to take advantage of changes in the structure of COCOM, such as the recent sale by Hitachi to the People's Bank of China of what can be considered the biggest order for large mainframes computers by China (US$25-30 million).[109]

PRC officials in Shanghai have indicated that they are looking to Japan for guidance on the formulation of an over-arching strategy upon which to pattern future development of the country's computer and electronics industry, e.g. Japan's "white paper" on electronics and machine-building industries in the 1950s--which laid the basis for its movement into the area of "mechatronics." Thus, while the Chinese remain leery about

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agreement in 1985 with the CEIEC and the North China Terminal Equipment Corporation to produce 16-bit microcomputers in the latter's Baoding facility in Hebei. FBIS-PRC, February 6, 1985, p.D3.

[108]"Japanese Computer Software Group Feted in Beijing," Xinhua, July 25, 1983 translated in FBIS-PRC, July 26, 1983, p.D3.

[109]Financial Times, February 14, 1986, p.5. The Hitachi deal is important because it could help promote significant sales of additional Hitachi computer products to other banks in China. Some US computer firms believe that Hitachi attempted to take advantage of the pending relaxation in COCOM controls in late 1985. By setting up the sale prior to the COCOM announcement, Hitachi could complete the sale if the appropriate changes were made (which it did) or if the sale could not go through, it could blame the US for blocking the sale.

excessive dependence on Japan, the Japanese experience and thinking will continue to exert a certain influence on China's own development pattern. At the same, it is also true that if US companies offer the "right" combination of training, technology transfer, and financing, they can take advantage of China's apparent "political" preference for dealing with the US.110 (See cases below.)

The concerns among US firms that they have been loosing sales to China because of prevailing export control restrictions seem to have been largely resolved as a result of the December 1985 relaxation in both US and COCOM controls. (See Table 5) Under these new guidelines, China will have access to a substantial array of advanced computing machinery and related equipment. While it is true that some delays continue to exist in the processing of applications, the fact is that recent changes (manifested in the identification of 27 categories of items designated for liberalized treatment) have greatly improved the process by which applications for licenses are reviewed and acted upon.

110Among some of the US 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 set up 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 MEI 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.

Yet, while controls on computer hardware have been relaxed, many firms still feel that controls on software exports remain overly restrictive. This is particularly true regarding the software for computer networking, which China badly needs if it is to make effective use of its increasing numbers of computers. In addition, software for CAD/CAM/CAE/ and CAT also remains tightly controlled in the eyes of many US firms. According to interviews conducted in China and the US, the problem of excessive control over software exports must be resolved if US firms are to make significant inroads into the Chinese computer market.[111]

Two Brief Examples of US Computer Firms in China

IBM's approach to the China market seems to stand out among US firms. 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 also has set up a training facility in China to support its sales--past, present, and future. In many respects, IBM's success in the PRC has had much to do with the fact that

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[111]The problems with controls on software exports are followed closely by the fact that China's patent law, which was approved in April 1985, does not cover protection of software. Questions remain about how a firm can protect its proprietary software, and whether or not the PRC government will commit to the use of either a copyright law or its patent law to provide greater security to foreign firms that bring their software into China.

Chinese computer officials have considered IBM products (along with the DEC 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 to the PRC government that IBM was making a long term commitment to China. In the same year, through its subsidiary in Japan, IBM introduced the Model 5550 to China, a multifunction, Chinese language large microcomputer that was well received. The machine is attractive to the Chinese not only because of its ability to efficiently handle Chinese characters, but also because its processing capabilities and performance are far and above any comparable machine produced by China on a mass production basis. In early 1985, IBM donated 100 of the machines to four Chinese universities: Beijing University, Qinghua University, Fudan University and Shanghai Jiaotong University. In May, IBM began training classes for 40 teachers and students to operate the computers. By the end of summer 1986, IBM introduced 3 new models of the 5550 series, all of which offered the same or greater storage capacity while selling at up to 30% less than the original Model 5550. Chinese officials would like IBM to enter into a joint venture to manufacture the 5550 in China. The idea of entering into such a joint venture runs counter to IBM's general approach in the past to international marketing. Nonetheless, negotiations are continuing at this time.

Another example of a US firm that has been increasingly successful in China is Wang Laboratories, Inc. Wang began doing business in China as early as 1972, though its business in the PRC did not really take off 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 US$17 million.[112] Along with direct sales, Wang set up 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 sale and production of small machines, with the hope that these sales will lead to purchases of larger machines--around which all of the smaller machines can be connected and networked. Its major competitive advantage in China has been its Chinese character operating system, known as the VS (ideographic VS) system.

In 1980, Wang began negotiating with China's MEI's about the possibility of establishing a joint venture in the PRC. Three proposals emerged out of these discussions: 1)a jv with the Shanghai Computer Corporation in Shanghai; 2)a jv with the Xiamen

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112"Wang Starts Computer Sales Drive," China Daily, February 21, 1986.

Development Corporation in Fujian; and 3)a jv with the Beijing 738 Wire Communication Factory in Beijing. Initially, the aim was to introduce a CKD operation for its VS system at the Beijing 738 facility, a CKD operation for the Wang Office Assistant in Shanghai, and a CKD operation for the IPC (ideographic professional computer) system in Xiamen. Wang was to provide the machinery and related equipment as well as cash in setting up the production lines, while the Chinese would provide the manpower, some capital investment, the buildings, and other infrastructural support.

In each of the three proposed cases, Wang's major aim was to replicate its existing facilities in the US or elsewhere. Wang's orientation in setting up a joint venture(s) in China was to stress consistency with its proven operations. For example, Wang will not bring second-hand equipment into China; nor did it anticipate introducing any drastic changes in the mode of operation. Its hope was to utilize capabilities and knowledge at its production sites in Ireland, Scotland, Puerto Rico, Australia, Mexico, and Taiwan to assist with the start-up of its China ventures. Wang expressed 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 PRC officials that the equipment intended for use in China was equal to that being used in the Wang facilities in Taiwan. This

fact precluded the emergence of a major "technology transfer issue" 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 of 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. China wanted as much training as possible.

Second, the question of foreign exchange remittance remained unsettled. It was agreed that after the 3rd year, each venture would have an export requirement of up to 25% of the output. China's aim is 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. (In general, PRC officials frequently apply unbearable pressure on foreign firms to source locally.) 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 preclude the emergence of broad perspectives on marketing approaches. And, 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 real 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 has been to keep its ventures small while minimizing unnecessary exposure, and using as a few expatriates as possible to prevent a drain on the joint venture's resources.

Since initial discussions began, the three proposed projects have been restructured due to a variety of factors on both sides. Wang's intention, with Chinese government support, is to initiate its first joint venture in Shanghai. Instead of producing the Office Assistant at this site, however, the IPC (ideographic PC)

will now be produced. The change was necessitated by the fact that the performance of the IPC has gone up and the price has gone down, thus reducing the attraction of the earlier product. The venture, which is due to come on line in early summer 1986, will require extensive renovation of an existing facility in Shanghai. The decision to proceed first with the Shanghai venture in China was not without its problems as the MEI 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, MEI acquiesced.

H. National Security and China's Computer Development

As noted, one of the principle driving forces behind computer development in China is the defense establishment, which through the Science and Technology Department of the National Defense Science, Technology and Industries Commission, provides financial and organizational support for computer development to facilities under the Ministry of Electronics Industry (East China and North China Computer Research Institutes), the Chinese Academy of Sciences (Institute of Computing Technology), the Ministry of Space Industry, and various universities.[113] In general, many of

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[113]The personnel from these various organizations have together formed a critical mass of key individuals. See "Computer Scientists Aid Nuclear and Space Programs," FBIS-PRC, September 3,

these facilities are not wholly dedicated to the military, but perform tasks for both civilian and military organizations.[114] The PRC missile program, nuclear weapons program, and its now emerging commercial space program are major sources of demand in terms of enhanced computer capabilities.

It appears likely that the general upgrading of the research and production infrastructure for microelectronics will help contribute to both military and civilian computer developments. This is especially true in view of the recent admonition encouraging closer interaction between the military and civilian sectors.[115] Moreover, Zhang Aiping, Minister of Defense and former director of the NDSTIC, has on several occasions stressed the need for greater attention to electronics and computer development.[116] As such, representatives from the NDSTIC sit on the State Council's special leading group for electronics and

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1982, p.K20.

[114]A good example involves the number of civilian entities involved in the May 1980 launch of China's ICBM. See Gu Zengpei, "Talking About Achievements and Problems in Our Nation's Electronics Technology Based on the Launching of the Cargo Rocket Into the Pacific," Dianzi Kexue Jishu, #120, November 1981, pp.43-48. For a discussion of these issues in the context of the Nanjing Radio Factory see also Dong Yu and Chen Jinyu, "Integration of Military and Civilian Production," Jingji Guanli, December 5, 1983, pp.31-33.

[115]See "Transfer of Military Technology to Civilian Use Is a Major Component of China's Technical Markets," Kexuexue Yu Kexue Jishu Guanli, #4, April 12, 1985, pp.6-7.

[116]"Zhang Aiping Urges Electronics Industry Growth," Xinhua, January 31, 1985 translated in FBIS-PRC, February 1, 1985, p.K13.

computer development, further supporting the high level of attention being given to the computer industry by China's defense leadership.

Two good examples of military-civilian interaction involve the development of the 757 10 mips mainframe computer by the Institute of Computer Technology under the Chinese Academy of Sciences and the Galaxy, a 100 mips computer developed by the National Defense Science and Technology University in Changsha. Both projects appears to be especially significant because they reflect a growing Chinese interest in supercomputers.[117] In a recent article by Qian Xuesen, the Cal Tech trained scientist most often associated with China's missile program, the functional role and evolution of supercomputers in the US and Japan are discussed, highlighting the importance for China of maintaining a presence in

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[117]While there are both potential military and civilian applications for supercomputers, the national security implications seem to be the most critical from the perspective of technology transfer. According to a Newsweek report, the importance of supercomputers lies in the fact that "these technologies will make possible a new breed of weapons and military hardware. Smart weapons--drone aircraft, unmanned submarines, and land vehicles--that combine artifical intelligence and high powered computing can be sent off to do jobs that now involve human risk." See William Marbach, et.al., "The Race to Build a Supercomputer," Newsweek, July 4, 1983. These machines are also useful in the design of very large-scale integrated circuits, such as advanced memory chips. See Businessweek, November 28, 1983, p.109. While China currently lacks the capabilities to make a significant push in these areas, development of such machines--supported by direct and indirect acquisition of foreign technology--could allow the Chinese to make much more rapid progress than might otherwise have been the case, particularly if such development is designated a high priority by the central leadership..

this area of important technological change.[118] In particular, Qian talks about the growing role of intelligent machines for solving not only mathematical problems, but in transforming the nature of work and how man and machines relate to one another.[119] He closes his article, however, with an admonition that supercomputer technology is treated like the technology for producting atomic weapons, etc. in the West, and therefore China must establish its own independent efforts to realize technological advances in this area.[120] The two projects discussed below seem to reflect this latter perspective.

The 757 project, which originated in the mid-1970s, was ostensibly begun at the bequest of the Ministry of Nuclear Industry, while it was still known as the 2nd Ministry of Machine-Building. The project was designed to emphasize China's technological self-reliance; the electronic components and

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[118]Qian Xuesen, "On the Question of the Fifth Generation Computer," Ziran Zazhi (Journal of Nature), Volume 8, Number 1, January 1985, pp.3-9.

[119]Among the problems cited by Qian for application of supercomputers are non-linear partial differential equations, non-linear finite element analysis, and multi-order perturbation methods. Some of the applications of supercomputers noted by Qian include aerodynamics, the diffusion of gases, nuclear explosion technology, chemical molecule design, and quantum color dynamics.

[120]One of the other interesting aspects of the Qian article is his discussion of the debates over design in China during the development of the Galaxy computer. Implicitly, Qian suggests that Chinese computer scientists had not adjusted to the changing economic structure of computer technologies, whereby components were decreasing in cost and therefore did not have to be used as sparingly as they may have been in the past.

semiconductors needed for the computer were to come from domestic sources. The task of overall coordination was given to the CAS; along with providing technical support, the Institute of Computer Technology had to interface with the Institute of Metallurgy (CAS, Shanghai branch), the Beijing Dongguang Factory (#878), the Ministry of Electronics Industry, the Ministry of Chemicals Industry, the CAS #109 Factory, the Institute of Semiconductors (CAS), and the National Defense Science and Technology Commission--which provided overall funding. One machine was produced by the early 1980s; it is now being "upgraded" to the 30 mips level with the magnetic core memory being replaced by integrated circuits and the major components being imported from abroad instead of purchased from domestic sources.

A similar example is found in the case of the Galaxy computer, which is said to be a Chinese version of the powerful Cray 1.[121] The Galaxy is projected to have a data processing capacity that can handle 100 million operations per second.[122] It is primarily being used for weapons-related calculations and petroleum exploration and weather forecasting.[123] The development

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[121]"Galaxy Sparks Illuminate China," Renmin Ribao, January 5, 1984, p.3.

[122]"Chinese Supercomputer Unveiled," China Pictorial, March 1984, pp.1-2.

[123]In addition to the work associated with the Galaxy project in Changsha, the Chinese have also developed an advanced array processor (NCI-AP2701) that has a processing capability of "tens of millions" of instructions per second. It was developed by the North China Computer Research Institute of the Ministry of

of China's first "supercomputer" began in May 1978 and was accomplished by sending out "an investigation and Research Group many times to all parts of the country in order to gather extensive information and materials from both China and abroad."[124] Moreover, "some 20 groups, including Hunan University, Hunan Teacher's College, Fudan University, Wuhan University, the Ministry of Space Industry, and the Information Institute of the NDSTIC, detailed essential technical personnel" to work on the project, reflecting the proven ability of the NDSTIC to bring together critical resources to accomplish a high priority national goal.[125]

Even though the Chinese have officially announced the manufacture of one Galaxy machine, based on discussions in China and the US there is evidence that China may have actually built two Galaxy-like computers. One of these machines may be in Beijing at the Ministry of Petroleum Industry and the other still in Changsha. In contrast to the 757 project, however, the Galaxy relied on imports for over 90% of its component and semiconductor

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Electronics Industry. The new machine has projected applications in mineral prospecting, medicine, power management, and national defense.

[124]A good reflection of China's level of understanding vis-a-vis supercomputer technology is reflected in a survey of supercomputer architecture in the journal Dianzi Xuebao, Volume 11, #3, May 1983, pp.91-98 translated in JPRS-CST-85-006, March 6, 1985, pp.43-58. The Chinese are also extremely interested in the so-called "fifth generation" computer and have already begun some preliminary research in this area. China Daily, June 5, 1985.

[125]China Daily, December 22, 1983, p.1.

needs.[126] Upon its completion in May 1983, the State Council organized 95 computer experts and technicians from 29 different organizations to assess and evaluate the final product.[127] More recently, a preprocessor microcomputer for the Galaxy was developed by the NDSTU and put into production at the Tianjin #2 Radio Plant.[128] The preprocessor will help the Galaxy reduce operational costs and more efficiently handle large-scale projects.

In most cases (though not necessarily in all cases) internal technology sharing must be assumed in considering the sale of advanced computers to the PRC.[129] The only factor working against such sharing is the bureaucratic rivalry among Chinese organizations, though this appears to be much less of a serious problem when the defense sector is involved. As far as China's willingness to abide by existing US guidelines is concerned, the evidence is much less clear. In some cases, China continues to use Hong Kong as a site for procuring sensitive technologies as well as using HK-based firms as sites for training PRC nationals

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[126]Personal communication, Beijing, January 1986.

[127]"Galaxy Super-Computer," Beijing Review, January 2, 1984, p.8.

[128]"Defense University Develops Super-Microcomputer," Xinhua, December 29, 1985 translated in FBIS-PRC, December 30, 1985, p.K18.

[129]A variety of physical devices as well as devices internal to the computer and its software can be used to prevent unauthorized access. In the case of the latter, attempts at access by unauthorized persons can be detected.

in technical areas presently prohibited for sale to China under US export controls.[130]

With respect to diversion of US technology, the only thing that can be said up to this point is that Chinese officials have been reluctant to go on public record to commit to a policy of non-diversion to third countries because it violates their sovereignty. Recent changes in the COCOM and export control guidelines, however, necessitate the issuance of an "end-user" certificate by MOFERT certifying that "all items... exported to the PRC are for use in the PRC and will not be reexported to a third country."[131] The dilemma faced by the US in this context, particularly with respect to the sale of larger machines, is no different than that associated with the Sino-American nuclear power agreement; either we feel confident about China's willingness to be a responsible international actor or we do not.

Aside from supercomputers, enhanced computer capabilities, including acquisition of foreign microprocessor technology, also have actual and potential application in China's strategic programs. The accuracy of China's intermediate and

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[130]"Information Systems: Hong Kong Winning Name of China's Smugglers' Cove," MIS Week, May 22, 1985, p.20.

[131]The "inclusion" of MOFERT in the proceessing of licenses places part of the bureaucratic burden on the PRC side by giving the Chinese side a vested interest in reviewing and issuing certification requests as rapidly as possible. From a political perspective, it also places the major responsibility for non-diversion in Beijing's hands.

intercontinental missiles, for example, could be upgraded by relatively minor improvements in computerized guidance system operations.[132] These computer-related improvements would allow for better prelaunch calibration of the gyroscopes and accelerometers as well as better in-flight performance.[133] Computers also have begun to make their presence felt within the conventional warfare and training elements of the PRC military.[134] The military side of the Jiangxi Nautical Instrument Factory has introduced a minicomputer to assist with militia and reserve troop statistical work.[135] Additionally, the academies of the People's Liberation Army have begun to introduce all sorts of electronic computers for training and battlefield simulations.[136] For example, CEIEC has been promoting the sale of the SHMX II-II anti-tank missile simulator abroad after it has been successfully

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[132]China's recent advances in its space program reflect a host of computer-related advances both in terms of performance and general application.

[133]See John Tirman, ed., The Militarization of High Technology (Cambridge: Ballinger Publishers, 1984), pp.45-61.

[134]From an overall perspective, computers have the potential of significantly decreasing the cost of weapons systems and related military equipment while signficantly improving performance levels and characteristics.

[135]Zhongguo Minbing, February 9, 1985, pp.42-43 translated in JPRS-CPS-85-065, July 1, 1985, p.113.

[136]According to one US weapons expert, simulations are revolutionizing the training of pilots and other equipment operators. Computer simulators recreate, at reasonable cost, the fast-paced combat conditions that are often too dangerous and expensive to duplicate in reality. See William Perry and Cynthia Roberts, "Winning Through Sophistication," Technology Review, July 1982.

introduced with PLA training programs.[137] Moreover, China's entire orientation to military logistics on and off the battlefield has been influenced by the availability and potential application of computers.[138]

I. The Socio-Political Impact of Computers

As the technological changes associated with computers move ahead, the contribution of these changes to social stability tends to grow weaker and weaker.[139] Viewed from such a perspective, the potential impact of computers on Chinese societal development could be significant. In many cases, decisions about export control cases rarely reflect the tradeoffs between the benefits that increased computerization might provide, e.g. stimulating greater political openness, versus the national security risks involved. Propelled by catchy phrases such as Toffler's "third wave," the Chinese have gone for computers in a big way, perhaps much faster than they even realize. In many cases, it seems clear that Chinese leaders have not considered the full range of socio-political impacts that persons such as Daniel Bell, Herbert Simon, and Sheryl Turkle have spoken about in their analysis of computers

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[137] Xiandai Junshi, #103, June 1985, p.7.

[138] Cheng Fang-kuang, "Reform of Logistics Work in the Chinese Communist Army," Chung-kung Yen-chiu, January 15, 1986, pp.103-109 translated in JPRS-CPS-86-027, March 26, 1986, pp.95-107.

[139] Wilson Dizard, The Coming Information Age, 2nd edition (New York: Longman, Inc, 1985).

in the West. Major changes are on the horizon for China in the workplace, in educational institutions, and in their political system if present trends towards the use of computers continue.[140]

To some extent, the problem posed by the proliferation of computers in China represents many of the other problems associated with technological change in the PRC: Chinese leaders believe that they can capture the advantages of advanced technology while minimizing socio-political and cultural change. History has shown that this is a difficult, if not impossible challenge. Many questions remain about what a "Chinese-style information society" will look like.[141] Moreover, recent discussions in China about the creation of a national computerized system for personal identification to replace the presently used system of hand-written ID cards raises potentially serious human rights issues for the US--particularly since the Chinese are looking to US firms to source the equipment and software to establish such a capability.

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[140]One issue that the Chinese have yet to encounter on a large scale concerns the problem of transborder data flows. This issue, which strikes at the heart of questions regarding national sovereignty and control, seems likely to emerge in China as more and more multinational firms arrive in the PRC with computer systems that wish to communicate with and transfer data to the computer systems of their parent in the US or other locations.

[141]Based on a number of articles in the Chinese press, there is a growing concern about computer security. Following the lead of the US Department of Defense decision in 1981 to set up a special computer security center, the Chinese have begun to introduce various forms of security devices, including passwords, access control matrices, encryption devices of a rather sophisticated nature, e.g. permutation schemes to encode data.

J. Projections of China's Computer Future

Technology transfer has played an important role in China's computer development, though mainly through indirect rather than direct means. Three types of technology transfer have occurred: a)import of computers as equipment for actual applications; b)use of foreign computers as models for reverse-engineering and imitation; and c)use of Western components for manufacture of domestic and foreign designed machines. In most cases, it is clear that the Chinese have benefitted from their expanded access since the late 1970s to foreign equipment and technical literature--though the full extent of the impact remains uneven and uncertain at this point. Largely through the process of reverse engineering, however, the Chinese have used knowledge of foreign designs and operating principles to advance their current mainframe and micro computer development programs. Progress has been appreciable with respect to the latter category, with 8-bit machines and more recently 16-bit computers most clearly reflecting the results of foreign "borrowing." And, as the case of the Great Wall microcomputer indicates, when foreign design concepts have been mastered, "replication" has become much less difficult since it has become easier (due to export control relaxation) for China to secure many of the necessary foreign semiconductor and integrated circuit components to build such machines.

At the same time, however, because of the limits inherent in the role of reverse engineering as an effective vehicle for technology transfer, the contribution of foreign imports to overall domestic technological advance has been less than anticipated. These "process" problems have been compounded by China's own shortcomings with respect to personnel and components production and quality as well as overall manufacturing techniques. Moreover, as the requirements for so-called "customized" components have grown, the Chinese have found themselves overly dependent on more standardized imported components that are unable to meet more specific design needs or on a domestic industry that all too often cannot meet component supply requirements in terms of numbers and reliability.

Nonetheless, by the end of the decade, even though the Chinese will not significantly close the gap with the West and Japan in overall computer technology, China will move ahead in a number of facets of its computer industry. And, while recent economic reforms may be one driving force behind this progress, the major impetus will still lie within government hands. Through its current efforts to build a broad-based research and production infrastructure for computer development, both central and local government organizations will, in effect, be absorbing the start-up costs for establishment of a viable computer industry. High-level bodies such as the Leading Group for Electronics under the

State Council promise to ensure that sufficient resources are made available for these purposes. Additional pressures from the Chinese military, which are likely to increase over time as they seek out a larger share of existing resources, will also support continued emphasis on computer development.[142] Thus, the essence of the strategy for computer development will be similar to that of electronics, that is, a "two pronged strategy," whereby the ability of the central government to orchestrate critical projects through its tasking authority will be combined with use of market forces to stimulate innovation in terms of both design and application.

China's banking system and financial institutions appear to be one of the largest potential clients for both domestic and imported foreign computers.[143] The five key banks in China, the People's Bank, the Bank of China, the Industrial and Commercial Bank of China, the Agricultural Bank of China, and the People's Construction Bank of China all plan to greatly expand the use of computers to conduct their business and link their offices throughout the country. Along with banking, other major uses will be in the tourist/travel industry and the education system as well as in general overall industrial management and national defense.

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[142]The demand for computers is also likely to come from the need for better radar and navigation systems, training simulation equipment, and command and control capabilities as well as from strategic weapons programs.

[143]"Banking on Computers," China Daily, October 2, 1984, p.2.

Based on the successful implementation of the current strategy for computer development, the following "pockets of excellence" are likely to emerge:

a)Software development. Software development will continue to be a high Chinese priority in terms of investment and R&D activities. China does not have the burden of a large inventory of ill-structured programmes to maintain. Given the potential to build a "clean" software industry, combined with the low cost of Chinese technical labor, it is likely that China will close the prevailing software gap at a faster pace than hardware. This may result in a significant Chinese presence in global software markets, particularly if it can build "alliances" with Western computer firms that have access to the latest hardware developments and also have established market access. Included in this category is Chinese character-based software covering the full spectrum of industrial, financial, and scientific programs.

b)Microcomputer development. In view of the progress that has been made in the design of machines such as the Great Wall 0520, which is said to be a clone of the IBM PC/XT, China will gradually take the lead in producing what may turn out to be one of the "microcomputers of the Third World."[144] In view of China's cost

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[144]To test the acceptability of the Great Wall computer, it was recently shown at an exhibition in the US in November 1985.

structure as well as its current ability to imitate and reverse engineer Western designs, a Chinese-built microcomputer could be competitive with prevailing Western models, especially if the Chinese can parallel their progress in computer development with similar improvements in microelectronics technologies.[145] Even if this does not materialize, it is possible to visualize a scenario whereby the Chinese become major OEM (original equipment manufacturers) producers for some of the larger computer manufacturers. Over the longer term, PRC efforts could be boosted by various forms of technological cooperation from Singapore, Hong Kong and even Taiwan--all of which have a growing familiarity with Western levels of sophistication.

c)Supercomputers. Even though the Chinese will remain generally 5-7 years behind in their ability to mass produce both micro and minicomputers, they will continue to be adept at channelling their limited resources and overcoming existing organizational barriers to attain state-of-the-art technology levels in a number of key defense-related areas, foremost among them being large computers. Chinese computer specialists have paid careful attention to supercomputer development in the West and Japan (as well as such

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[145]In 1983, China exported its first set of computers, the BCM-III, which is an 8-bit, single board computer. According to reports, 1000 units were sold to West Germany--though interviews in that country did not indicate the existence of this product in the retail marketplace. Discussions in Beijing in January 1986, however, did reveal that the BCM-III happens to be one of the computer series that cannot find an adequate market in China, let alone be sold in large numbers abroad.

projects as VHSIC--the effort to create very high speed integrated circuits), and have a good grasp of developments towards production of the so-called "fifth generation" computer. The Galaxy program manifests a determination to close the prevailing gap with the West, a determination that is apparently supported by the availability of all sorts of financial, technical, and personnel resources. And, while some questions remain about the performance of the Galaxy as compared with the Cray, the fact remains that the Chinese were apparently able to master not only the electronics aspects, but more critically, the cooling technologies that lie at the heart of the Cray system. If such is the case, this does suggest a potential area where China could make substantial progress over the next five years.

Progress in each of these areas holds important implications for the US. From an economic perspective, improved application of computers, be they foreign or domestically produced, will assist the Chinese in all facets of their modernization program. Given the US policy of support for the four modernizations program, it is reasonable to conclude that the US should promote and facilitate the expanded use of computers in China. Cooperation programs and educational exchanges associated with information systems and technologies should be given adequate political and financial support. Without such support from the US Government (and US allies), many of the improvements in managerial efficiency, productivity, and coordination that are needed to

modernize the PRC economy will be delayed or inhibited from occurring. As such, export controls that unneccesarily restrict the sale of equipment and related items to China in support of economic modernization should be adjusted or removed.

From a commercial perspective, Chinese manufacturers, if joined together with US firms through joint ventures, etc., could serve as important production complements to America's computer industry in much the same way that Taiwan and South Korea do today. At the same time, however, it is also clear that China does not want to be a mere appendage to the US economy, and will increasingly encourage "domestication" of its computer industry, gradually decreasing the amount of direct control foreign firms have over this high priority industry--but not decreasing the push for expanded levels of technology transfer. This suggests that access to the Chinese market may become increasingly scarce as Chinese capabilities improve. In effect, the transfer of technology to the PRC may provide for some short-term rewards, but as presently structured, the currently emerging relationships between US and PRC firms may not provide the basis for long-term commercial cooperation.

On the military side, there is little doubt that the acquisition of foreign computers and related technologies will assist the PRC in all facets of its military modernization program. The real question is how far and how fast will China's

military progress? Of greatest concern should be the potential contribution of China's computer revolution to strategic weapons programs. It remains to be seen whether the risks of directly or indirectly supporting such programs can be successfully ascertained at this point in time based on our current information base and knowledge of Chinese intentions. For the present, this level of uncertainty suggests that caution should be our guiding principle in managing advanced computer sales to the PRC in the short-term. Moreover, the likelihood of internal diversion from approved civilian users to unauthorized military end-users remains very high--and so do the potential security risks if such diversions do take place. Before further significant relaxation in present controls does occur, it would do the US well to gain more insight into the future of the post-Deng succession, the precise meaning to the US of China's "independent" foreign policy posture, and the evolving role of the PRC military within the realm of domestic politics and foreign policy decision-making.

Chart 1
Organization of China's Computer Industry
(within the MEI)

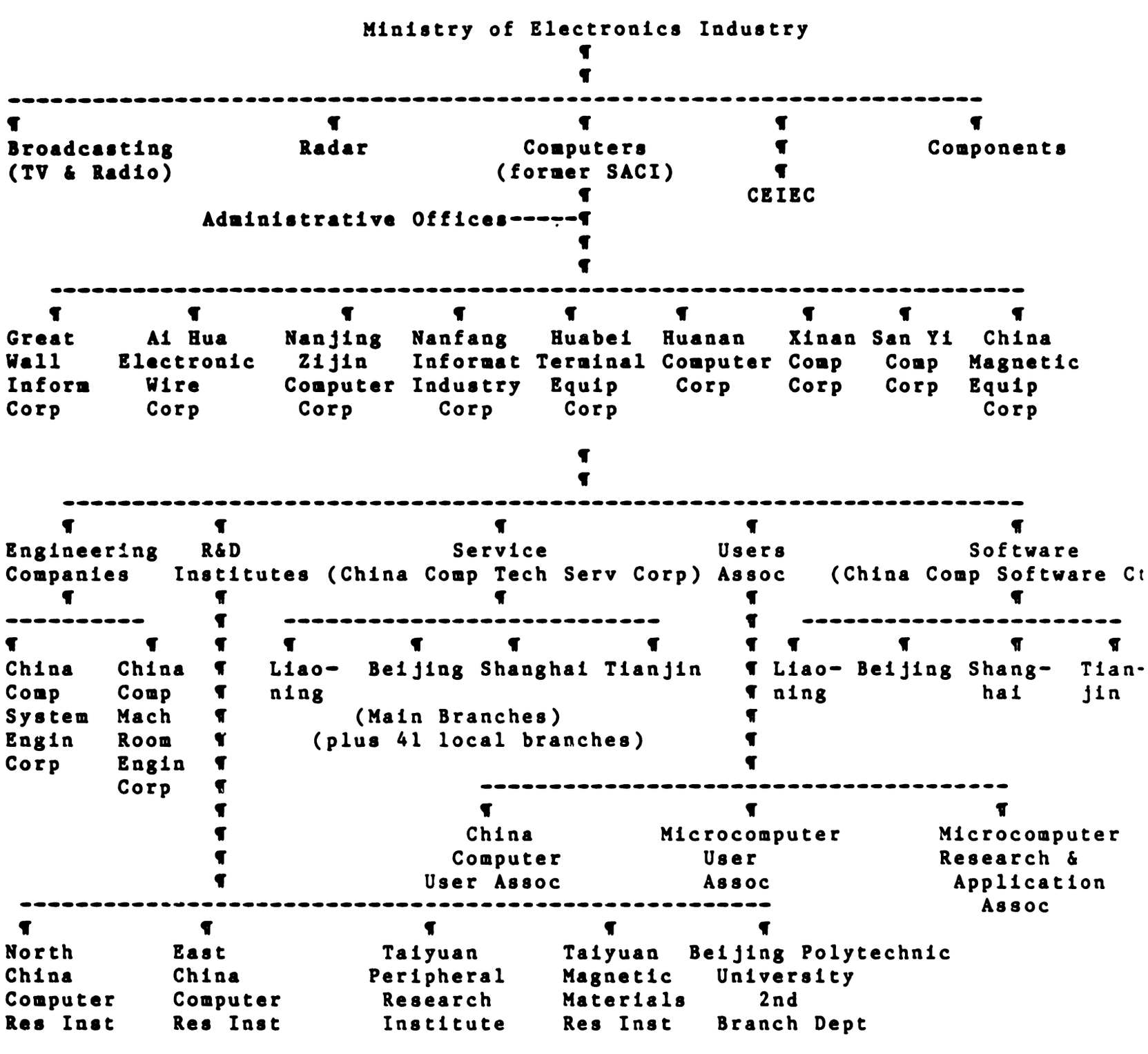

Chart 2
China's Electronics Industry

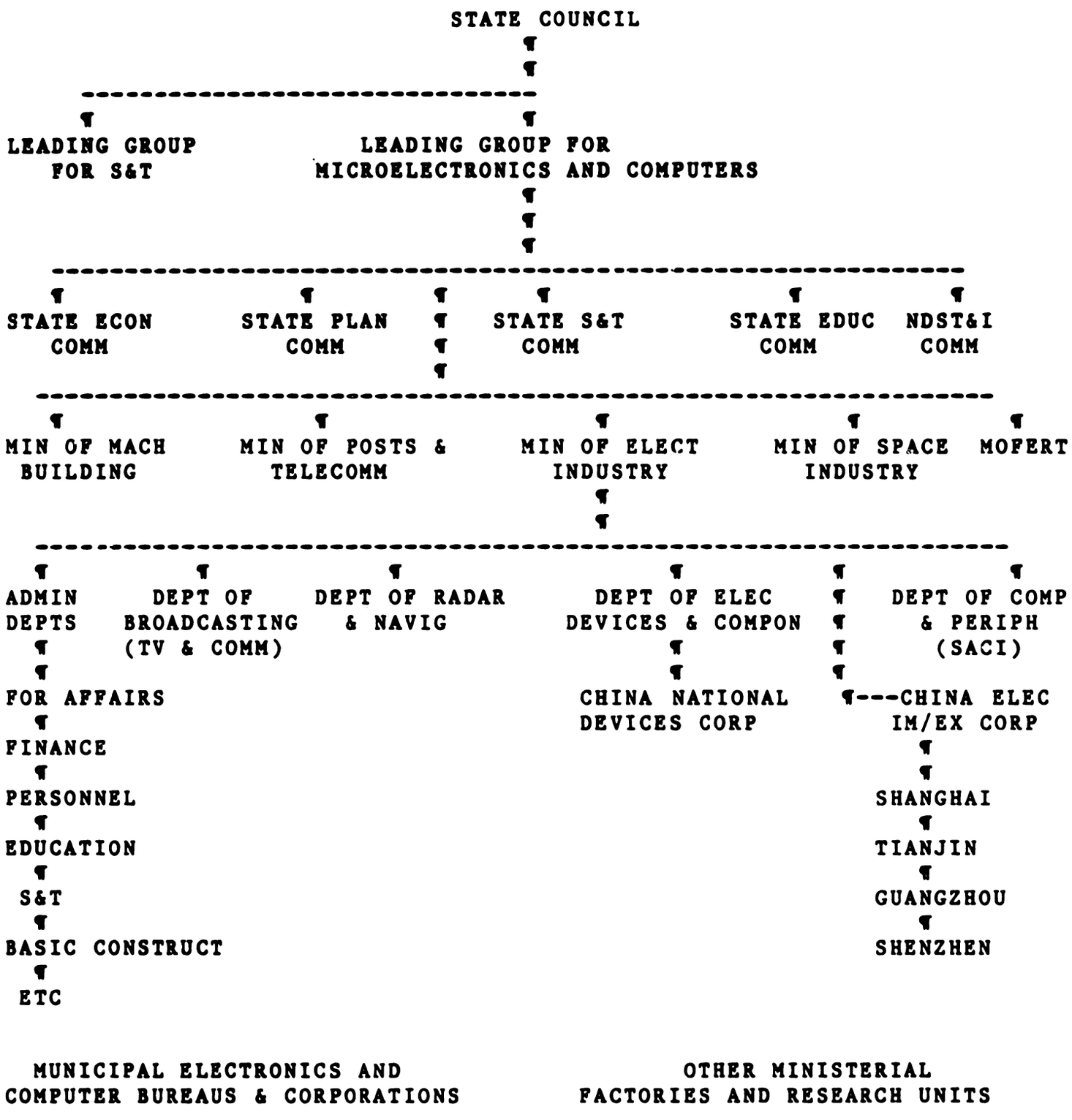

Chart 3

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
1979	Development of DJS-052 microprocessor (8 bit, one chip)
1983	Development of China's first supercomputer ("Yinhe" ["Galaxy"],100 MIPS) by the S&T University for National Defense in Changsha
1983	Development of the 0520 microcomputer (IBM PC compatible) by the MEI Institute No.6 and production by Beijing Wire Communications Factory
1983	Development of the "757" 10 MIPS parallel computer by CAS Institute of Computer Technology
1983	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 (CPU: MC 68000)
1985	Development of NCI-AP 2701 floating point array processor by MEI North China Institute of Computer Technology
1985	Development of NCI-2780 super-minicomputer (32 bit) by North China Institute of Computer Technology (Clone of DEC VAX 11/780?)
1985	Development of 8030 computer by East China Institute of Computer Technology (compatible with IBM 370/138)
1985	Development of YH-X1 super-minicomputer by the S&T University for National Defense in Changsha
1985	Development of YH-F1 emulator by the S&T University for National Defense in Changsha

Source: Assorted Chinese and English-language publications.

Chart 4

China's Leading Computer Facilities

Name	Location
A. Manufacturing	
Beijing Wire Communicaations Factory	Beijing
Beijing #3 Computer Factory	Beijing
Tianjin #2 Computer Factory	Tianjin
Nanjing Wire Communications Factory	Nanjing
Shanghai Computer Factory	Shanghai
Shanghai Broadcasting Equip Factory	Shanghai
Hangzhou Magnetic Equipment Factory	Hangzhou
Suzhou Computer Factory	Suzhou
Wuxi Computer Factory	Wuxi, Jiangsu
Lishan Microcomputer Factory	Xian
Shenzhen Aihua Electronics Company	Shenzhen SEZ
B. Research & Development	
Huabei Computer Research Institute	Beijing
Huadong Computer Research Institute	Shanghai
Institute of Computer Technology, CAS	Beijing
Chengdu Institute of Computer Applic	Chengdu, Sichuan
National Defense Univ for S&T	Changsha
Qinghia University	Beijing
Shanghai Jiaotong University	Shanghai
MEI Research Institute #6	Beijing(?)
MEI Research Institute #18	Changsha
MEI Research Institute #52	Taiyuan
MEI Research Institue #53	Liaoning

Source: The China Directory of Machinery and Electronics Enterprises (Beijing: Machine-Building Industry Publishing House, 1984) and China Scientific Research and Technology Services Handbook (Beijing: Guangming Daily Publishing House, 1984).

Table 1

Mini and MainFrame Computer Sales to China

(as of January 1985)

Manufacturer	# of Installation
Burroughs	38
Control Data	18
Data General	20
Digital Equipment(DEC)	350
Fujitsu	74
Hewlett-Packard	66
Hitachi	97
Honeywell	108
IBM	100
Nippon Electric(NEC)	20
Prime	19
Siemens	20
Sperry	8
Toshiba	10
Wang	220
USSR/East Europe	40
Others	31
Estimated Total	1,239

Source: International Data Corporation, Hong Kong, Sept 1985.

Table 2

US Computer & Related Equipment Sales to China
(in thousands of dollars)

Item	1981	1982	1983	1984	1985
Analog & Hybrid Computers	163	5041	1715	2082	6767
Digital Computers	5158	11337	11324	25265	80062
Digital Central Processing Units	5179	2169	10816	32494	35411
Random Access Aux Storage	1052	1049	1849	1519	7399
Serial Access Aux Storage	140	430	680	1995	5204
Terminals	699	1108	2241	2261	3900
Printers	645	626	1063	1814	3454
Communication & Peripherals	268	1644	2301	8006	9175
Parts, etc.	3763	8376	11913	20476	31710
Microprocessor Integrated Circuits	104	25	4	50	47
Printed Circuit Boards	258	58	557	1407	2245
Cathode Ray Tubes	8	91	22	179	417

Source: Office of Chinese Affairs, US Department of Commerce, 1986.

Table 3

Selected Chinese Microcomputers

Computer	Manufacturer	CPU
DJS-060 Series (8)	Shenyang-Liaohe Inst	MC6800
DJS-060 Series (8)	Sichuan Solid State Inst	MC6800
DJS-054 (8)	Shanghai Computer Factory	8080A
DJS-033 (8)	Nanjing Wireless Radio Fact	6502
DJS-044 (8)	Beijing Wireless Radio Fact	Z80A
BCM-III (8)	Beijing #5 Computer Factory	Z80
DJS-065A (8)	Tianjin #5 Wireless Factory	MC6800
DJS-028 (8)	Guangzhou Computer Plant	Z80
DJS-083A (8)	East China Normal Univ	Z80
Great Wall 0520 (16)	Beijing Telecomm Equip Fact	8088
Zijin-II (16)	Nanjing Zijin Computer Factory	Z80
GF-20 (16)	Beijing-Guangdong Computer Ctr	Z80A
TP-801 (16)	Beijing Polytechnic University	8086
TP-86A (16)	Beijing Polytechnic University	8086
77-II (16)	Lishan Microcomputer Factory	8086(?)
TQ-0671 (16)	Tianjin Computer Factory	MC6800

(8) = 8-bit microcomputer
(16)= 16-bit microcomputer

Source: China Computerworld, Beijing, 1984-85.

Table 4

Estimated Computer Production in China

Type	1981	1982	1983	1984	1985
Single-Board Microcomputer	1500	5700	10499	35000	50000*
Microcomputer	380	1487	5436	27340	60000*
Minicomputers & Mainframes	147	223	364	700	1200*
TOTAL OUTPUT VALUE (RMB MILLION)	402.5	487	794	1589	3655*

Source: China Computerworld, Assorted Issues, Beijing. Almanac of China's Economy, Beijing, 1981-1985.

Table 5

New US Computer Export Regulations
(as of December 1985)

1. Digital computers: a)operated by civilian end-users for civilian purposes; b)are exported as complete systems or are enhancements of previously exported systems; c)have been primarily designed for non-strategic uses; and d) do not fall outside the scope of the following limits:

   A.--Total processing data rate of 155 Mbit per second and total connected capacity of main storage of 72 Mbit; or
   --Total processing data rate of 100 Mbit per second and total connected capacity of main storage of 134.5 Mbit.

   B.--Input/Output control unit:

   --Total bit transfer rate of 101 Mbit per second
   --Maximum bitransfer rate of any drum or disk drive of 34 Mbit per second
   --Total connected "net capacity" of 74,000 Mbit.

   C.--Array Transform Processors:

   --Equivalent multiply rate of 800,000 operations per second
   --Fast Fourier Transform of 1024 complex points--40 ms.
   --Word Length--38 bit.

2. Microcomputers:

   A.--Total processing data rate of 15 Mbit per second

   B.--Virtual storage capability of 512 million bytes

Source: Federal Register, Volume 50, #249, December 27, 1985.

Table 6

Selected Examples of PRC Computer Imports
& Forms of Cooperation with Foreign Corporations

Foreign Firm	PRC Organ	Nature of Project	Date
Control Data Corp (US)	Min of Petro Industry(?)	Sale of 2 Cyber 172	1976
Sperry Univac (US)	CNMIEC	Sale of 1100/11 & 1100/12 systems	1978
Hitachi (Japan)	CNMIEC	Sale of 3 mainframes & 2 M-160 mainframes*	1978
Hitachi (Japan)	People's Bank People's Insurance	Sale of 11 M-150 comp	1979
Burroughs (US)	Beijing Inst of For Trade	Sale of B3950 & B876 computers	1980
Fujitsu (Japan)	Tianjin Municipality	Establish large inform system	1980
IBM (US) (United Nations)	CNTIC	Sale of 16 series 4300 computers for census	1980
Sinclair (UK)	South China Comp Corp	Assembly of ZX-81 & Spectrum home computers	1983
Sperry (US)	China Computer Tech Services Corp	Technical services	1983
Sems (France)	Guangzhou Municipality	Manuf Solar 16 minicomp	1983
IBM (US)	Instrimpex	Sale of 11 4341 comps	1983
IBM China (US)	Min of Educ	Donate 100 5550 micros to MoEd	1984
Kanematsu-Gosho (Japan)	--	Marketing & service for IBM PCs: 5150/5160/5550	1984
General Robotics (US)	CEIEC	Assemble DEC-like mini-computers	1984
Honeywell (US)	Instrimpex	Service center	1984

Eastern Computer (US)	Henan Inter Econ-Tech Corp	Computer components & software	1984
Control Data Corp (US)	MEI/SACI	R&D and training in computer technology	1984
Hewlett-Packard (US)	CEIEC	JV for microcomputer assembly/manuf	1984
Burroughs (US)	Yunnan Elec EquipFactory	Distribute & assemble B20 & B25 microcomputers	1984
NEC (Japan)	North China Term Equipment Corp	Assembly of PC-9801F microcomputer	1984
Wang (US)	Xiamen Constr & Develop Corp	Assemble microcomputers & distrib Wang products	1984
Wang (US)	CEIEC (Shanghai)	Produce microcomputers	1984
Gould (US)	CNMEIEC/Tianjin Automation Factory	Assemble industrial programmable controllers	1984
Altos (US)	Shaoguan Radio Factory(Guangdong)	Sale of production line for 16-bit microcomputers	1984
Honeywell (US) (World Bank)	Ministry of Educ & CNTIC	Sale of 14 Systems (DPS 6 & DPS-8 plus software)	1984
Honeywell (US)	Great Wall Corp (MSI)	Sale of DPS-6 systems	1984
Sumitomo & NEC (Japan)	Min of Education	Sale of 305 8-bit PCs	1984
Fujitsu (Japan)	CNTIC & Metero-logical Ctr in Beijing & several universities	Sale of 24 FACOM series large computers (360R, 360S, & 340S)	1984
Hitachi (Japan)	CNTIC	Sale of 12 small & med comp for constr, civil engin	1984
Genisco (US)	Hunan Comp Factory	JV to produce comp graphics terminals	1984
Data General (US)	Tianjin Comp Corp	Sale of 32-bit MV line & 16-bit desktop comp	1984
Digicon Geo-physical (US)	Min of Petro Ind	Sale of seismic comp equip & software	1984

Cullinet (US)	China Comp Tech Service Corp	Application & develop of software	1984
Intel (US)	China Aero Tech Im/Ex Corp	Assemble 4000 86/310 & 286/310 microcomputers	1984
Chiu Hwa Elec (HK) William Elec Comp	Dalian Municipality	Manuf microprocessors & training	1985
Ling Lang Micro & Comp Corp (UK)	Guangdong Province	Manuf componts & microcomputer systems	1985
Prime (US)	Min of Railways	Sale of mainframe plus Medusa software	1985
Sord Comp (Japan)	CAS	Sale of 30-40 PCs plus est of PC training ctr	1985
DEC (US)	Min of Water Conservancy & Power	Sale of 4 VAX 11/780 minicomputers	1985
Prime (US)	Beijing Inst of Technology	Sale of Prime 9750 comp	1985
CDC (US)	Min of Petroleum Industry	Sale of 5 Cyber 180 computers & CAD/CAM software	1985
Groupe Bull (France)	CNTIC	Sale of 5 mainframes, 60 minis & 320 terminals	1985
Toshiba (Japan)	Nanjing Info Equip Corporation	Assembly of dot matrix printers	1985
Charles River Data Systems (US)	Tianjin Computer Factory	Subassembly of 32-bit Universe 68 computer	1985
Corporate Data Sciences (US)	Guangzhou/ Hong Kong	Sale of 4000 IBM PC/XTs 10,000 desktop comp	1985
Hitachi (Japan)	People's Bank	Sale of 15 computer systems (US$25-30 M)	1985
Hitachi (Japan)	Min of Railways	Joint development of software & sale of 30,000 microcomputers	1985
Urchida Yoko (Japan)	CAS	Joint development of computer software	1985

Sperry (US)	China Comp Tech Service Corp & Wuxi Comp Factory	Introduced MAPPER IC software system	1985
GE CALMA (US)	CNTIC	CAE/CAD equipment, incl. 60 Apollo workstations	1986
Mancos Computer (UK)	Hong Kong e.g. Chongqing Univ------>	Sale of general comps VAX 11/750	1986