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Authors

Kraemer, Kenneth L.
Dedrick, Jason

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Creating a Computer Industry Giant: China's Industrial Policies and Outcomes in the 1990s

Author:

Kenneth Kraemer and Jason Dedrick [1]
Center for Research on Information Technology and Organizations
University of California, Irvine
email: kkraemer@uci.edu , jdedrick@uci.edu

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ABSTRACT

Since 1978, China has been transforming its socialist economy into a mixed market system. At the same time, it has revised its nationalist technology strategy of emphasizing autonomous development to a more pragmatic approach of requiring foreign companies to transfer technology in return for market access, directing domestic R&D toward commercial purposes, and supporting local companies in high-technology markets. This change is evident in China's policies toward the computer industry. Since the mid-1980s, the government has focused on promoting production of PCs, peripherals, and software, by allowing foreign firms into the market but also promoting domestic PC makers. In addition, China has made large investments in a series of projects aimed at creating information infrastructure and stimulating computer use.

This article examines the development of China's computer industry, which is mainly focused around the personal computer (PC). It shows how China's shift from technological nationalism to pragmatism has enabled it to develop a domestic PC industry which dominates the local market. It also shows the limits to China as a market for foreign companies as the share of domestic firms continues to rise. Finally, it shows how Taiwanese companies have relocated to China in order to maintain their role as low cost contract manufacturers for multinational computer makers, and also have become contract manufacturers to China's PC companies.

CREATING A COMPUTER INDUSTRY GIANT:
CHINA'S INDUSTRIAL POLICIES AND OUTCOMES IN THE 1990s

INTRODUCTION

One of the most dramatic stories in the computer industry in recent years has been the emergence of China as a major market and leading producer of computer hardware. In 1990, there were only 500,000 PCs in a country with over 1.2 billion people. By 2000, over 7 million PCs were purchased in a single year. During the same time, China's production of computer hardware grew from less than $1 billion to $23 billion.

This explosion of computer use and production is the result of a number of factors, including rapid economic growth and the global spread of low-cost PCs. However, there were more specific forces at play also, primarily the industrial and technology policies of the Chinese government, and a flood of investment by foreign multinationals and Taiwanese manufacturers.

China's computer policies shifted in the early 1980s from an isolationist approach aimed at achieving technological independence to a more pragmatic strategy of developing national capabilities in order to create an internationally competitive computer industry (Kraemer and Dedrick, 1995). This approach clearly drew on the experiences of other Asia-Pacific economies such as Japan, Korea, Taiwan, and Singapore. Each of these had become leaders in different segments of the global computer industry with the strong support of government industrial and technology policies (Dedrick and Kraemer, 1998)

This paper documents the extraordinary growth of China's computer industry, including the roles played by domestic PC makers, foreign multinationals, and the little-known role played by Taiwanese manufacturers. It examines the impacts of government policies that promoted computer production and use, encouraged quasi-state owned enterprises to enter the PC industry, and required foreign firms to transfer technology in return for market access.[2]

It concludes that China is an important example of how strong government policy combined with entrepreneurial local companies can lead to development and upgrading of industry capabilities. However, much of China's approach only succeeded because of its unique attributes, namely its huge market potential and abundance of low-cost technical professionals and educated workers, both of which are a strong attraction to foreign firms. Other countries without these attributes would lack the leverage to attract foreign investors under such conditions, and domestic PC makers could not achieve economies of scale by selling only in the local market.[3] China will remain a difficult market for foreign companies to penetrate partly because of the natural advantages enjoyed by domestic companies, and partly because of China's strategy of promoting domestically-owned firms in key segments of the computer industry.

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[2] This research has been ongoing since 1993 through attendance at international conferences and field interviews in China, Hong Kong, Japan, Korea, Singapore and Taiwan. Much of the detailed data on domestic production and firms in China and Taiwan is from the Market Intelligence Center (MIC) and the Chung-Hua Institute for Economic Research. The primary longitudinal data sources are the *China Electronics Industry* (MEI, 1998), Reed's *Yearbook of World Electronics Data*, (Reed, 2000), *Asia IT Report* (MIC, 1999abc, 2001) and IDC's Country Database.
[3] This has been borne out by the experiences of Brazil and Mexico (Dedrick et al., 2001)

NATIONAL ENVIRONMENT

Several national environmental factors have influenced the development of China's computer industry, shaping the government's policy options, and affecting the decisions of domestic and foreign firms in the computer industry. First is the size and rapid growth of China's economy, which is the second or sixth largest in the world depending on the measure used,[4] and which has grown at double digit rates for two decades. The vast potential of this market has allowed the government to dangle market access as a carrot to foreign firms in return for various concessions.

Second is the development of China's computer industry within the context of its transformation from a centrally-planned economy to a mixed, or "market socialist" economy. While the other Asian economies pursued their industry development strategies within a capitalist market context, China has done so in a transitional economy, leading to unusual ownership structures that include both private capital and state ownership. This intertwining of government and markets makes it difficult to make the usual distinctions between market forces and government policy.

Third, like other Asian countries, China entered the computer industry after gaining experience producing consumer electronics products (mostly TVs and radios), which accounted for 50% of total electronics production in 1990. When demand for consumer electronics slowed in the early 1990s, Chinese firms were using only 50% of their production capacity, and both they and the government looked to PC production as a new growth opportunity. The Chinese government subsidized and restructured the industry in an effort to transform inefficient electronics firms (mostly state enterprises) and move them into the computer sector (Chung, 1999). By 2000, computer hardware accounted for 32% of total electronics output, while consumer electronics had dropped to 25%.

Fourth, China built its computer industry on the foundation of a large science and technology complex with technological capacities well beyond those of most developing countries. As part of its economic transition, China transformed its science and technology system to spur growth and development (Lu, 2000). This was done in part by creating state-owned but market-oriented enterprises linked to state research institutions in order to commercialize the technologies developed in those institutions. These enterprises include what are now the four largest Chinese PC makers—Legend, Founder, Stone, and Great Wall.

COMPUTER INDUSTRY POLICY

Computer policy goals

China's computer policy encompasses all types of computers, but is focused mainly on the PC industry as can be seen in the major goals of the Ninth Five-Year National Development Plan, 1996-2000:

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[4] There is a large disparity between the size of China's economy in dollar terms depending on whether market exchange rates or purchasing power parity (PPP) equivalents are used. At market rates, China's GNP is about US$1 trillion, while at PPP it is over US$4 trillion. This gap is vexing to market researchers trying to estimate the potential of China's market for various products.

- Increase the percentage of domestic components in Chinese-assembled computers, and increase the nation's capacity to produce peripherals such as monitors, printers, disk drives, add-on cards, and high-definition displays.
- Achieve a per capita national computer penetration of one percent; 20 percent among urban families.
- Develop two to three domestic microcomputer manufacturers into enterprises with an annual production capacity of over $1 billion.
- Apply computer technologies to the renovation of traditional industries.
- Develop uniform PC standards via a production licensing system in order to answer complaints about lack of service and intellectual property protection on clone PCs.

The Ninth Development Plan also emphasizes a series of "golden projects", which are intended to: (1) modernize the country's IT infrastructure on a very large scale, (2) integrate the central government with the provinces and integrate the ministries within the government, (3) stimulate computer use throughout the country, and (4) support the information technology industry. The Golden Bridge, which was among the first three golden projects initiated in 1993, is the key infrastructure project creating a national information superhighway, or backbone, off of which other projects are implemented. The other golden projects are concerned with applications that cut across the country or the government in areas such as customs, banking, taxation, education, health, agriculture, housing, and enterprises.

Central government policy institutions

Primary responsibility for the computer industry was initially given to the Ministry for the Electronics Industry (MEI). However, the convergence of computers and telecommunications put MEI in conflict with the Ministry of Posts and Telecommunications (MPT) on a number of issues, so the State Council combined MEI and MPT into a new Ministry of Information Industry (MII) (Carroll, 1998).   This is an important change because it eliminated much of the potential for the type of policy paralysis caused by bureaucratic competition seen in places such as Japan and Korea (Dedrick and Kraemer, 1998). The MII now plans China's information infrastructure, develops its national computer policies, and licenses government-supported companies. MII's strategy for development of the domestic industry has two key parts: leveraging access to China's market in exchange for technology and investment from foreign firms; and stimulating domestic firms through regulation and subsidies.

Policy towards foreign firms

China invited foreign computer makers to help develop its industry, often requiring them to transfer technology and form alliances with domestic companies in return for production licenses and market access. Multinational companies such as Hewlett-Packard, Toshiba, and Compaq formed joint ventures with local companies in order to market their own products and gain access to local distribution channels. IBM entered a joint venture with Great Wall in 1994 that provided IBM with local distribution channels and gave Great Wall access to IBM technology and manufacturing know-how (Lu, 2000).

China discouraged direct import of computers by imposing high tariffs and taxes, but reduced tariffs from 82% in 1992 to 35% in 1993 and is expected to reduce them to 15% with

WTO membership. The government regulated foreign vendors' access to its markets by limiting the production of foreign firms for the domestic market to a certain percentage of their export production. And, in order to encourage exports, the government also created "export processing zones" where imported materials used in production would be free from duties and taxes when they were directly exported.

It also slowed down foreign firms and increased their costs by certification processes regarding quality, local content, and export limits. The aim was to allow domestic firms time to get established. Despite all of these obstacles, the potential size and growth of China's computer market made it a business opportunity that many foreign vendors felt they could not ignore, and so the leading U.S. PC companies, Taiwanese companies, and a few Korean and Japanese companies all entered the market.

Policy towards domestic firms

The government's policy towards domestic computer companies was largely indirect. It promoted domestic enterprises, but did not directly intervene or manage these firms. Rather, it dealt with them as part of government restructuring and enterprise reform wherein the government advocated separating politics from enterprise management, transforming military enterprises into civil companies, combining research with industry and trade, and forming joint ventures with foreign firms.

Many domestic computer industry players who had operated on a small scale became favorites of their supervising government departments and quickly expanded their product range or scale of operation by partnering with, or transferring technologies from, foreign companies. The larger computer companies such as Great Wall, Legend, and Founder grew in this way.

The ownership structure of the Chinese PC makers is quite unusual from a western capitalist perspective, but is a reminder that there is still socialism in "market socialism." Market leader Legend is closely affiliated with the Chinese Academy of Sciences (CAS), the leading government research institution. Founder Group is affiliated with Beijing University, and Great Wall is a spin-off of the Ministry of Electronics Industry. Each of the enterprises was restructured into joint-stock companies, and went public on either the Hong Kong or local stock exchange. Yet each is controlled by a holding company that is owned by the affiliated government institution (Lu, 2000). In spite of their status as state-owned or collective enterprises, each is clearly managed in an entrepreneurial, market-oriented manner, and the Chinese PC market is highly competitive.

Perhaps the most important resource provided by the government was access to the technologies developed by state R&D institutions. For instance, Great Wall's initial PC was developed inside MEI research institutions, and Legend commercialized technologies developed in labs of CAS. These technologies enabled the companies to develop successful commercial products that sustained their growth and expansion into new industries, including PC manufacturing (Lu, 2000).

Local governments as policy institutions

China's provincial governments and large municipalities have played a direct role in the development of China's computer industry. Local governments seek to create or attract computer firms for employment, economic development, and the prestige of high tech industry.

Local governments have competed vigorously with one another to attract computer plants by offering lucrative government contracts in exchange for locating a plant in their area. They also have made further investments and/or helped to arrange financing through local banks and other institutions (Chung, 1999).

In contrast to MII, local governments did not set explicit policies or criteria for support. They were much more entrepreneurial. The greatest advantage for companies to ally with local governments is the "pipeline effect" through which the government acts as a conduit to provide for the company's needs (land, labor, capital) and promote its products to government agencies, state and private enterprises, and citizens.

COMPUTER USE

Although the central government did not play a direct role in managing domestic computer firms, it played a critical role in promoting the use of computers and expanding the market for computers. First, the lowering of tariffs and other market liberalization steps brought down the cost of computers, making them more affordable for users. Also, China's golden projects have stimulated demand at all levels of governments and in state owned enterprises for information and computerization.

Consumer PC demand was stimulated by the issuance in 1997 of the Five-Year Development Framework for Computer Education which introduced computers into elementary and secondary schools. It was also stimulated indirectly by China's one-child per family policy and the emphasis that Chinese families normally put on children's education as a means to a better future. With only one child, more parents can afford to buy computers, and many do so in order to give that child a better future (Wallace, 1998). So whereas consumers were only about 15% of the market in 1997, home PC purchases grew to 34.4% by mid-1999 (DOC, 1999: 2).

Competition among local vendors has led to rapid price cuts, further stimulating consumer demand. Local brands such as Legend and Founder undercut foreign companies, and white box clone makers cut even deeper, to prices that can be up to 50% less than foreign brands (Wallace, 1998). Given the limited disposable income of most Chinese families, the difference of a few hundred dollars in price can be critical.

Market size and growth

China's computer hardware market grew to $13.8 billion in 2000 from less than one billion in 1990. Market growth has been as high as 70% percent in 1993 when import duties were reduced, and averaged 31% a year over the 1990s (Table 1). PC sales reached 7 million units in 2000 from only several hundred thousand in the early nineties. Domestic PCs accounted for 80% of the market in 1998 compared to 67% in 1997. About 45% were domestic branded PCs and 35% were PC clones (white boxes). Foreign brands comprised 20% of the market (Chung, 1998: 22).

Table 1. China's computer hardware market (US$ millions)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000***
Total sales	970	1,260	1,580	2,686	3,457	4,253	5,361	7,025	9,331	11,664	13,763
Percent growth in sales	-	29.8	25.3	70.0	28.7	23.0	26.0	31.0	32.8	25.0	18.0

*Forecast. Source: Reed Electronics, *Yearbook of World Electronics Data*, 2000.
Average annual growth rate = 30.96% from 1990-2000.

Patterns of use

PC adoption has been rapid in large ministries and government agencies, partly as a result of the golden projects. Adoption has been most rapid in large enterprises, but there is also growth in the use of PCs in small and medium-sized enterprises. Although computerization is rapid in the coastal cities and provinces, it has barely begun in the rural and inland areas where adoption is hampered by low average incomes and educational levels. The rapid growth of the Internet is expected to drive consumer PC sales at a high growth rate as is recent vendor emphasis on services including door-to-door servicing, training, telephone consultation, and maintenance agreements.

The number of Internet subscribers grew to 2.1 million in 1998, to 9 million in 1999, and to 17 million by June 2000 (Anderson, et.al, 2000). However, Internet usage is metered and expensive, and government regulations regarding information content are discouraging to providers. By 2004, wireless phone and related information devices are expected to number around 240 million units (Anderson, et.al., 2000). In the short term, these devices might compete with PCs for consumer spending but in the long term they are likely to increase demand for Internet use, which is already available on mobile devices in China.

However, a lack of quality software in the Chinese language, lack of computer knowledge and the cost of Internet access still inhibit demand for the vast majority of the Chinese population. China still trails more developed Asia-Pacific countries on information infrastructure and computer use, but is ahead of developing countries such as India and Indonesia, and comparable to the Philippines and Thailand on some indicators (Table 2).

Table 2. Information infrastructure and computer use in Asia-Pacific countries

	Main phones lines per 1,000 pop., 1999	**Cell phone subscribers per 1,000, 1999**	**IT spending as % of GDP, 1999**	**PCs per 1,000 pop., 1999**	**Internet users per 1,000 pop., 1999**
China	**85**	**34**	**1.13**	**12**	**7**
Hong Kong	575	636	1.32	297	361
India	26	2	.53	3	2
Indonesia	29	10	.35	9	4
Japan	557	449	2.06	286	213
Korea	437	500	1.61	181	231
Malaysia	202	137	1.70	68	68
Philippines	38	38	.78	16	6
Singapore	481	418	3.22	436	243
Taiwan	545	522	1.34	197	205
Thailand	85	38	.63	22	13

Source: International Telecommunication Union, *World Telecommunication Indicators*. Geneva: International Telecommunication Union, March 2001.

COMPUTER PRODUCTION

China's PC industry began with assembly of imported kits in the early 1980s, but this led to overcapacity as many state enterprises entered the protected domestic market. MEI's Computer Bureau shifted gears in 1985 when a team of engineers from MEI-affiliated research institutions developed an IBM-compatible PC with superior capabilities for Chinese character generation and display. This product, the Great Wall 0520CH, was so successful that IBM and NEC both discontinued their existing models developed for the Chinese market. This success led MEI to form a corporation called the China Computer Development Corporation (CCDC) selling Great Wall brand computers. CCDC was modeled on the Japanese keiretsu system, with dozens of subsidiaries with capabilities in R&D, manufacturing, distribution, import/export, and finance (Lu, 2000: 154-157).

Great Wall computers were plagued by poor quality, and production could not satisfy technical or user demands for PCs. There was a large amount of smuggling of foreign-brand PCs via Hong Kong to meet the demand (Dedrick and Kraemer, 1998). Also, local firms began to assemble PC clones, or "white boxes" with imported or smuggled components. As a result, government agencies opened the door to foreign enterprises in the hope that foreign PC makers would help to develop the domestic industry and accelerate the rate of PC adoption.

Scale of the industry

The production of China's computer industry has increased from around $645 million in the early 1990s to an estimated $23 billion in 2000. The increase in production has made China number 5 in share of world computer production (Table 3). Based on the growth of the domestic market and the continuing inflow of investment by foreign computer makers, China should overtake Taiwan and Singapore soon.

Table 3. Top 10 countries' share of global computer production

	1985	1990	1995	1999	1999 Rank
US	49.2%	27.0%	26.5%	26.5%	1
Japan	18.9%	29.2%	25.2%	16.7%	2
Singapore	1.2%	3.9%	7.3%	7.7%	3
Taiwan	1.0%	3.3%	5.6%	6.5%	4
China	**0.0%**	**0.4%**	**1.9%**	**5.5%**	**5**
UK	4.6%	5.1%	4.7%	5.0%	6
Germany	5.7%	5.6%	2.8%	3.4%	7
Ireland	1.5%	2.1%	2.2%	2.9%	8
Malaysia	0.04%	0.2%	1.8%	2.8%	9
Brazil	2.8%	2.6%	2.3%	2.7%	10

Source: Calculated from Reed Electronics, *Yearbook of World Electronics Data*, 2000.

PCs comprise 46% of total production, and peripherals account for 30%. The output value of peripherals nearly doubled between 1996 and 1997, partly from domestic firms and partly from Taiwanese firms manufacturing in China (Chung, 1999). The number of PC units produced has increased rapidly from about 200,000-300,000 units in the early 1990s (Chung, 1999) to over 4 million PCs in 1998 (DOC, 1999).

Composition of the industry

The domestic vendors have been oriented mostly towards the local market where they have grown at the expense of multinational vendors as well as local white box makers. Domestic companies had 80% of the market in 1998 while foreign companies had 20%, a remarkable change from the early nineties when foreign companies had 60% of the market (Chung, 1999). Despite their loss of market share, some foreign vendors have participated in the market's growth at the high end (e.g., servers). Also, foreign and foreign-joint-venture firms accounted for nearly 75% of China's exports, as they have used China as a low-cost export platform.

The dramatic change that has taken place in the PC industry in recent years is illustrated in Table 4, which shows the extent to which domestic PC makers came to the fore between 1997-1999. In 1997, six of the top ten PC makers in China were foreign, accounting for 26% of total PC sales, whereas only four were in the top ten in 1999, accounting for 17% of sales. In contrast, three new Chinese PC makers (Langchao, Shida, and Hisense) entered the top ten in 1998 alone, and together with the four firms in the previous top ten (Legend, Tontru, Founder, and Great Wall), they accounted for 39% of total PC sales in China.

Broken down by product category, Legend was number one in desktops (19.4% in 1999); Toshiba was number 1 in laptops (22.4% of the market in 1999); and IBM was number 2 in both desktops (6.2% in 1999) and laptops (16.7% in 1999). The majority of laptops sold by Chinese companies were manufactured by Taiwanese contract manufacturers in China or Taiwan (Chung, 1999, Pt. 2:24). The Chinese consumer desktop market is the key bastion of strength for domestic vendors, where Legend is number one with 23.6% of the market in 1999 and white box makers have about half of all consumer desktops (IDC, 2000). The ascendance of domestic companies appears to have continued in 2000. News reports citing IDC claim that Legend's market share rose to 30.8% and Founder to 9.4%, while HP's share dropped sharply to just 3.7% (China Online, 2001).

Table 4. Top-10 PC Sellers in China, 1997-1999

1997			1998			Jan-Sept 1999		
Brand	Units sold (000s)	Market Share (%)	Brand	Units sold (000s)	Market Share (%)	Brand	Units sold (000s)	Market Share (%)
Legend*	436	12.5	Legend*	585	15.7	Legend*	694	19.4
IBM	245	7.0	IBM	267	7.2	IBM	223	6.2
Compaq	228	6.5	Founder*	218	5.8	Founder*	197	5.5
Tontru*	201	5.8	Compaq	203	5.4	HP	193	5.4
HP	188	5.4	Great Wall**	192	5.1	Great Wall**	119	3.3
Founder*	135	3.9	HP	186	5.0	Compaq	105	2.9
AST	95	2.7	Tontru*	144	3.9	Dell	79	2.2
DEC	80	2.3	Langchao*	114	3.1	Start*	65	1.8
Great Wall**	75	2.1	Shida*	110	3.0	Langchao*	62	1.7
Acer	72	2.1	Hisense*	76	2.0	Hisense*	54	1.5
Subtotal	1,755	50.1	Subtotal	2,095	56.2	Subtotal	1,792	50
Others	1,745	49.9	Others	1,985	43.8	Others	1,794	50
Total	3,500	100.0	Total	4,080	100.0	Total	3,586	100.0

* Indicates Chinese companies; ** Indicates Sino-foreign joint ventures.
Source: Chung (1999) P2:22; IDC (2000).

Nearly all of the PC industry is located in the coastal region of China. IBM and Compaq have PC assembly facilities in Guangdong province, where a complete supply chain supports their operations and access to Hong Kong is easy. HP and NEC are located in Shanghai and Dell in Xiamen. Taiwanese firms are concentrated in Guangdgong, Fujian, and Shanghai. China's domestic vendors concentrated in the Beijing area in the early years, but have spread to southern and eastern China, especially the area around Shanghai and the corridor along the Shanghai-Beijing railroad. Some domestic PC makers such as Legend, Founder, and Great Wall also have facilities in southern China because of supply chain considerations and access to export markets.

Role of multinational corporations

Beginning in the 1990s, some foreign companies set up PC production in China to get around high tariffs and regulations prohibiting foreign companies from trading directly with Chinese customers. Foreign PC makers worked with local distributors, formed alliances with domestic enterprises, made use of their partners' sales channels, and/or aligned themselves with local governments seeking high-tech companies. Most U.S. vendors have joint ventures with one or more domestic PC makers to produce desktops, laptops, servers, and peripherals (Table 5). These joint ventures include the leading branded domestic PC makers (Legend, Great Wall, Stone). Japanese and Korean companies have not made much headway in the China market except for Toshiba, which leads in the laptop market and has a joint venture with Tontru.

[Insert Table 5]

The government policy of exchanging market access for investment in domestic companies has led foreign vendors to build more production facilities in China, step up local purchasing and hire local employees. Such localization strengthens the position of overseas vendors in negotiations over tariffs and domestic sales quotas, as they can argue that they earn foreign exchange, build up local industry, and relieve unemployment. Furthermore, the vendors also allow the government to arrange for partners in joint ventures because these Chinese partners "often have strategic locations and a reserve of local good will" (MIC, 1999c, 21).

However, these efforts to become more localized have not guaranteed sales for the foreign vendors. In fact, their market shares dwindled in 1998 because the Chinese PC makers, by ruthlessly cutting prices, successfully sold to domestic customers. In response, foreign vendors increased their joint ventures with local partners, hoping to not only reduce the risk of sudden policy shifts, but also to attract the purchasers of low cost PCs (MIC, 1999c, 22).

Role of Taiwanese companies

Taiwanese firms play a leading role in China's computer industry. They first entered China in search of low-cost labor and production sites for components and peripherals, but have since expanded their production to include PCs. They also have expanded into contract manufacturing for foreign and Chinese firms, and are trying to penetrate China's computer market with their own brand name products.

Taiwanese PC makers entered China in the early nineties with low-end, shoestring operations intended to hold costs and risks to a minimum. They used old equipment and labor

intensive assembly to process products for export in Guangdong Province and in Fujian Province, which is directly across the straits from Taiwan. Investments often were routed through Hong Kong to circumvent Taiwanese government restrictions on direct investment in China. Taiwanese companies have markedly increased their investment since 1995 in response to price pressures from the U.S. PC companies and fierce competition among Taiwanese suppliers and manufacturers. In addition to the original production base in Guangdong Province in southern China, an eastern base around Shanghai has been created. Most Taiwanese investment is now directed to Jiangsu Province, including Shanghai and nearby cities (Table 6).

Table 6. Taiwanese PC makers' recent investments in China

Company	Date	Amount	City (province)	Product(s)
Acer	1999	$200 million	Zhongshan (Guangdong)	Motherboards, will begin notebook PCs in 2001
Twinhead	2001	$12.5 million initially	Kunshan (Jiangsu)	Low-end PCs, terminals, components. Capacity of 100,000 PCs/month
Inventec	2001		Shanghai (Jiangsu)	Notebook PCs, capacity of 200,000 units/month
Compal	1999-2002 (7 plants planned)	$30 million as of Nov. 2000	Kunshan (Jiangsu)	Monitors, notebook PCs, wireless products
Quanta	2000	$26 million	Shanghai (Jiangsu)	Motherboards and bare-bones notebook PCs.
FIC	2000 (plans announced)		Shanghai or Suzhou (both Jiangsu). Also adding plants to existing facilities in Guangzhou (Guangdong)	Notebook PCs in Shanghai or Suzhou. PCs, motherboards, peripherals in Guangzhou.
Arima	2000	$22 million	Wujiang and Suzhou, Jiangsu province	Notebook PCs

Source: Collected from various news reports.

The expansion was also due to the rise of the low cost PC market in China. Taiwanese PC makers realized they would have to localize production if they wanted access to China's large market. Consequently, Taiwanese firms like FIC, GVC, Twinhead, and Huasheng built production facilities in Shenzhen, Beijing, Wuhan, and Chengdu (Chung, 1999).

The Market Intelligence Center in Taiwan indicates that the proportion of Taiwanese computer hardware and software products produced offshore increased from 25% of gross output in 1995 to 51.7% in 2000 (MIC, 1999b). A large proportion of that production was in mainland China, and the proportion has increased since 1998 (Table 7). In 2000, Taiwanese firms produced from 78-95% of components and peripherals offshore, and 60-90% was produced in mainland China. Taiwanese firms also produced 84% of their desktops offshore, with 45% in China, and 47% of their motherboards offshore, with 45% in China (MIC, 2001).

Table 7. Taiwan firm production in China

Type of product	Offshore production as percent of total[a]			China production 1998	
	1995	1998	2000	1998	2000
All products	25.0	43.0	51.7.	n.a.	n.a.
Components					
Power supplies		91	95	64	90
Keyboards		91	95	59	86
Mice		89	95	74	95
Cases		75	80	45	71
Monitors		71	81	35	60
Sound cards		67	n.a.	68	n.a.
Mapping cards		64	n.a.	64	n.a.
CD-ROM/DVD/RW		59	78	43	69
Scanners		38	86	32	85
UPS		25	n.a.	25	60
Graphics/video cards		18	n.a.	18	20
Motherboards		36	47	34	45
PC systems					
Desktops		89	84	8	45
Laptops		.01	7	0	7

[a]Total production includes production in Taiwan, China, and all other overseas locations (e.g., The Americas, Europe, etc.). Source: (MIC, 1999b; MIC, 2001).

Taiwanese firms have been prevented from producing certain high-end products such as notebook PCs on the mainland by Taiwan government restrictions, referred to as the "no-haste, be patient" policy. Taiwan's notebook makers, who account for almost half of the world's output, have worked around the ban by making components and base units and shipping them abroad for final assembly. It is expected that the government will end these restrictions under pressure from the industry, and all of Taiwan's major notebook manufacturers have invested in mainland facilities to produce complete notebooks when that time comes (Clendenin, 2001).

As the movement into notebooks suggests, the technology level of products made by Taiwanese firms in China has gone up significantly since 1998. Monitor makers have begun manufacturing high-end LCD monitors on the mainland. Scanner production and motherboard production have also moved (MIC, 2001). Taiwanese companies reportedly want to move into marketing and sales, but they are late to the game and face strong competition from China's domestic branded producers as well as white box makers (Chung, 1999).

Despite the fact that domestic companies dominate the Chinese market, Taiwanese companies are doing much of the PC and PC-related manufacturing. While it is well known that Taiwanese companies have been manufacturing for foreign multinationals in China, it is less well known that they have also been manufacturing for China's domestic companies as well.

China's domestic PC industry

Production

At the end of 1998, there were about 250 licensed PC companies in China. Although China's computer industry is becoming more concentrated, it is still decentralized and mostly

small in scale—some say too decentralized for achieving scale economies. Domestic companies are scattered all over China with major production centers in the Beijing, Shanghai, and Guangdong areas, but the newer PC makers eschew these locations for other provincial and local government centers where they can gain special advantage as local champions.

      Legend Computer, the largest firm, manufactured 770,000 computers in 1998 (Table 8). The fact that it also made motherboards as an original equipment manufacturer for other PC makers gave it scale economies as the company grew. By 2000, sales of Legend brand PCs were over 2 million units, and the company announced plans to open a new plant in Shanghai that would increase its total production capacity to 4.5 million (Tsang, 2001). By comparison, Compaq, the world's leading PC maker, sold over 17 million units in 2000 (Dataquest, 2001). It has been reported that MII plans to require a minimum production scale of 500,000 units a year for licensed companies (ATIP, 1999).

Table 8. Production of top PC vendors in China, 1997-1998

Vendor	Unit output 1997 (1,000s)	Share of total output, 1997 (%)	Unit output 1998 (1,000s)	Share of total output, 1998 (%)	1997-1998 Growth Rate (%)
Legend Group	450	27.0	770	24.6	71.1
Great Wall Computer Group	260	15.6	410	13.0	57.7
Tontru Group	210	12.6	380	12.0	81.0
Founder Group	135	8.0	290	9.0	114.8
Compaq China Ltd. *	250	15.0	260	8.2	4.0
Hewlett Packard China Ltd.*	20	.01	240	7.6	20.0
Langchao Electronic IT Group	40	.02	160	5.1	300.0
Shida Group	12	.01	160	5.1	1233.3
Qinghong Electronic International Ltd.	51	.03	150	4.7	194.1
Changjiang (Yangtze River) Computer	30	.02	150	4.7	400.0
Hisense Group	10	.01	130	4.1	1200.0
Tsinghua tongfang	10	.01	60	1.9	500.0
Total	1658	100	3160	100	90.6

* Foreign companies. Source: Zhonglian-Fujitsu Economic Consulting Co. Ltd., compiled based on the IT planning of the Electronics Branch of the Industrial Research Institute. (April, 1999).

      Domestic computer companies have been entrepreneurial and aggressive competitors, engaging in price wars with foreign vendors and one another. These struggles for market share have stimulated market growth. While foreign vendors are building production facilities in China to supply China's high-end market, China's domestic PC makers are leveraging their low costs into market domination in the burgeoning low-cost PC segment.[5] When China's branded PC companies attain sufficient market share, they are expected to move into the higher end market (e.g. servers and workstations, where foreign firms now dominate) and may also expand into the global low-cost PC market (Chung, 1999).

      White box makers held an estimated 50% of the PC market in 1997, selling low-cost machines often bundled with bootleg software (DOC, 1998). MEI subsequently enforced new quality standards, pushed stiffer licensing standards and procedures and shut down many unlicensed manufacturers. IDC reports that the white box makers comprised only about 40% of

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[5] Foreign vendors tend to focus on the US$1,000-1,500 price band, whereas local brands focus on the $500-1,000 band, with white box makers most heavily represented in this band (IDC, 2000).

the market in 1999, and will decrease further in importance as domestic branded companies take more market share at the low end (IDC, 2000).

New Chinese vendors are pursuing a localized strategy of building plants as joint ventures with key provinces and municipalities to win contracts from governments and government-owned enterprises. It is reported that Chinese PC makers like Haixin, Star, Langchao, Qinghua, and Tongfang entered the lower product echelons in cities where they could make the most of their geographical advantages (Chung, 1999). It is unclear whether these firms will be able to build sales channels outside their regional bases in order to grow. It is also unclear whether these firms will be profitable, or survive in the long run.

Sales and distribution

Most computer sales in China are through indirect channels or vendor sales forces. Direct sales by phone or Internet are very small because the communications infrastructure is limited (technologically and geographically) and credit card ownership is still uncommon. Dell Computer's direct sales approach reportedly only works effectively with larger customers that have their own internal management information systems (MIS) departments. By contrast, Legend has flourished in the consumer and SME markets by establishing an extensive national network of distributors and retailers.

Distribution can be difficult for foreign PC makers, due to the lack of well-established channels and trade transparency. Because of government regulations and the physical size of the market, foreign companies often must rely on local distributors and dealers to sell their products even if they have set up their own sales offices locally. Establishing joint ventures or strategic alliances with local manufacturers or even competitors is not unusual. For example, HP products are distributed through Legend, which manufacturers its own PCs. Compaq computers are distributed through the Stone Computer Group, which produces its own brand name PCs. Compaq also has set up partnerships with smaller regional PC makers.

PERFORMANCE OF CHINA'S COMPUTER INDUSTRY

China's computer industry has gone from virtually non-existent in 1983 when it targeted the industry for development to become the number five computer hardware producer in the world in 1999. China's total PC production increased from 300,000 units in the early 1990s to 4 million PCs in 1998.

China has achieved its national policy goal of increasing exports in order to earn foreign currency. Computer exports have increased dramatically between 1990-1998 from $227 million to over $10 billion (Table 9). Moreover, China has an overall trade surplus in computers—totaling $4.86 billion in 1998, compared to a deficit of $325 million in 1990. Exports grew rapidly after 1994, when China established export-processing zones and offered tax breaks to attract overseas investment.

Table 9. China's computer trade balance (US$ millions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Exports	227	314	820	1,258	2,006	3,750	5,315	7,543	10,169
Imports	552	668	1,344	1,344	1,763	2,403	2,876	3,868	5,300
Trade balance	-325	-354	-524	-86	233	1,347	2,439	3,675	4,869

Source: Reed Electronics, *Yearbook of World Electronics Data*, 2000.

China's exports are mainly a result of production by foreign computer vendors (Table 10). Domestic vendors are primarily concentrated on the domestic market, although a few such as Legend have begun exporting to other countries in the Asia-Pacific region. The trade surpluses are mainly generated from four products: PCs, monitors, hard disk drives, and printers (Table 11).

Table 10. China's computer hardware exports by type of vendor

	1996	1997	1998
Foreign-invested	40.0%	42.2%	51.8%
Joint-invested	36.0	34.7	21.9
State enterprise	18.0	17.6	22.0
Joint cooperation	5.0	4.3	3.0
Other	1.0	1.3	1.3

Source: (MIC, 1999c: 18).

Table 11. China's trade surpluses by computer product (US$ billions)

Product	**1996**	**1997**	**1998**
PCs	.07	.07	.13
Printers	.45	.72	.77
Monitors	.77	1.1	1.7
Hard drives	.08	-.01	1.9
Computer products total	2.7	4.2	5.2

Source: Peoples Republic of China Customs, cited in Chung (1999), Pt. 2: 26-27.

CONCLUSIONS, CHALLENGES, AND LESSONS

China as a developmental state

Starting with Japan in the 1960s and 1970s, and continuing with Singapore, Korea, and Taiwan in the 1980s, the Asia-Pacific region has become the leading global producer of computer hardware and associated components such as semiconductors, storage, and displays. The success of these countries has involved a strong role for the so-called developmental state (Johnson, 1982). Strategies varied considerably across the countries, as did outcomes, but these economies as a group were highly successful in developing globally competitive hardware industries (Anchordoguy, 1989; Wade, 1990; Dedrick and Kraemer, 1998). China's own policies are consciously similar to those of its neighbors in many ways, but have been adapted to fit China's unique national environment and its strategic objectives.

At the core of China's computer industry strategy is the government's desire to catch up technologically while maintaining central control over key aspects of the economy and reducing China's dependence on foreign technologies. For instance, in a February 2000 editorial, the People's Liberation Army Daily, which speaks for China's military, argued that China must develop its own software. It wrote: "Without information security, there is no national security in politics, economics and military affairs. While learning from others, China should not be under their control" (Goad and Holland, 2000). This willingness to learn from outsiders without surrendering technological or economic control has been a guiding philosophy behind China's computer policies.

Commensurate with this philosophy, China has opened its computer sector to foreign firms in order to attract investment and technology, and has promoted exports by joining the global production networks of the MNCs. However China is unwilling to give foreign firms control of its computer market. The government directly limits the role of foreigners in telecoms, datacoms, and Internet services. In computer hardware, its approach is to promote domestic firms through direct and indirect support such as favored treatment in government procurement and access to technologies developed in the state R&D institutions.

China's desire to develop strong domestic computer makers with indigenous technological capabilities is similar to that of Japan, Korea, and to a lesser extent, Taiwan. Each provided financial and technical resources to domestic companies, and in some cases protected them from foreign competition. China's strategy of extracting concessions from foreign MNCs in return for market access is most similar to Japan, which likewise had a large and attractive market. With much smaller domestic markets, Taiwan and Singapore relied more on partnerships with MNCs, which provided critical access to global markets.

In terms of policy institutions, China clearly learned from the problems created by bureaucratic competition in Japan and Korea, where ministries of industry and trade competed over policy turf with telecoms ministries, often leading to conflict and duplication of effort. The action that China took, consolidating its equivalent ministries into the MII, is more reminiscent of Singapore's. At different times, Singapore was able to resolve such bureaucratic competition through restructuring. On the other hand, China struggles with competition between the central government and provincial/local governments, sometimes leading to redundancy and excess capacity.

Finally, unlike its neighbors, China has pursued its computer policies in a transition economy that still retains important vestiges of its socialist roots, including state ownership of most companies. While it has tried to create industrial conglomerates similar to Japanese keiretsu or Korean chaebol, the basic ownership structure remains much different, as even firms listed on stock exchanges remain under the control of government agencies or collectives. In this sense, the Chinese developmental state is a different breed from its neighbors. It remains to be seen how those differences will affect the industry's development, especially in a more open market environment after China's expected entry into the WTO.

The potential of Greater China and Taiwan's role

The most surprising finding in this research has been the degree to which China's PC industry is linked with Taiwanese firms for production capacity, technical know-how, and capital investment. Most of China's laptop PCs are made by Taiwanese firms, which also manufacture peripherals and components for desktop computers assembled by the Chinese computer makers.

Taiwanese investment would be even greater if the Taiwanese government relaxed its controls on mainland investment.

While political relations add greatly to the risk involved, Taiwanese companies are investing at a rapid pace in mainland China, seeking a place in the fast-growing market. The resulting combination of Taiwan's management and design skills and relationships with leading global computer companies; China's low-cost labor (from factory workers up to engineers) and its potentially huge market; plus Hong Kong's commercial capabilities, make Greater China a formidable competitor in the global computer industry. Combined computer hardware production by mainland China and Taiwan should top Japan in 2001, and will soon also surpass the entire ASEAN region.

Greater China is succeeding as an export platform to the global PC industry, as well as a producer for the domestic Chinese market. China is expected to be the number two PC market in the world by 2003 or 2004. It already is the second largest market for mobile devices, a market now being targeted aggressively by Taiwanese computer makers. In the wireless market, which is more evenly distributed among European, U.S., and Asian firms, Greater China can have a much larger impact on technological trajectories than it has in PCs, which are dominated by U.S. standards.

An important question is what will happen to Taiwanese companies as China's own manufacturers improve their capabilities. Will China's domestic firms continue to rely on Taiwanese companies as suppliers, or will they replace them? Will the foreign vendors continue to rely on Taiwanese companies producing in China or turn to Chinese companies? From Taiwan's point of view, an equally big issue is whether Taiwanese companies will succeed by abandoning Taiwan and moving most of their production to China, and if so, what will be left for Taiwan to do.

Lessons for foreign companies

For foreign companies, China remains a large but often difficult market in which to do business. Not only are local firms favored by the government, they also benefit from their intimate knowledge of the market. Two of the world's largest PC makers, Compaq and HP, have seen their market share fall sharply in China in recent years.

Success requires partnering with domestic Chinese companies in order to gain access to distribution channels and markets. The IBM/Great Wall partnership has been the most successful example. However, many partnerships have led to disappointment, as the two sides were unable to collaborate effectively. In some cases Chinese distributors have defaulted on credit extended to them by foreign vendors.

While there are many potential pitfalls in dealing with traditional distribution channels, it is not easy to bypass these channels by going direct, as Dell is finding out. Dell's direct model does not work well with individual consumers or SMEs in China because they lack experience in PC use, and also are not comfortable with ordering a product they cannot touch or see in advance. Dell has had to develop relationships with local distributors and resellers who can give it access to large corporate accounts where it is used to operating. This strategy has helped Dell gain a 2.2% share of the China market in 1999, even after a late entry.

Finally, it is vital to have manufacturing capabilities inside China, both to avoid tariffs and to show a commitment to the Chinese market. Such a commitment is needed if one hopes to

sell to government agencies and state enterprises, which make up most of the large business and institutional markets.

Implications for developing countries

China's success in developing its computer industry has limited application for other developing countries. China has been able to succeed with an import-substitution strategy that was largely unsuccessful in India, Brazil, and Mexico during the 1980s (Dedrick et al, 2001; Dedrick, Kraemer and Palacios, 2001). China succeeded in large part due to the size and dynamism of its market, but other factors also played an important part. Chief among these were China's policy of exchanging market access for foreign technology, requiring foreign MNCs to export much of their production, persuading foreign MNCs develop joint ventures with domestic companies, and allowing Taiwanese companies to set up production networks in China to support domestic companies. Few, if any, developing countries would have such desirable markets or be able to attract foreign investment on terms so favorable to the host country.

On the other hand, other developing countries can follow China's strategy of promoting computer use to modernize its economy and create demand for local firms. Also, development and exploitation of national capabilities to support computer production and use have been key to China's approach. These include human resources, R&D institutions, and information infrastructure, all of which can be upgraded in most developing countries. Finally, while China has favored domestic firms, it has maintained a highly competitive local computer market. This benefits computer users and also helps domestic firms prepare to compete in markets outside China.

Opportunities and risks

There is a famous Chinese saying, "May you live in interesting times," which captures some of the conflicting currents in China's PC industry. Some regard the saying as a blessing, while others view it as a curse. So it seems with the PC industry in China. The growth in the PC market has been tremendous, creating opportunities for domestic and foreign PC makers alike. However, foreign PC makers have seen their market shares shrink dramatically, while domestic Chinese makers have seen their shares grow. The result will be financial losses for some companies, an industry shakeout, and greater concentration in the domestic industry. The influx of Taiwan's highly successful PC makers into China involves great opportunities and risks for those companies and for those outside of Greater China. Finally, China's often contentious relationship with the U.S., and its entry into the WTO portend new opportunities and challenges.

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Table 5. Major Foreign Companies' PC and Peripheral Plants in China in 1998

Company	Desktop	Laptop	Server	Peripherals	Mother Board	Others
HP	JV in Pudong, Shanghai Assembly Contracting (Legend)		JV in Pudong, Shanghai			Color inkjet printer JV plant Shanghai, Waigaoqiao
Compaq (including DEC)	JV with Stone, Heguang, Shida), solely owned plant in Shenzhen					
IBM	JV with Great Wall in Shenzhen	JV with Great Wall in Shenzhen	Solely owned plant in Shanghai, Waigaoqiao	Hard-drive JV plant in Shenzhen, (Hailiang)	JV with Great Wall Technology in Shenzhen	Solely owned magnetic head plant (IBM Shenzhen); POS JV plant with Tianjin Info.
Dell	Solely owned plant (Xiamen, Fujian Province)					
Siemens	Solely owned plant (Fuqing)					
NEC	JV (Yangtze)					
Toshiba		Evaluation (Guangdong)	JV with Tontru			
Acer				Solely owned plant producing monitors, keyboards, and CD-ROMs (Acer Suzhou)	Solely owned plant (Acer Zhongshan)	Solely owned plant producing software and networking equipment (Acer Shanghai Hi-Tech Software)
Lufei		JV with Jianda				
Weiguan	Solely owned plant (Dongguan, Guangdong)					Solely owned plant producing monitors (Shenzhen)

Source: Chung (1999) Pt1: 16, Table 3-8. Compiled based on IT plan of the Electronics Branch of the Industrial Research Institute. (June, 1999)