Enter the Dragon: China's Computer Industry

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By carefully nurturing its domestic computing industry through tightly controlled partnerships with foreign manufacturers, China has become the fourth-largest computer maker in the world.

China's shift from technological nationalism to a more pragmatic strategy of developing national capabilities in conjunction with multinational corporations has transformed its economy. Consistent with this transformation, China has revamped its industrial and technology policies, moving from an isolationist approach aimed at achieving technological independence to become a major producer of computer hardware and a major market for information technology products.

In 1990, China had only 500,000 PCs in a country of more than 1.2 billion people. By 2000, mainland Chinese purchased more than seven million PCs in a single year. During the same time, China's production of computer hardware grew from less than US$1 billion to US$23 billion.[1]

China's policies clearly drew on the developmental approach of other Asia-Pacific economies such as Japan, Korea, Taiwan, and Singapore. Each of these became leaders in different segments of the global computer industry through the strong support of government industrial and technology policies.[2]

REGIONAL AND NATIONAL ENVIRONMENT

A combination of factors influenced the growth of China's computer industry, including the roles played by domestic PC makers, foreign multinationals, and Taiwanese contract manufacturers. In addition, government policies promoted computer production and use, encouraged quasi-state-owned enterprises to enter the PC industry, and invited foreign investment while requiring foreign firms to transfer technology in return for market access.

Regional environment

Starting with Japan in the 1960s and 1970s, and continuing with Singapore, Korea, and Taiwan in the 1980s, the Asia-Pacific region became the leading global producer of computer hardware and associated components such as semiconductors, storage, and displays. Strategies varied considerably in the various countries, as did outcomes, but these economies as a group proved highly successful in developing globally competitive hardware industries. Successful government policies most commonly involved a combination of export orientation to achieve global competitiveness and strong efforts to develop national capabilities such as infrastructure and human resources.[2]

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China's computer-industry strategy includes similar elements, as it has promoted exports and invested heavily in building an information infrastructure. On the other hand, China's strategy also embodies the government's desire to catch up technologically while maintaining central control over key aspects of the economy, reducing its dependence on foreign technologies. For example, a February 2000 editorial published in the *People's Liberation Army Daily*, which speaks for China's military, argued that China must develop its own software. The editorial stated, "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."[3] This willingness to learn from outsiders without surrendering technological or economic control has been a guiding philosophy behind China's computer policies.

Conforming with this philosophy, China has opened its computer sector to foreign firms—including US, Taiwanese, and a few Korean and Japanese PC companies—to attract investment and technology. It has also promoted exports by joining the global production networks of multinational corporations.

Because it is unwilling to give foreign firms control of its computer market, the government directly limits the role of foreigners in telecommunications services, data communications, and Internet services. In computer hardware, it promotes domestic firms through direct and indirect support such as favored treatment in government procurement and access to technologies developed in state R&D institutions.

China's desire to develop strong domestic computer makers with indigenous technological capabilities echoes that of Japan, Korea, and, to a lesser extent, Taiwan. Each of these economies has 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 multinational companies in return for limited market access parallels Japan's earlier strategy, which also relied on a large and attractive market to entice foreign corporations. With much smaller domestic markets, Taiwan and Singapore relied more on partnerships with multinational companies, which provided critical access to global markets.

Although China 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 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 telecom ministries, often leading to policy inertia and redundant efforts. China's policy approach more closely parallels Singapore's, which has resolved bureaucratic competition through restructuring and top-level intervention.

China's strategy embodies the government's desire to catch up technologically while maintaining central control over key aspects of the economy.

The Chinese government initially assigned primary responsibility for the computer industry to the Ministry for the Electronics Industry. However, the convergence of computers and telecommunications put the MEI in conflict with the Ministry of Posts and Telecommunications on several issues, especially with each ministry having its own telecommunications operating company. To eliminate this competition, the State Council combined the two ministries with segments of other ministries to form the new Ministry of Information Industry, which has clear supremacy over most IT policies.

MII plans China's information infrastructure, develops its national computer policies, and licenses and selects key government-supported companies. Its strategy for developing domestic industry has two key parts:

- leveraging access to its market in exchange for technology and investment from foreign firms, and
- stimulating domestic firms through regulation and subsidies.

While its policies are consciously similar to those of its neighbors in many ways, China has adapted them to fit its unique strategic objectives and national environment.

National environment

Several 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. The following three are the most crucial.

Mushrooming domestic market. China's domestic market has grown at double-digit rates for two decades, becoming the second or sixth largest in the world, depending on whether analysts use market exchange rates or purchasing-power-parity equivalents to measure the market's size. At market rates, China's GNP is about US$1 trillion, while in purchasing power parity terms, it is more than US$4 trillion.

China has pursued its strategies in a transitional economy, leading to unusual structures that include both private-capital and state ownership.

The Chinese government has spurred the growth of the computer hardware market directly by promoting the use of computers, lowering tariffs and thus lowering the price of PCs, and promoting computerization of state-owned enterprises. Observers also indirectly attribute the expansion of the PC market to China's One-Child Policy and the Chinese belief in education, as many Chinese parents have bought PCs to help their children with schoolwork. Not surprisingly, the Chinese government dangled access to its PC market as a carrot to foreign firms in return for various concessions.

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

Strong technological base. 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.[4] It did so partly by creating state-owned but market-oriented enterprises linked to commercializing the technologies developed in state-owned research institutions. These enterprises now include the four largest Chinese PC makers: Legend, Founder, Stone, and Great Wall.

COMPUTER INDUSTRY POLICY

Computer technologies have been a Chinese government priority since it introduced the first long-term science and technology development plan in 1955. A computer was first built in China in 1958, copying a Soviet model. In the 1970s, China began producing computers for industrial and commercial uses, and its first microcomputers were built in 1977. However, these computers relied on imported components and were produced in small quantities.[4]

China's drive to create a commercially oriented computer industry formed part of a larger effort to create an electronics industry, which formally began in 1986 with the Seventh Development Plan. In that plan and subsequent ones, China's electronics industry received special emphasis and support as a "pillar" industry that would lead development of the entire economy.

Computer policy goals

China's computer policy encompasses all computer types but focuses mainly on the PC industry, as expressed in the major goals of the Ninth Five-Year National Development Plan, 1996-2000:

- 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 PC manufacturers into enterprises with an annual production capacity of more than US$1 billion;
- apply computer technologies to the renovation of traditional industries; and
- develop uniform PC standards via a production licensing system to answer complaints about lack of service and intellectual property protection on clone PCs.

The Ninth Development Plan also emphasized a series of "golden projects" intended to serve several purposes:[5]

- modernize the country's IT infrastructure on a very large scale,
- integrate the central government with the provinces and integrate the ministries within the government,
- stimulate computer use throughout the country, and
- support the information technology industry—specifically the hardware, software, and information services sectors in computers and telecommunications.

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 to market their own products and gain access to local distribution channels. IBM negotiated with MEI on a joint ven-

Table 1. Major foreign PC company activities in China.

Foreign company	Joint venture (JV) or wholly owned (WO)	Chinese partner	Products, operations
IBM	JV	Great Wall	Desktop and notebook PCs, storage products, motherboards
	WO		Servers
Compaq	JV	Stone Group	Desktop PCs
	JV	Star Group	Notebook PCs
Hewlett-Packard	JV	Legend	Desktop PCs, inkjet printers
Dell	WO		Desktop and notebook PCs
Acer	WO (3 separate units)		Monitors, peripherals, motherboards, software, networking equipment
Toshiba	JV	Tontru	Servers
NEC	JV	N/A	Desktop PCs
LG Electronics	JV	Tontru	Monitors
Siemens	WO	N/A	Desktop PCs

Source: C. Chung[6] and Market Intelligence Center[7,9]

ture agreement in 1984, but they failed to agree on details and IBM ended up going alone for a time. However, IBM failed to penetrate the Chinese PC market, and ultimately entered a joint venture with Great Wall in 1994. This venture provided IBM with local distribution channels and gave Great Wall access to IBM technology and manufacturing know-how. Table 1 lists major foreign PC makers, their Chinese joint-venture partners, and their activities in China.[6-9]

Although China has discouraged the direct import of computers by maintaining high tariffs and taxes, it reduced tariffs from 82 percent in 1992 to 35 percent in 1993 and is expected to reduce them to 15 percent upon joining the World Trade Organization. The government regulated foreign-vendor access to its markets by limiting the production of foreign firms for the domestic market to a certain percentage of their export production.

To encourage exports, the government created export processing zones in which imported materials used in production are free from duties and taxes when exported directly. The government also slowed foreign firms and increased their costs with certification processes regarding quality, local content, and export limits. All these measures were intended to allow domestic firms time to become established.

Domestic firms

The government has promoted domestic enterprises, but it does not directly manage these firms. Rather, it has dealt with them as part of governmental restructuring and enterprise reform. It has advocated separating politics from enterprise management, combining research with industry and trade, and forming joint ventures with foreign firms.

Many domestic computer makers who had operated on a small scale became favorites of their supervising government departments and quickly expanded their operations by partnering with, or transferring technologies from, foreign companies. Major 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 it reminds us that the market structure still contains elements of socialism. Market leader Legend is closely affiliated with the Chinese Academy of Sciences, the leading government research institution. Likewise, Founder Group is affiliated with Beijing University, and Great Wall is a spin-off of the Ministry of Electronics Industry. Each of these 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 owned by the affiliated government institution.[4] Despite their status as state-owned or collective enterprises, each is clearly managed in an entrepreneurial, market-oriented manner, making the Chinese PC market highly competitive.

Providing access to technologies developed by state R&D institutions has proven a key government resource. For example, researchers developed Great Wall's initial PC inside MEI research institutions, and Legend commercialized various technologies developed in CAS labs. These technologies enabled the companies to develop successful commercial products that sustained their growth and expansion into new industries, including PC manufacturing.[4]

Local governments as policy institutions

In addition to the central government, China's provincial governments and large municipalities have contributed to the development of the nation's computer industry. In contrast to the indirect role of the state through the MII, the local governments

The government acts as a conduit for providing the company's needs while promoting its products to other governments, enterprises, and citizens.

play a direct role, providing the infrastructure, building sites, financing, and other support required to create or attract computer firms that offer employment, economic development, and the prestige of having a local 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. In contrast to MII, local governments took a more entrepreneurial approach that avoided setting explicit policies or criteria for support. If its plans fit with the well-being of the locality, a small company could receive support and expand quickly into an enterprise group or public company with a much higher value.[6]

Companies that develop alliances with local governments benefit from the pipeline effect. In this arrangement, the government acts as a conduit for providing the company's needs—such as land, labor, and capital—while promoting its products to other governments, enterprises, and citizens.

Multinational corporations' role

Beginning in the 1990s, foreign companies set up PC production in China. In the early years, they held as much as 60 percent of the market, but their share has subsequently declined as local manufacturers moved to the fore. High tariffs combined with government regulations to prohibit foreign companies from trading directly with the Chinese companies. Consequently, foreign PC makers began to set up production in China and work with local distributors by employing strategies such as

- pursuing joint ventures with domestic companies,
- forming alliances with domestic enterprises favored by the government,
- using their partners' sales channels to sell their own products, or
- aligning themselves with local governments seeking high-tech companies.

Table 1 shows that most US vendors participate in joint ventures with one or more domestic PC makers to produce desktops, laptops, servers, and peripherals. These ventures include the leading domestic PC makers: Legend, Great Wall, Tontru, Star, and Shida. Except for Toshiba, which is a leader in the laptop market and has a joint venture with Tontru, Japanese and Korean companies have not made headway in the Chinese market.

For overseas vendors, the benefits of setting up local manufacturing sites in China are especially significant. During negotiations over tariffs and domestic sales quotas, "they can argue that they earn foreign exchange, build up local industry, and relieve unemployment."[8] Further, these vendors also let China's local governments make arrangements and selections for their joint-venture partners because these Chinese partners "often have strategic locations and a reserve of local good will."[8]

However, these efforts to become more localized have not guaranteed success. Foreign vendors' market shares actually dwindled in the late 1990s because Chinese PC makers, by ruthlessly trimming their prices, successfully sold to domestic customers. In response, foreign vendors increased their joint ventures with local partners, hoping not only to reduce "the risk of sudden policy shifts," but also to attract the purchasers of low-cost PCs.[8]

Taiwanese companies' role

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 they have since expanded the scale and level of their operations to include PC production. They have also expanded their role to doing contract manufacturing for foreign and Chinese firms and trying to penetrate China's computer market.

Taiwanese PC makers initially entered China in the early 1990s with low-end, shoestring operations intended to hold costs and risks to a minimum. They often routed investments 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 US PC companies and fierce competition among Taiwanese suppliers and manufacturers. Also, Taiwanese PC makers realized, as other multinationals had, that they must localize production if they wanted access to China's large market. Consequently, in the past several years major Taiwanese firms such as Acer, Quanta, Arima, Hon Hai, FIC, GVC, Twinhead, and Huasheng have built production facilities in China.

The share of Taiwanese companies' computer hardware and software produced outside Taiwan increased from 25 percent of gross output in 1995 to 43 percent in 1998 and to 51.7 percent in 2000.[9] A large proportion of that production took place in mainland China. In 2000, Taiwanese firms produced from 78 to 95 percent of various components

Table 2. Top five countries' share of global computer production.

Country	1985 (percent)	1990 (percent)	1995 (percent)	2000 (percent)	2000 rank
US	49.2	27.0	26.5	26.1	1
Japan	18.9	29.2	25.2	16.3	2
Singapore	1.2	3.9	7.3	7.6	3
China	0	0.4	1.9	6.8	4
Taiwan	1.0	3.3	5.6	6.5	5

Source: Calculated from Reed Electronics Research, *Yearbook of World Electronics Data*, 2001.

Table 3. China's computer trade balance in millions of US dollars.

	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 Research, *Yearbook of World Electronics Data*, 2000.

and peripherals offshore, with 60 to 90 percent produced in mainland China. Taiwanese firms also produced 84 percent of their desktops offshore. They produced 47 percent of their motherboards offshore with 45 percent produced in China.[10]

Taiwanese government restrictions—referred to as the "no-haste, be patient" policy—have kept its firms from producing certain high-end products on the mainland, such as notebook PCs. 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 in China, then shipping them abroad for final assembly. However, analysts expect that the government will end these restrictions under pressure from the industry. Anticipating a change in the rules, all of Taiwan's major notebook manufacturers have invested in mainland facilities to produce complete notebooks.[11]

COMPUTER INDUSTRY PERFORMANCE

China's domestic computer hardware market grew to US$13.8 billion during 2000, up from less than US$1 billion in 1990. Market growth climbed as high as 70 percent in 1993, when import duties were reduced, and averaged 31 percent a year throughout the 1990s. PC sales reached 7 million units in 2000 from only several hundred thousand in the early 1990s.

Meanwhile, as Table 2 shows, China's computer industry, virtually nonexistent in the early 1980s, became the world's fourth-largest computer hardware producer in 2000. Total production reached US$23.1 billion, over four times the US$5.6 billion produced in 1995.

China has achieved its national policy goal of increasing exports to earn foreign currency. Computer exports increased dramatically between 1990 and 1998, from US$227 million to more than US$10 billion, as Table 3 shows. Moreover, China had an overall trade surplus in computers totaling US$4.86 billion in 1998, compared to a deficit of US$325 million in 1990. Exports grew dramatically after 1994, when China established export-processing zones and offered tax breaks to attract overseas investment.

China's exports mainly result from production by foreign computer vendors. China's domestic vendors concentrate primarily on the domestic market, although a few, such as Legend, have begun exporting to other countries in the Asia-Pacific region. Four products mainly generate the trade surpluses: PCs, monitors, hard-disk drives, and printers.

ISSUES AND IMPLICATIONS

Analysts report that Chinese brand-name PCs are "very advanced systems and very competitive with the multinationals."[12] The country's domestic PC makers have grown by focusing on the middle and lower end of the market and taking market share from foreign vendors and clone makers. However, price competition among domestic vendors has reportedly driven margins to near zero,

Taiwanese companies are investing rapidly in mainland China, seeking a place in this fast-growing market.

bringing about reorganizations, acquisitions, and changes in top management at some Chinese PC companies.

Chinese PC makers also lack the economies of scale enjoyed by vendors such as Compaq, Dell, HP, and IBM, who have sales volumes of nine to 17 million PCs per year. In contrast, a fragmented domestic market is leading to low production by individual Chinese PC makers, with the exception of market leader Legend. Local and regional government incentives to domestic PC makers may encourage expanded production by smaller vendors, leading to market fragmentation and excess capacity.

A major challenge for China's computer industry will be to move beyond production of standard PCs for the domestic market and low-value peripherals and components for the global market. With China's strong base of technical skills and its ability to attract foreign investment and technology, the country has a reasonable chance to do so. Legend is moving into software, Internet services, and information appliances, while other hardware makers are expanding their scope as well. However, developing a more knowledge-intensive industry will require relaxing controls on information and providing greater government protection of intellectual property.

Greater China

Perhaps the most significant development in China's computing industry is the degree to which its PC segment links to Taiwanese firms for production capacity, technical know-how, and capital investment. It is widely known that Taiwanese companies have undertaken manufacturing for foreign multinationals in China, but it is less well-known that they have also been manufacturing for China's domestic companies.[6] Taiwanese involvement would be even greater if the Taiwanese government relaxed its remaining controls on mainland investment.

Despite these controls and the political risks involved, Taiwanese companies are investing rapidly in mainland China, seeking a place in this fast-growing market. This trend combines Taiwan's management, design skills, and relationships with leading global computer companies with the mainland's low-cost labor at all levels, potentially huge market, and Hong Kong's commercial capabilities. As a result, Greater China promises to be a formidable competitor in the global computer industry.

Greater China is succeeding already as an export platform to the global PC industry as well as a producer for the domestic Chinese market. Combined computer hardware production by mainland China and Taiwan was expected to outpace Japan in 2001. Analysts anticipate that China will be the second-largest PC market in the world by 2003 or 2004. China already has the second-largest market for mobile devices, a market that Taiwanese computer makers are now aggressively targeting. In the wireless market—which is more evenly distributed among European, US, and Asian firms—Greater China can have a much stronger impact on technological trajectories than it has on PCs, which US standards dominate.

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 foreign vendors continue to rely on Taiwanese companies producing in China or will they 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 offers a large but often difficult market in which to do business. Not only does the government favor local firms, these firms also benefit from their intimate knowledge of the market. In recent years, the world's second- and third-largest PC makers, Compaq and HP, have both seen their market share in China fall sharply.

Success requires foreign companies to partner with Chinese companies to gain distribution-channel and market access while they also operate their own independent subsidiaries. The IBM-Great Wall partnership offers the most successful example of this practice. However, many partnerships have led to disappointment, with the two sides unable to collaborate effectively. In some cases, Chinese distributors have defaulted on credit that foreign vendors have extended to them.

While many potential pitfalls in dealing with traditional distribution channels remain, bypassing these channels by selling direct is difficult, as Dell found out. Dell's direct model does not work well with individual consumers or small and medium-sized enterprises in China because they lack experience in PC use. Chinese consumers also feel uncomfortable with ordering a product they cannot

touch or see in advance. Dell built an assembly plant in China to support its direct model there, but it has also been forced to develop relationships with local distributors and resellers who can give it access to large corporate accounts.

Finally, having manufacturing capabilities inside China is vital, both to avoid tariffs and the value-added tax and to show a commitment to the Chinese market. Such a commitment is needed if a company hopes to sell to government agencies and state enterprises, which make up most of China's large business and institutional markets.

Implications for other developing countries

China's success in developing its computer industry has limited application to other developing countries. China has succeeded with an import-substitution strategy that proved to be much less successful in India, Brazil, and Mexico during the 1980s. This success is due in large part to the size and dynamism of China's market, but other factors also played an important role. Chief among these were China's policy of exchanging market access for foreign technology, requiring foreign multinationals to export much of their production, insisting that foreign multinationals develop joint ventures with domestic companies, and letting Taiwanese companies 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 their economy and create demand for local firms. Also, China has focused on developing and exploiting national capabilities to support computer production and use. These capabilities include human resources, R&D institutions, and an 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 approach benefits computer users and also helps domestic firms prepare to compete in markets outside China.

China's computer industry policies have succeeded in expanding both production and computer use, taking advantage of domestic capabilities as well as attracting leading multinationals to produce in China. Although China's growing PC market has created opportunities for domestic and foreign PC makers alike, the latter have seen their market shares shrink dramatically, an outcome consistent with the government's desire to avoid foreign domination of its IT sector. Among domestic PC makers, Legend has leaped well ahead of its competitors. It and other branded PCs have taken market share away from white-box clones, a trend also consistent with government objectives. Meanwhile, investment by Taiwan's PC makers has helped China become part of the global PC production network, while also increasing Taiwan's economic linkages to China.

China has become a major force in the global PC industry, as both the most attractive growth market and as a large producer. It has done so through a combination of industry promotion and entrepreneurial energy that has taken advantage of the country's unique characteristics. New challenges loom as China joins the World Trade Organization and faces more pressure to completely open its market to foreign competition. By now, however, China's PC makers are strong enough to compete on an even footing in their home market. Some may also be ready to compete in other markets as well, potentially presenting a new challenge to today's global PC leaders. ■

Acknowledgment

This research was supported by a grant from the US National Science Foundation's directorates for Computer & Information & Science Engineering, Information and Intelligent Systems, Computation and Social Systems, and the Alfred P. Sloan Foundation.

We gratefully acknowledge the editorial assistance of Margaret Vona in preparing this manuscript.

References

1. *Yearbook of World Electronic Data*, Reed Electronics Research, Oxford, UK, annual editions and electronic databases, 1991-2001.
2. J. Dedrick, and K.L. Kraemer, *Asia's Computer Challenge: Threat or Opportunity for the United States and the World?* Oxford Univ. Press, New York, 1998.
3. G.P. Goad and L. Holland, "China Joins Linux Bandwagon," *Far Eastern Economic Rev.*, 24 Feb. 2000, p. 8.
4. Q. Lu, *China's Leap into the Information Age: Innovation and Organization in the Computer Industry*, Oxford Univ. Press, Oxford, UK, 2000.
5. P. Lovelock et al., *China's Golden Projects: Reengineering the National Economy, Case 9-396-283*,

Harvard Business School, Cambridge, Mass., 1996.
6. C. Chung, translation of working paper titled "Information Technology," subsequently published as "IT Industry in China" in *Current Development of High-Tech Industries, Policy Trends, and the Evaluation of Potential Competitiveness: The Case of Mainland China*, Chung-Hua Institute for Economic Research (CIER), Taipei, June 1999.
7. Market Intelligence Center, "China's PC Vendors," *Asia IT Report*, Aug. 1999, pp. 15-24.
8. Market Intelligence Center, "The Chinese PC Industry," *Asia IT Report*, Nov. 1999, pp. 13-24.
9. Market Intelligence Center, "Taiwanese IT Investment in China," *Asia IT Report*, Aug. 1999, pp. 11-14.
10. Market Intelligence Center, "Exodus of Taiwan's IT Industry (I)," *Asia IT Report*, Jan. 2001, pp. 33-36.
11. M. Clendenin, "Mainland Fever," *Electronic Eng. Times*, 29 Jan. 2001, p. 1.
12. M. Pecht et al., *The Chinese Electronics Industry*, CRC Press, Boca Raton, Fla., 1999.

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