NATIONAL COMPUTER POLICY AND DEVELOPMENT IN CHINA

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I. INTRODUCTION[2]

Economic reforms of the past fifteen years have transformed China from a centrally-planned socialist economy to a mixed market system. The government has introduced market incentives for farmers, put state enterprises on a more commercial basis, given more authority to enterprise managers and opened the economy to more foreign investment in order to create what it calls a "socialist market" economy. These reforms have already produced high rates of growth in output and exports, especially in the coastal areas which are involved most heavily in export-oriented manufacturing.

Economic reform in China has been accompanied by a similar shift in technology policies away from the nationalistic strategy of self-reliance which prevailed until the 1980s. The government has moved to a more pragmatic strategy of importing advanced technology and directing domestic technology development toward commercial purposes. This shift is driven by economic necessity, as China realizes it must upgrade its technology rapidly to compete internationally. It is also made easier by the end of the Cold War and the fall of the

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2 The research for this article was conducted during two visits to China, one in 1993 as part of an international conference on "Informatization and Economic Development" (Li et.al., 1994) and another in 1994 as part of a similar confernce on "The Information Industry and International Cooperation".

Data on production and use of computers in China are extremely difficult to obtain, and often unreliable. Our estimates were obtained from IDC, China Research Croporation, Institute for the Information Industry, and a confidential industry source. Our estimates were confirmed by the Chinese Academy of Social Sciences (CASS), which reviewed the draft manuscript and supplied some missing data. Finally, developments in computing are changing rapidly as regional and local governments try to create and attract information industries. Greater depth of reporting on China computing development requires regional focus and study.

Soviet Union, which have lessened the security threat to China and allowed easier access to international technology.

The change in technology strategy has been reflected in China's policies toward information technology (IT). Until the 1980s, China attempted to develop the capacity to produce a full line of computer hardware and software, incorporating as much indigenous technology as possible. After 1984, the government began to shift away from the goal of self-sufficiency in IT to emphasizing IT use in all sectors and production of internationally competitive IT products. The strategy consciously incorporates elements of the policies of Japan, Korea, Taiwan and Singapore to promote IT production and use.

Thus, China's policies toward information technology (IT) have shifted from nationalism toward the pragmatism of its Asian neighbors. China is commited to "informatization" as a means of modernization and reform of its economic system. Chinese political leaders define the level of information infrastructure as an indicator of modernization and development, feel they are behind the developed world, and have set targets for improving their information infrastructure. The push for informatization began in 1984 when Premier Deng Xiaoping emphasized the importance of informatization to China's four reforms. It has been reinforced in many subsequent speeches and in the ten- and five-year plans and programs of the government.

Informatization refers to both the production and use of IT hardware, software and services. IT use, or the application of IT to all sectors of the economy, appears to be uppermost in the minds of government planners. China feels it has a long way to go to "catch up" with the developed world on informatizaton indicators such as telephones, computers, and on-line databases in use.

The development of information industries, or the production of computers and telecommunications equipment, development of software, and creation of information services is also part of the planning agenda. The impetus for the development of domestic information industries is multifaceted. It is partly a matter of national self-reliance, partly a

concern about job creation and job loss prevention, and partly a desire to enter the international marketplace with high-technology, high value exports.

China's strategy for computer technology has shifted in the past decade from an ideological quest for technological autonomy to a pragmatic pursuit of informatization of the economy.[3] China is developing its information industries and information infrastructure simultaneously. It is using the lure of its massive market to attract foreign technology and capital to upgrade its technologically-lagging infrastructure while at the same time transferring technology to the local economy through joint ventures between foreign and domestic enterprises. These domestic enterprises are profit-oriented, export-oriented and increasingly free of State financing and detailed policies regarding their operations. However, they are responsible for performance within broad guidelines set by the State ministries of which they are a part.

The results of the more pragmatic approach to IT policy have been a rapid increase in use of IT, even though overall use is still quite low, and a rapidly growing computer industry. Computer use, as measured by annual investments of government agencies and enterprises, has increased about 20% annually since 1980, and shows no signs of slowing. The recent reduction of import duties and taxes on computer hardware and software might actually increase investment growth over the next several years. Production of computer hardware grew at an annual rate of 31% from 1989 to 1992. Given its market potential, its large pool of engineers and computer professionals and its low cost unskilled and semi-skilled labor force, China is likely to become a major producer of at least some types of computer hardware and software in the future. Investment in IT in all economic sectors is sure to

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3 Lacking modern telecommunications in most of the country, China is placing first priority on building local and long distance networks, and developing international linkages. Lacking capital markets, China is seeking joint ventures, international aid, direct foreign investment, and export promotion as means of obtaining capital for development. Its big attraction to foreign industry is the 1.12 billion populaton, which spells big markets for everything from basic infrastructure such as telecommunications and computer networks to consumer goods such as TVs and VCRs, to services such as the telephone and information services.

increase rapidly as well. The future of the IT sector will depend heavily on the evolution of economic reform in general and technology policy in particular.

While China's computer strategy appears on the surface to be fairly successful, China is only beginning to develop the basis for competition in the world IT market. Its computer exports occur primarily through joint ventures with multinationals which use their own technology and marketing channels. Indigenous technological capability in China is still nascent.

The China case illustrates a mixture of government intervention and an increasingly market economy. Within this context, China's industrial policy is that government plays a key role in directing and guiding the economy and protecting and promoting domestic industry through strong bureaucratic guidance. But China's model also gives a strong role to individual enterprises, both public and private, industry groups, and market forces. In this regard, China's model has many similarities with the Japan model of the developmental state, especially during the 1960s and 1970s, although China's industrial structure is clearly much different from Japan's.

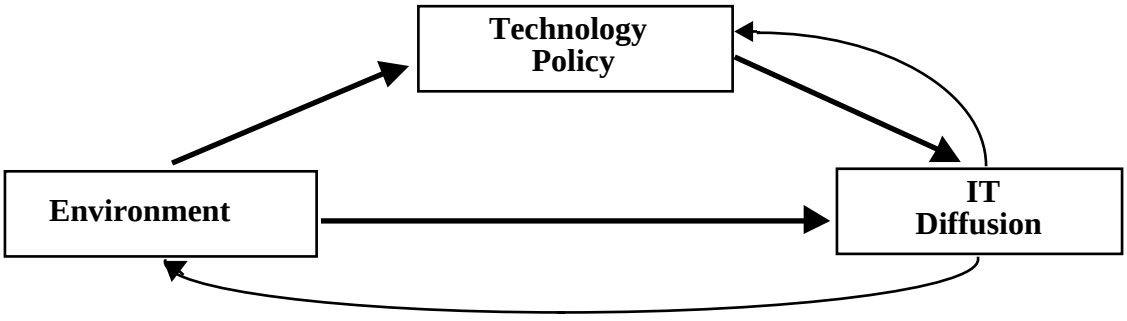
While China is shifting its policy direction from nationalism to pragmatism, much of the change has been in rhetoric so far, and actual policy changes have been more *ad hoc* than part of a coherent strategy. The need for change is clear and policymakers have moved beyond the old ideologies of nationalism and socialism in their pronouncements. However, there is not yet a clearly defined vision of the future of IT in China, nor is there is an institution in government with the authority to develop a national IT plan and coordinate its implementation.

This paper examines China's *technology policies* and the *diffusion of IT* in the context of the country's broader *economic and political environment*.. The framework for the analysis employed is presented in Figure 1. The framework posits that environmental variables influence IT production and use both directly and through the mediation of

government technology policy. The environment and policy choices are in turn affected by the diffusion of IT in the economy and society.

The environment represents the existing comparative strenghts and weaknesses of a country, while technology policy represents the strategic choices a nation makes about support for the promotion of IT production and use. One country, enjoying strength in several key industries, might decide to promote the use of IT in those industries and throughout the economy as a way of maintaining and enhancing its national competitive advantage (e.g., Singapore, see Gurbaxani, et.al., 1990; and Sweden, see Crozier, 1990). Another country, with a small but highly educated population, might promote hardware, software or information services production aimed at niche markets (e.g., Australia, see Dedrick and Kraemer, 1993a; and Taiwan, see Kraemer and Dedrick, 1994). Another, with a large domestic IT market and strong consumer and industrial electronics industries, might promote the large scale production of computer hardware to compete in world markets (e.g., Japan, see Anchordoguy, 1989; South Korea, see Dedrick, Kraemer and Choi, 1994). The importance of the framework is that it assists in characterizing and assessing the relative strengths and weaknesses of different policy apporaches, given a particular national enviornment.

Figure 1. Framework for Analysis



Section II discusses the China *environment*, analyzing the changing economic environment and the quality of infrastructure available to support IT production and use. Section III recounts the history of *technology policies* related to the production and use of IT, and analyzes the plans for the future of IT. Section IV looks at *IT use and production* in China over time and compares the level of use and production to selected other countries. Finally, Section V draws conclusions about the China case and its relevance to the broader issues of industrial and technology policy.

II. ENVIRONMENT

Economic Environment

The Chinese economy is large and growing at a tremendous pace. Revised figures from the World Bank, based on purchasing power parity (PPP) exchange rates, rank China as the world's third-biggest economy with a GDP of US$2.87 trillion in 1992 (*Economist*, 1993), although some economists dispute this figure as too high. Economic growth has been in double digits for 1991, 1992 and 1993. The size of the China market makes it a magnet for foreign companies and provides the government with a valuable bargaining chip in dealing with those companies. Just as Japan was able to use access to its domestic computer market to negotiate favorable terms for technology transfer from IBM and others, China can use its large market as a source of negotiating leverage.

Since 1978, China has tried to create what it calls "a socialist market economy." It is explicitly striving to follow some parts of the Japanese model in which the government plays a key role in directing the economy. Chinese academics have defined the Japanese model as a mixture of a market economy, strong bureaucratic guidance, worker participation, low income disparity, and wealth in the hands of companies and industrial groups rather than individuals. They point out that in the late 19th Century, the Japanese government privatized most major industries by auctioning off state enterprises, a process which China will have to

follow to move further towards a market economy. According to Feng Zhaokui of the Chinese Academy of Social Sciences, there is more research done in China on the Japanese economy than on any other foreign economy (*Los Angeles Times*, 1993).

So far, China has been able to make the transition from socialism to a market economy without the tremendous disruptions faced by Russia and the other former Soviet republics. The next stage of this transition, which will involve privatizing state enterprises, will be challenging, since it threatens the Communist Party's control over key economic sectors. The post-Deng Xioaping era promises uncertainty and possible turmoil, but in the longer term, China appears on the way to becoming a major economic power. One of the keys to achieving such status will be China's ability to catch up with its Western and Asian competitors in advanced technologies such as IT.

IT Infrastructure

The production and use of information technologies typically requires a supporting infrastructure consisting of several key elements. For IT use, these include *human resources*, especially skilled workers capable of using computer systems and application programmers capable of developing and adapting systems to local needs, and dependable *telecommunications and power networks*. The production of IT products and services requires those factors, plus several others. One is specialized human resources: IT professionals such as computer engineers, programmers, systems analysts and electronics engineers; manufacturing professionals such as production engineers and quality control specialists; and marketing, finance, distribution and other management experts. Another requirement is the *research and development* capabilities to design new products and production processes and to apply existing technologies to new applications. Still another is an existing capacity in *complementary industries* such as consumer electronics and electronic components to supply products and relevant expertise. Finally, both production and use require *capital markets* capable of supporting investment in IT.

Human resources

China's population as a whole is not especially well educated compared to developed or newly industrializing countries, and does not have high levels of scientists, engineers or programmers as a percent of its population (Table 1). But China's population is so large that the gross number of those professionals is very high. For instance, China has about four times as many programmers as South Korea. So IT producers and users have a large pool of skilled professionals from which to choose.

Table 1. Human resource indicators for Pacific Rim nations

	Tertiary Enrollment (% of 20-24 year olds)[1]	# of Scientists and Engineers 1988[2,3,4]	Sci. & Eng. per 10,000 workers[2,3]	Bachelors degrees in Sci. & Eng. 1990[2,3]	Masters & Ph.D.'s in Sci. & Eng. 1990[2,3]	Number of Programmers[5]
U.S.A.	60	949,200	75.6	169,726	66,508	1,693,000
Japan	30	505,500 ('91)	74.9	106,508	36,549	850,000
Korea	37	70,500 ('90)	48.8	51,266	7,070	236,500
Taiwan	28	46,200 ('91)	27.1	15,483	4,011	116,000
Singapore	19	5,876	37.2	2,498	200	15,000
Malaysia	7	5,537	7.1	1,316	649	n.a.
Indonesia	n.a.	32,038	1.7	n.a.	n.a.	460,000
India	6	2,000,000[6]	65.6	n.a.	n.a.	1,252,500
China	**2**	**309,000**	**5.6**	**206,115**	**20,787**	**990,000**

[1] UNDP, 1991 [2] PECC, 1991 [3] NSF, 1993 [4] ROC, 1993 [5] Whiting 1992

[6] Silicon Valley Indian Professionals Association (note: definition of scientists and engineers may be different from other countries)

Telecommunications networks

China currently provides telecommunications services to about 20% of its 1.2 billion population, mostly in large urban areas in the costal and southern provinces. China wants to achieve 40% penetration of telephone services by the year 2000. This means that China wants to do in 15 years what Japan did in 40 years and the US did in 80 years. Of course, modern technology permits China to move much faster than these other countries, but the goal is ambitious nonetheless. China's strategy is to build a single, unified network to provide basic telephone services under a monopoly agency while allowing competition for non-basic services. The rationale is that a unified network is needed and that only a monopoly provider can raise sufficient revenues to provide universal service (Cai, 1993).

Responsibiity for China's telecommunications infrastructure rests with the Ministry of Posts and Telecommunications (MPT). The MPT is a monopoly provider which also has a regulatory role governing licenses and new entrants. However, change is in the wind as there are many contenders for building and operating China's information highways (Figure 2). It is expected that within two years, the provider and regulatory roles of MPT will be split and two agencies created. The regulatory agency will regulate the industry and set prices for all contendors (thereby limiting real competition). The provider side will be placed in competition, with other providers being private enterprises, governments ministries, and possibly multinationals in the future.

Figure 2. Contenders for China's Information Highways

Contender	Role
Ministry of Posts and Telecommunications	Current monopoly supplier. Has (MPT) regulatory and provider roles.
Ji Tong Corporation, Ministry of Electronics Industry (MEI)	Company set up by MEI to operate wireless systems. Needs license from MPT.
People's Liberation Army (PLA)	Runs paging, cellular and satellite communications businesses.
People's Bank of China and Ministry of Railroads	Along with PLA & MEI want to set up data highway linking private networks.
News Corporation	Star-TV. Chineese have banned use of satellite dish.
Motorola & Ericsson	Suppliers of wireless technology.

Source: Adapted from *Business Week,* November 8, 1993

The Ministries of Electronics and Railroads, the People's Liberation Army, and the People's Bank of China jointly want to set up a competing telecommunications network to the State monopoly. MPT officials claim there will be no second network, but that it is government policy to make use of all existing capacity (Cai, 1993). This is taken to mean that the PLA, railroad ministry and others may use the private networks they have and even sell services on these networks to others, but they may not expand or join together to provide a public network competing with MPT.

While China continues to provide telecommunications services domestically, it has opened up the market for telecommunications equipment and software (network and customer premises equipment such as switches, PBXs, phones, etc.). MPT-owned factories are no longer government-subsidized, but independent profit-oriented enterprises which must make it on their own, competing openly with each other and with outsiders such as AT&T, Ericsson, and Motorola.

The stakes in telecommunications are large because of explosive growth.[4] There were 17 million phone lines in 1993 and 100 million phone lines are expected to be in place by the year 2000. MPT's revenues for the first six months of 1993 were US$3.6 billion, a 60% increase over the same time in the previous year.

Before reform, all telecommunications growth was supported by the central government. Since reform, the level of central government support has remained the same at about 400 million renminbi (RMB) annually, but it is only one tenth of the total annual investment of 40 billion RMB annually. The remainder comes, about one-third each, from user charges and fees,[5] domestic loans and leases,[6] and foreign investment (Cai, 1993).

China has used preferential state policy to foster telecommunications growth. It views telecommunications (along with computing) as a pioneer sector for stimulating economic growth and opening up China to the outside world. Consequently, combined taxes on telecommunications have been reduced to 48% of total revenues (Cai, 1993).

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4 The entire information industry is relatively small, constituting 0.2% of China's GDP. Telecommunications is the main body of the information industry in China as in most countries. The output value of telecommunications is ten times that of the information processing industry, or 22.4 billion yuan vs. 2-3 billion yuan, respectively in 1992. However, the information processing industry is growing fast, with increases of 20-30% per year in output value, and it is expected that it will exceed the output value of telecommunicaitons in time (Gaofeng, 1993)

5 Users are willing to pay large fees (US$800) in advance for a telephone installation, which they must wait 6-12 months to receive (Cai, 1993).

6 Local authorities are very important to helping build telecommunications networks. As put by one local expert, "They know how to deal with the little old lady who sits on a chair in front of her house and will not let the construction crews dig a trench for the cable on her property. Without them, construction would be much slower." Local governments seldom have cash, but they contribute other things such as free land, low cost labor, and local problem solving (Cai, 1993).

Research and development

China's research and development spending totalled 40 billion RMB, or 0.72% of its GNP in 1991. This compares to 2.77% for Japan, 1.91% for Korea, 1.70% for Taiwan and 0.91% for India (Table 2). About half of China's R&D is financed by government agencies and half by enterprises (including state enterprises). In the past, R&D was concentrated on defense technologies or on basic research, with little effort made to develop commercial technologies. This trend is starting to change as the economy becomes more market-oriented and government science and technology policies change.

Table 2. R&D Expenditures in Asia-Pacific Nations

	R&D as % of GDP	Govt. as % of R&D	Industry as % of total R&D
U.S.A.	2.67 ('91)	43.7	51.7
Japan	2.77 ('91)	16.2	77.9
Korea	1.91 ('90)	15.9	84.1
Taiwan	1.70 ('91)	45.8	51.7
Singapore	0.90 ('90)	45.8	54.2
India	0.91 ('91)	n.a.	n.a.
China	**0.72 ('91)**	**60.0**	**40.0***

* Includes national enterprises
Sources: PECC, 1991; ROC, 1993; NSF, 1993

Complementary industries

China has a large electronics industry, with production of US$16.8 billion in 1991 (Young 1992), but the industry is still technologically backward and not yet able to serve as a base for developing a computer industry. Most of the industry's production consists of consumer electronics and components with little industrial electronics production[7]. There are numerous factories producing the same products, few of which are achieving economies

[7] The electrical and electornics industry is broken down as follows:
- Electrical products (appliances, switches, generators, etc.)
- Electronics production:
  - Consumer electronics (TVs, radios, VCRs, microwaves, etc.)
  - Industrial electronics
    - Telecommunications equipment
    - Computers (systems and peripherals)
    - Electronic components (e.g., semiconductors, mainboards, motors, screens, etc.)

of scale. The industry is also plagued by aging equipment, low labor productivity and shortages of parts and components (Simon, 1992).

Current semiconductor production equals only about 25% of domestic demand. Production by 1995 is expected to reach 500 million integrated circuits (ICs), but demand is forecast to be 1.2 billion ICs. Neither the electronics industry nor the computer industry is able to meet the demand of its own sector, let alone transfer many resources to another. Still, the existence of these complementary industries means that related technology and human resources exist within the economy. People and technologies can and do move from one industry to another in some cases.

In 1992, the Chinese government created China Electronics Corp., or Chinatron, a conglomerate of 100 industrial enterprises, 37 research institutes, seven universities and other organizations (Young, 1992). The conglomerate's 1991 revenues of US$3.3 billion equals 20% of China's total electronics production. Chinatron's companies include Great Wall Computer Group and the Computer Systems Engineering Company (CSEC). Chinatron has the look of a business conglomerate such as the Japanese *keiretsu* or the Korean *chaebol*, which transfer resources among their member companies and provide the financial power to undertake large capital investments and entry into new markets. However, Chinatron lacks the links to trading companies, banks and other industries which were important to the success of the Japanese and Korean groups.

Capital markets

Capital markets are extremely limited in China, although stock exchanges have recently been created. Resources for the computer industry come from three primary sources: central government, provincial and local governments, and foreign sources (aid, loans, foreign direct investment, joint ventures). As of late 1993, the government had authorized 150 state enterprises to issue shares on stock exchanges in Shanghai, Shenzhen, Hong Kong and New York (Jefferson & Rawski, 1994). The Legend Group and the Beijing Stone Group,

China's most successful non-governmental computer companies, listed on the Hong Kong stock exchange in 1993.

The Chinese government plans to reorganize the banking system in 1994. There will be three types of banks: a central bank, commercial banks, and specialized banks to finance projects that do not meet commercial loan standards but are considered economically important (Jefferson & Rawski, 1994).

Comments on Environmental Factors

Rapid assimilation of IT and development of the IT industry will both require a stable investment environment and further deregulation of the economy. Human and capital resources are available in China, but it is important that they be deployed effectively. Market incentives will be necessary to encourage application of technologies such as IT to achieve production efficiency and product quality. Development of an IT industry will depend on continued growth of domestic demand as well as attraction of foreign investment.

The computer and telecommunications sectors have benefited from economic reforms in general and from the more pragmatic approach to technology policy taken in recent years. If the trend towards increased market orientation and pragmatism continues through the transition to the post-Deng Xiaoping era, IT use and production should continue to grow rapidly. The use of IT, or "informatization" of China as it is called there, can also facilitate the creation of more efficient markets by making timely market information available to producers and consumers in the huge Chinese market.

III. TECHNOLOGY POLICY

China has targeted science and technology in recent years as a key to economic growth and competitiveness. In order to encourage researchers to respond to the needs of industry, the government has simply cut the budgets of state-sponsored research institutes. This has forced them to turn to industry for funds, meaning they must serve industry's needs.

The share of state grants in R&D spending by large and medium enterprises dropped to just 7% in 1991, with enterprise funds (i.e. profits) becoming the main source of funding for R&D.

The government has a number of technology programs aimed at upgrading its R&D capabilities and applying technology to existing industries. One plan, called 863, started in 1986 and targets eight strategic technologies for development, including IT, biotechnology, energy, materials, automation, lasers, space and telecommunications. One success has been the introduction of computer integrated manufacturing (*Electronic Business Asia*, 1993).

In 1988, the State Science and Technology Commission launched the "Torch Plan" to accelerate the development and commercialization of new technologies including computers. The program provides funding to research institutes and and their related enterprises to develop new high tech products that would meet market needs. In the past, research institutes developed products that often had no relation to market needs and laboratory prototypes that seldom made it to market. The Torch Plan aimed at turning around this state of affairs. There is related plan to create 50 development zones and to improve the technology base of Chinese industries. The government is encouraging research institutes and business firms to link up to a national databank loop and is pressing foreign multinationals operating in China to make commitments to local sourcing, training and technology transfer.

According to government plans, by the year 2000 more than 12,000 projects of the Torch Plan will be implemented. One-third of them will produce export-oriented products and 50 percent of the products will be manufactured in the development zones. One Torch Plan success story is Beijing University's "Super" desktop publishing system which is reportedly used widely throughout the country.

Information Technology Policy

In 1992, China ran a trade deficit in high-tech product imports/exports, with the largest components of the deficit being computers and manufacturing technology integration

products (deficit of US$2.3 billion). This indicates areas where China is still weak in high-tech products (Han, 1993)

In response to its continuing trade deficits in IT and its desire to promote the informatization of China, the government has identified development of computer production and promotion of computer use as matters of national priority. It also has a policy of promoting telecommunications, but it is not explicitly linked to the computer policy. They are led by different ministries, the Ministry of Electronics Industry (MEI) for computers and MPT for telecommunications, which appear to be on independent tracks. The fact that the MEI is proposing to develop a national data network suggests that the ministries are in bureaucratic competition and that MEI has developed a constitutency in other government agencies and in the new enterprises spun off from various government agencies.

China's most important resources in IT are its market size and its large pool of computer professionals and engineers. These provide the domestic demand and human resources needed to support IT production and act as a strong attraction to multinational computer companies with technology that China needs. The Chinese government is requiring that they trade direct investment and their technology (usually older technology) for access to China's market and manpower. In addition, China is requiring the MNCs to export a considerable proportion (about 50%) of local production to try to reverse its trade deficit in IT.

Evolution of China's IT policy

From 1981-85, during the early reform period, the government's objective was to build a domestic computer industry and avoid technological dependency on the West. It sought foreign investment and technology with which to develop its own mass-production facilities from scratch. While there were no takers for such investment opportunities, foreign vendors set up direct sales activities and exported computer equipment to China during the period, much of it in mainframes from IBM (III, 1992; Hui and McKown, 1993a).

By 1986, the government's attitude toward technology transfer began to change, and the government began to encourage joint-ventures where foreign vendors would bring technology and manufacturing skills and local companies would provide inexpensive labor and access to domestic markets. The government still sought to build a broad-ranging computer industry from mainframes to PCs to components.

By 1991, the government had abandoned its course of complete self-reliance in computer production and entered a third phase of development. The government decided to import high-end computers such as mainframes and minicomputers and to manufacture personal computers and peripherials in China. This pragmatism was in response to the slowness with which the computer industry was developing. At the same time, the government decided to focus on the software and information services sectors of the computer industry. The software sector was particularly targeted for development to capitalize on China's large pool of programmers.

The government is still trying to come to grips with how to deal with the information services sector, particularly as it involves access to the many computer databases of the State Information Center and the government ministries. This is a case in which the desire to maintain control over information can conflict with the objective of developing an information services industry. Services such as on-line databases are valuable tools for government and industry, but allowing more people to have increased access to data could be threatening to the power elite in government.

China's electronics industry, including computers, was given priority status by the government in March 1993. This status provides the industry with preferential treatment, increased government investment and exemption from periodic austerity measures to the year 2000. The aim is to accelerate development of the computer industry because it is viewed as critical to modernization of all sectors in the economy.

IT Policy Institutions

There is no national authority with overall coordination responsibility for information industries in China. Rather, as in many countries responsibility is split among several government agencies. Public telecommunications is mainly the responsibility of the MPT. Computers and data processing are primarily the responsibility of the Ministry of Electronics Industry. Information services such as databases are primarily the responsibility of the State Information Center, which is under the State Planning Commission. For each, there is one or more related industry associations, including the China Telecommunications Industry Association, China Information Industry Association, China Computer Industry Association and China Software Industry Association.

R&D, education and training, export promotion and other activities which affect the computer and telecommunications industries are handled by other ministries. It is unclear how much coordination there is among these agencies regarding informatization, but it is clear that there is no interagency body or or overall coordinating agency. Moreover, because of China's size and the trend toward decentralization of decision making to encourage development, much of what actually happens is influenced by provincial and local governments. The central government sets policy and undertakes large national projects, but execution is local for the most part.

IT Policy and the Ministry of Electronics Industry

Prior to March 1993, responsibility for the computer industry was part of the Ministry of Machine Building and Electronics Industry. The machine building part swamped the electronics part, so the government separated the two and set up MEI as an independent ministry to give greater emphasis to development of the industry. (At an earlier time still, MEI was independent, but was merged with MMBI.)

Since March 1993, responsibility for China's computer industry rests with the MEI, and specifically with its Computer Department. MEI also has a Telecommunications Department which is concerned with setting policy to link the government's many private data networks. As part of China's governmental reform, which tries to separate government function (policymaking, regulation) from enterprise management, the Computer Department has been reorganized to serve mainly as a policymaking and regulatory body for the industry instead of sending down specific plans and quotas to state-run enterprises under the department. The Computer Department has about 30-40 people organized into five groups as shown in Figure 3.

Figure 3. Organization of MEI's Computer Department

Office	Function
Information Systems	Organization & implementation of large-scale information systems. What kinds of national information systems should China build and how should it build them? How bring agencies together to cooperate? What should China do about electronic data interchange (EDI)?
Electronic Information Application	Promote application of computers to reform domestic industries. What things should China use to help its industry and commerce; which applications are most helpful and useful? e.g., CAD/CAM.
Computer and Application Products	Formulate plans for development of computer hardware and software products. What should be China's strategy with regard to various kinds of computer products? What should China develop on its own and what should it do with foreigners?
Computer Software	Develop plans for construction of software parks. Oversee management of software registration and approval process. Should China develop a "Chinese operating system? What should China do about Windows NT? How to get a Chineese version?
Coordination	Handle department daily administrative work.

Source: IDC, 1993: 230-231.

MEI's strategy for developing the computer industry in China has five key elements:

1. Expedite national economic development.

Although MEI's objective is to promote development of the computer industry in particular, the industry's development is seen more broadly as a means of expediting modernization and national economic development. China's political leaders view the computer industry as an accelerator for economic development and modernization of all its industry sectors. Therefore the computer industry and national information systems are given high priority in the ten and five-year plans. Greater resources are targeted for promoting the industry and promoting the application of computers throughout the economy.

2. *Focus on lower end computer products.*

MEIs development strategy for the domestic computer industry is oriented around microcomputers, workstations, software and peripherals--dubbed MWSP. Through the mass export of these low-end products, MEI hopes to earn foreign exchange to import higher-end systems and the technology needed to sustain growth and development at the lower end. The value of China's exports exceeded $1 billion in 1992 (III, 1992). While the value of these exports is 22 times that in 1987, it is a small fraction (less than 0.5 %) of global computer sales.

3. *Separate the management of enterprises from the government functions of policymaking and regulation.*

In the past, all enterprises were an integral part of, and managed directly by, the ministry. Now enterprises are semi-autonomous, somewhere between totally planned and totally market. For example, all enterprises are encouraged to export their products but domestic enterprises have different requirements from joint ventures. Purely domestic companies are not required to export; they produce for the local market and they can import components needed for production. Joint ventures on the other hand must export. There is no exact amount of production that must be for export versus the domestic market, but the range is generally 60-70% of production for export and 30-40% for the domestic market.

MEI owns 216 computer factories, 36 of which are PC facilities. Approximately five of these state-owned enterprises produced 82% of China's total domestic computer output in 1992 (Hui and McKown, 1993a).

4. *Lower import duties and taxes.*

In the past, MEI has used import duties and taxes to protect domestic vendors. However, import duties were reduced from 82% in 1992 to 35% in 1993, and are expected to be reduced to 15% in the future. The reasons for change are several.

The first is that MEI has learned that industry protection through import duties results in higher prices for computers to other economic sectors and therefore conflicts with the broader goal of expediting national economic development through IT use.

The second reason is that the current policy is being systematically undermined by enterprises inside and outside China through "double screwdriver operations". The total of import duties and taxes on PCs is usually more than 35% for a completely assembled computer. However, the tax on components is only 17%. As a result, some companies in Hong Kong (and to a lessor extent, Singapore) buy completely assembled computers from abroad, take them apart, and bring them into China at the 17% rate. They then reassemble them in China and sell them at the same or slightly lower price than other computers. The current 17% spread between taxes on components and assembled computers provides incentive for such activity. While not illegal, it is subverting the policy. The market for these screwdriver operations plus blackmarket sales is estimated to be about one-third of the annual computer sales in China.

The third reason for change is that China expects to become a member of GATT in the near future and therefore will be required to reduce its import duties to around 15%. These changes will put China's domestic computer companies under severe competition. The computer industry wants protection for a longer period of time, but MEI feels that it cannot impede application of the technology to other industries just to support the computer industry. It is expected that by 1995, government subsidies to domestic computer companies will be discontinued and they will have to compete on their own merits or go out of business.

The MEI policymakers are trying to find a balance between too much protection and no protection at all. Along with reducing the taxes on imports, China is trying to provide a more supportive environment for its industry through measures

such as tax incentives for R&D (Hsu Kung-Shih. 1993). MEI is also encouraging companies to go public to raise their own capital. So far, these efforts have been few and small.

5. *Use foreign vendors to push the domestic market and vendors.*

China doesn't have enough production capacity to meet its own needs for computers, nor does it have the technology to produce advanced products. So the government encourages joint ventures in which foreign companies are given access to the local market in exchange for transferring technology to their Chinese partner. In the past China refused foreign technology but now it is promoting joint ventures more frequently and on more favorable terms to the foreign partner.

IT Policy Initiatives

MEI has plans for four major initiatives over the next five years. These are: (1) constructing technology and software parks, (2) building a new data communications network, (3) developing a five year plan for the computer industry, and (4) finding a common ground between the country's academic and industrial spheres in order to speed up product commercialization. The five year plan has not been published and no details are available on strategies for finding a common ground between academia and industry, but specific projects are underway for (1) and (2).

Technology Parks

The Shen Zhen special economic zone in southeastern China is the site of a high-technology park established in the mid-1980s. From 1985 until 1993, 680 million RMB worth of investments by government and business as well as foreign loans went into developing an advanced information infrastructure in Shen Zhen. This includes investments in telecommunications, data communications networks, electronic data interchange (EDI) and a number of information systems.

Shen Zhen has become an important base of information industries, with more than 500 IT companies. Personal computers and components are produced by Great Wall and

Legend in Shen Zhen and it is the leading site in China for the production of liquid crystal displays. As of 1991, there were more than 150 software companies in Shen Zhen with 2,000 employees. These companies produced revenues of 73 million RMB and exports of US$5.2 million.

Another technology park is Shanghai's Caohejing Hi-tech Park, opened in 1988 with support from 13 research institutes. As of 1991, Caohejing had attracted 29 foreign joint ventures with the 37 state factories already operating in the area beforethe park opened. Total investment in these ventures was US$310 million, with US$190 million coming from foreign investors (China Trade Report, 1991).

Other technology parks have been announced across China, apparently with the idea of spreading the Shen Zhen and Shanghai models to other regions. It is not clear, however, that many other regions have the basis for developing successful high-technology industries as do Shen Zhen, with its location in the internationally-oriented industrial base of coastal south China, or Shanghai, which is considered to be China's leading commercial center.

Promotion of Datacommunications Networks

Although the Ministry of Posts and Telecommunications (MPT) is responsible for all telecommunications in China, its capacity is limited. MPT can provide for public communications (the telephone), but it cannot simultaneously extend the telephone system throughout the country and provide the higher capacity data networks that are needed by the ministries and enterprises.

Consequently, many ministries have built their own data communications networks over the last decade and longer. These networks exist in the Ministries of Railroads, Electric Power, and Customs, the Bank of China, the People's Liberation Army, and the State Information Center. There is a need and opportunity for someone to step in and tie these networks together.

MEI has set up its Telecommunications Department to work with these ministries and build such a data highway under a newly formed company called the Ji Tong Corporation.

MEI has the support of other ministries because it is not proposing to take over their networks–only to link them and provide them with greater capacity.[8]

MEI's approach is to set up a communications network based on satellites whereas MPT has a network based on underground cable. MEI must obtain approval from MPT to build its network. MEI says its network is not competitive with MPT's; rather it can be viewed as a backup for MPT and vice versa. MPT reportedly doesn't like MEIs proposal but cannot refuse approval because modernization, not bureaucratic turf, is the key issue.

The "Triple Gold" program was launched in 1993 by President Jiang Zemin to accelerate the pace of modernization in China. The aim is to step up networking, financial automation, and trade/commercial automation. The networking project is refered to as the Golden Bridge project. It involves construction of a national public data communications network throughout China based on satellite technology. It would connect the computer operations and databases of all government ministries and provinces. The financial and commercial automation projects are aimed at setting up EDI among banking institutions in China and between the banks and commercial enterprises (Zhang, 1993).

The Golden Card project refers to automating the payment system for bank credit cards. It involves automating the banks and commercial establishments (stores, hotels, restaurants) and connecting them all through a communications network that will handle electronic payments. It also involves a program to promote credit card usage by individuals, enterprises, and commercial institutions. Experimental work is underway in Ansham city.

The Golden Customs project refers to an economic information network for foreign trade based around EDI. The impetus for this project is the growing trend of foreign

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8 One observer characterized what is happening as follows:
"MEI cannot openly step into the telecommunications area and say it will do part of MPTs job. So, MEI says telecommunications is MPTs job. But, MEI says it is concerned with the computer 's application in the country and data communication is part of the application. The computer industry has the capability to do data communication, and there is a need to be fulfilled. The need is to connect all of the private networks for the smooth functioning of the economy. So MEI will do a project for the whole nation. It will set up a high speed data highway to connect all of the private networks for the benefit of the economy (Anonymous)."

countries to switch to EDI for processing trade documents and the fear that China will be left out of world markets if it doesn't switch to EDI. As put by one observer: "Those who can't put EDI technology into use by the turn of the century will be rejected out of world trade mercilessly" (Anonymous).

IV. POLICY OUTCOMES: CHINA'S IT SECTOR

IT Use

The government of China has promoted computer use throughout all industry sectors primarily as a means of making industry more competitive. Computer use grew slowly as a result of China's early policy of self-reliance and COCOM restrictions on the sale of computers to Communist countries. In 1980, China began to import foreign computers and software products for use in business, banking, and State information gathering (e.g., census). These included large mainframes as well as medium-sized and small computers. By the end of 1983, annual sales of these computers exceeded 700 units at an annual value of 860 million RMB. The total installed base was 4,545 computers, not including PCs (Table 1). Computer use greatly expanded in 1984, increasing fourfold over previous years, as informatization became identified with China's four reforms and China's policy of self-reliance for computers was further relaxed. Overall growth in computer use has continued steadily ever since. As shown in Table 3, market growth between 1983 and 1991 was more than 10 times, from 520 million RMB to 6 billion RMB (US$1.1 billion). The market is expected to grow to 10 billion RMB (about US$1.85 billion) by 1995.

Table 3. China's Computer Market, 1981-1995

Year	83	84	85	86	87	88	89	90	91	95
Sales -100M RMB	8.6	36.8	46.3	39.8	40.8	45.2	50.5	55	60	100
Installed Units* (1,000s)	4.5	5.4	6.4	7.1	7.6	8.2	8.8	9.4		
Installed PCs (1,000s)	30.0	75.8	130.0	198.6						

*not including PCs
Sources: III, 1992; IQTE, 1994

The computer hardware market in China is heavily weighted toward PC use. Sales of PCs in 1992 were three times the combined sales of mainframes, midrange computers and workstations (Table 4). This is partly due to the affordability of PCs and also to the fact that COCOM restrictions do not generally apply to PCs.

Table 4. IT Sales in China by Product

	1992		1993*	
	US$M	% growth	US$M	% growth
Mainframe	60	12	76	27
Midrange	80	12	150	88
Workstation	70	12	90	29
PC	507	33	560	11
Other Hardware	250	18	275	10
Total Hardware	967	21	1151	19
Software and Services	250	23	320	28
Total IT Market	**1217**	**17**	**1471**	**21**

*Estimate
Source: China Research Corporation, 1993

The personal computer market in China is estimated at 200,000 to 220,000 unit sales for 1992 (China Research Corp., 1993; other industry sources). The leading suppliers are AST Research, with 26% of the market and Compaq, with 17%. The leading Chinese suppliers are Great Wall, with 10% of the market and Legend, with 9%. The two leading PC vendors worldwide, IBM and Apple, have failed to make much of a dent in the Chinese market due to higher prices and the perceived incompatibility of Macintonshes and IBM's PS/1 and PS/2 machines with standard IBM-compatible PCs. Over half the market consisted of Intel type 8088 and 286 machines, putting China several years behind the U.S. in adoption of new technologies. Less than 15% of PCs in China are connected to local area networks (LANs), with the number of networked PCs growing 12-15% per year (China Research Corp., 1993).

The Chinese computer market is still tiny relative to the size of the country's population and even its economy. A measure of computing capacity is installed MIPS (millions of instructions per second). Taken in proportion to its population and GDP, China's level of installed MIPS falls far behind the East Asian NICs and new NICs, and is even

slightly behind India (Table 5). At its present growth rate in IT investment, it will take decades for China to catch up with its neighbors as a user of IT.

Table 5. Installed Computing Capacity in Asia-Pacific Countries, 1990

	MIPS per 1000 population	MIPS per US$million GDP
Singapore	110.0	7.8
Taiwan	63.3	n.a.
Korea	25.1	2.8
Philippines	3.9	1.7
Indonesia	1.5	0.5
India	0.6	0.5
China	**0.5**	**0.3**

Source: Juliussen and Juliussen, 1990

Computer Imports and COCOM restrictions

Total imports of computers reached US$1 billion in 1992. PC imports rose 46% from 1991 to 1992. Imports from the U.S. are still restricted by COCOM regulations, which limit the sale of computers with over 67 million theoretical operations per second (MTOPS). Prior to 1994, the limit was 12.5 MTOPS (IDC, September 30, 1993). The increase allows computers based on chips such as Intel's Pentium to be sold in China. The U.S. computer industry is urging further loosening of COCOM restrictions to remove barriers to competing in the fast-growing China market. China can already acquire more powerful computers from other countries, so the restrictions are not very effective in limiting China's access to advanced computing technology. At a time when the Chinese government has decided to import high-end computers, COCOM restrictions are keeping advanced U.S. workstations and supercomputers out of the Chinese market. However, Cray Research was able to get exemptions and sell three S-MP/11 supercomputers to universities in China in 1993.

IT Production

Nature of the computer industry

The computer industry in China is small, both in terms of the number of businesses and the annual output. On the hardware side, there were 199 companies in 1991. There are

no general purpose mainframe manufacturers. There is one minicomputer joint venture with DEC making PDP-11s and VAXs. The remainder are PC and PC-component manufacturers. Five of the PC manufacturers account for 80% of the total domestic output.

On the software and information services side, there are 216 enterprises. Government has 20% of the information agencies in the country, but these control 80% of the available information or databases.

Domestic production

Data on domestic computer production is difficult to obtain. Available figures place domestic production of all types of computer equipment in 1992 between US$1.1 billion (Elsevier, 1993) and $US2 billion (IDC, September 15, 1993). The Chinese Academy of Social Sciences' Institute of Quantitiative and Technical Economics (IQTE) puts hardware output at US$1.2 billion in 1991 (Table 6).

Table 6. IT Production in China, 1983-1991.

	1983	1984	1985	1986	1987	1988	1989	1990	1991
Computer hardware production									
Million RMB*	812.8	1612.4	1292.2	1366.1	2022	3108	4055	3687	6182
US$ million	411	695	440	396	543	835	1077	800	1205
Exports (US$ million)					45	120	105	174	230
Imports (US$ million)					415	650	392	372	406

* Constant 1980 value for 1983-1989, constant 1990 value for 1990-1991.
Ratio of constant prices in 1990:1980 is 1.0378:1.

Source: ITQE of Chinese Academy of Social Sciences:
Taken from *Electronics Industry Yearbook of China, Mechanics & Electronics Industry Yearbook of China, Statistical Yearbook of China*

The leading private sector domestic producer is the Beijing Stone Group, which had sales of US$360 million in 1992. State-owned Beijing Legend Computer Group produced 40,000 PCs and China Great Wall Corp. produced another 20,000 (*Electronic Business Asia*, 1993).

Production of personal computers is expected to increase rapidly, reaching 1.5 million units by 1995 (*Electronic Business Asia*, 1993). The rapid growth in production will be fueled by foreign investment as well as the growth of local companies. AST Research will begin producing PCs in 1994 in the Tianjin Economic Development Area in partnership with the

Tianjin Kangda Industrial Company. Production from the plant is expected to be 100,000 in the first year and reach 200,000 by the third year (IDC, September 15, 1993).

Little data is available on the software industry, but estimates from the Chinese Academy of Social Sciences' Institute of Quantitiative and Technical Economics (IQTE) place software industry output at US$31 million for 1991. This number presumably only includes packaged software, as the value of custom programming is undoubtedly larger.

V. CONCLUSIONS

China has undertaken a number of economic reforms in the past fifteen years, in a process referred to by Naughton (1994) as "growing out of the plan." China has not chosen to take a "big bang" approach to creating a market economy, but has taken a more incremental path. This approach has injected life into the Chinese economy, resulting in rapid growth and dynamism. Economic reform has been accompanied by a shift in technology policy away from the pursuit of technological autonomy and toward a strategy of assimilating foreign technology to modernize the economy. China is also beginning to redirect some of its own science and technology efforts away from defense and basic science toward development of commercial technologies.

The changes taking place are clearly seen in the policies related to information technology. IT policy is no longer aimed at developing indigenous production capabilities in large computer systems at the expense of users. Instead, policies are now oriented toward promoting computer use and targetting personal computers and components for production. This more pragmatic approach is better suited to China's technological capabilities and the rapid advances in information technology worldwide.

China's IT policies have included initiatives to promote use and production. To promote use, the government is improving the national information infrastructure (NII) by upgrading the telecommunications network in general and developing data communications networks in particular. To promote production, the government has set up software parks and

has maintained tariffs to provide protection for local producers. They have also put state computer enterprises on commercial footing, creating enterprises to serve as a basis for a domestic computer industry.

China's information technology policies seem to have had some success so far. Computer use and computer production are growing dramatically in recent years. On its own, China's domestic computer industry cannot possibly meet the demand, especially for high-end products. Consequently, China has adapted its policy very recently to promote more joint ventures between Chinese and foreign companies. It is likely that these ventures will meet China's own target of 50% domestic production of PCs by the year 2000.

The key to the success of China's technology policy seems to be rooted in pragmatism. The leaders of China's national computer policy appear willing to change and adapt when existing policies are not achieving their goals or when new opportunities appear. This type of flexibility is critical to responding to the rapid changes in computer technology and international markets. The future of computer policy in China will no doubt depend on the future of broader economic reforms, but there appears to be little chance of a return to the days of ideology-driven protectionism in the computer sector. The demands of international markets and domestic development will continue to put tremendous pressure on the Chinese government to continue its pragmatic course on computer policy.

The major challenge facing China in developing and implementing IT policy will be the need for policy coordination. Promotion of IT involves a broad range of policy issues, including trade, R&D, telecommunications and education. Studies of IT policy in countries such as Australia (Dedrick and Kraemer, 1993), New Zealand (Kraemer and Dedrick, 1993) and Korea (Dedrick, Kraemer and Choi, 1994) illustrate the problems arising from lack of policy coordination. These include competition over bureaucratic turf, inability to formulate coherent policies, slowness to respond to changing conditions and lack of cooperation between public and private sector institutions.

The cases of Japan in the 1960s and 1970s (Anchordoguy, 1989) Singapore (Gurbaxani, et al., 1991) and Taiwan (Kraemer and Dedrick, 1994) show what can be accomplished when there is strong policy coordination in government and cooperation with the private sector. Those countries have become major IT producers, although Japan has stumbled in recent years as bureaucratic competition has hampered its ability to respond to the personal computer revolution. Singapore has also promoted IT use by the public and private sectors to improve its competitive position in the international economy.

China already shows signs of trouble in coordinating IT policy. While the MEI has the strongest position, it must compete with MPT over issues involving the national information infrastructure (NII). The importance of NII has boosted the influence of telecommunications ministries in Japan and Korea, especially relative to their ministries of trade and industry. China is already experiencing a turf battle between MEI and MPT over data communications networks.

The huge investments expected in China's NII for equipment, software and network services will create tremendous demand for IT products and services. Whoever controls those investments will have *de facto* control over much of China's future IT policy. Other decisions, such as the rate and nature of privatization, allocation of capital and establishing educational priorities are critical to IT production and use, and will be made and implemented by a variety of institutions, public and private. Without some mechanism for coordinating all of those decisions, it will be impossible to implement a coherent strategy for IT production, use and information infrastructure.

China's ability to develop such a coordinating mechanism will depend largely on the outcome of the ongoing political transition and whether future political leaders have the desire and ability to develop a national IT strategy, achieve a consensus to support the plan, and coordinate the many institutions involved in implementing such as plan. In the absence of such political leadership, another scenario for policy coordination can be imagined. In it, one agency, such as MEI, would develop alliances with other agencies and use revenues from

its associated enterprises to implement its own vision of IT policy. MEI's creation of a wireless communications network despite MPT's objections would be a sign that it might be able to carry out such a scenario.

For now, China's leaders have gone far in moving from their nationalist strategy to IT policy to embrace a more pragmatic approach. They still have a long way to go, however, in developing and implementing a comprehensive strategy to deal with the many issues raised by their desire to promote the informatization of China.

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