

# Developing and Innovating the ICT Industry

China's information and communication technology (ICT) industry influences the role of technology in the country's economy and society and affects efforts to build an information society. ICT markets contribute to gross domestic product (GDP), generate export revenues, create jobs, and produce consumer goods that meet domestic demand.

China's government has been promoting the ICT industry since the mid-1980s by supporting domestic companies and research and development (R&D) efforts. In addition, the government has provided incentives to attract foreign investment—while also requiring foreign firms to transfer technology in return for market access. Given the size and potential of China's market, many foreign firms have been willing to make this tradeoff, even under conditions they would not accept in other countries.

The Chinese ICT sector has grown rapidly. The domestic ICT market was valued at \$156 billion in 2004, up 13.2 percent over the previous year.<sup>1</sup> According to the Organisation for Economic Co-operation and Development (OECD), China led the world with \$180 billion of ICT exports in 2004, surpassing the United States.<sup>2</sup> At the same time, the Chinese ICT market is characterized by several ironies:

- Although China is a leading exporter of semiconductors, it still needs to import chips to meet local needs.
- Although Chinese firms export third-generation (3G) mobile technologies, these same technologies have yet to be commercialized in the mainland.
- Although Lenovo, China's leading personal computer (PC) firm, is the third largest in the world, there are only an estimated 65 million computers in a country with a population of over 1 billion people.

This chapter discusses four strategic ICT markets: hardware, software (including services and outsourcing), information and network security services, and digital

media—and the policies needed to develop the industry by stimulating innovation and supporting R&D.

## Hardware

China's hardware market was \$23.6 billion in 2004. Two of its strategic sectors are integrated circuit (IC) production and PC production.

### Integrated Circuit Industry

Sales revenue for the domestic IC industry has grown quickly in recent years, jumping almost 200 percent between 2000 and 2004 to reach \$6.7 billion. Such growth reflects the introduction of new products by domestic design houses and the opening of new foundries (where chips are manufactured). Strong domestic demand for semiconductors, government backing (box 4.1), and venture capital have also contributed to the rapid growth of China's IC design market. Today there are over 450 IC design firms in China (Yu 2005). Since about 90 percent of IC demand in China is met by imported chips, testing, packaging, and assembly accounts for the lion's share of industry sales (figure 4.1).

The rapid development of foundries is creating an environment where IC design firms can begin to succeed (box 4.2). Proximity to foundries lowers costs, makes it

#### Box 4.1 Government Initiatives toward the Integrated Circuit Industry

In the 1990s limited investment was identified as the primary reason for the slow growth of China's IC industry. Now the government is inviting foreign investors to fuel the industry's growth. According to Fabless Semiconductor Association, the industry received \$3.5 billion in investment between 2000 and 2002—equivalent to the total of all previous investment in the sector.

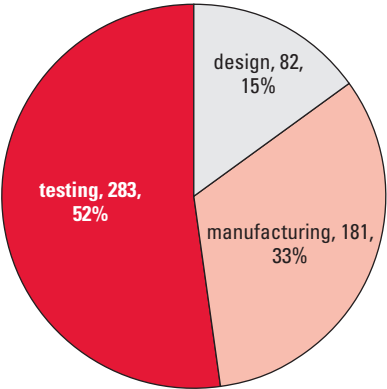
The government views semiconductors as a strategic industry and has offered extensive support to companies involved in IC design and manufacturing. Support has come from central and provincial governments and science parks.

As for promotional policies for the IC industry, the government published Document 18 (Policies for Encouraging the Development of Software and Integrated Circuit Industries) in 2000 and proposed several actions to support the industry, including publicly subsidized bank loans, government investments, tax breaks, and funding for design centers.

Central government policies are complemented by local incentives to attract IC manufacturers. Local governments often compete to attract investment. For example, Beijing offers a *Shanghai + 1* policy to add a year to any financial incentive offered by Shanghai.

Source: IFC 2005.

**Figure 4.1 Sales Revenues for China’s Integrated Circuit Industry by Segment, 2004**  
(\$ millions %)



Source: Yu 2005.

easier for design firms to put their chips in production and ultimately bring their products to market, and provides better access to technology. The Yangtze River Delta District, including Shanghai, Zhejiang, and Jiangsu provinces, has the potential to become the center of China’s IC industry. A few cities in the area form a critical mass that is likely to fuel continued growth of the industry.

**Box 4.2 The Key Factor for Developing Integrated Circuit Design Capacity**

When investors started to show interest in China’s IC industry, the general view was that design capacity was the bottleneck limiting the industry’s growth. However, in 2000 a group of industry representatives pointed to the need for foundries to attract design talent and develop a more complete value chain, including testing and packaging. It was the lack of foundries, rather than design capacity, that was impeding the industry’s development.

Following this foundry-first strategy, in April 2000 the Semiconductor Manufacturing International Corporation (SMIC) was founded by Richard Chang, former CEO of a Taiwanese chip-maker. SMIC received heavy government backing and some \$1.5 billion in initial investment. Led by SMIC, a large number of foundries have been established in China, including Grace Semiconductor in Shanghai, Huahong in Shanghai, UMC in Suzhou, and TSMC in Ningbo. The opening of SMIC’s fifth factory in 2004 was a significant breakthrough for the Chinese semiconductor industry, and China has become one of the world’s fastest-growing IC markets.

Because of the industry’s momentum, the number of IC design companies in China has also started to grow. In 2000, there were fewer than 100, and most were state-owned companies or device makers with limited design capacity. By 2005 there were over 450 design houses.

Source: IFC 2005.

Despite the industry's rapid growth, a large gap remains between demand and supply, leading to high imports. China accounted for 13 percent of global demand for semiconductors in 2003, up from 7 percent in 2000 (Chase, Pollpeter, and Mulvenon 2004), as more manufacturing in IC-intensive industries—including telecommunications, consumer electronics, and digital television—moves there. With domestic IC consumption growing at almost twice global rates, demand is growing much faster than production capacity. As a result, 90 percent of domestic demand is met by imports; despite the growing number of foundries (see box 4.2), imports are expanding rapidly. In 2004 China imported \$55 billion of semiconductors.

The IC design market remains small and at an early stage of development. About 90 percent of the design firms formed in recent years have fewer than 150 employees and 50 design engineers. Many companies with the strongest R&D capability are still developing their first products and have yet to generate revenue. According to CEInet (2004), 90 percent of the chips manufactured in China are exported. A large share of these exported chips end up being re-imported after processing. This means that foreign companies add value to chips produced domestically for consumption ultimately in China, highlighting China's position at the low end of the IC industry value chain.

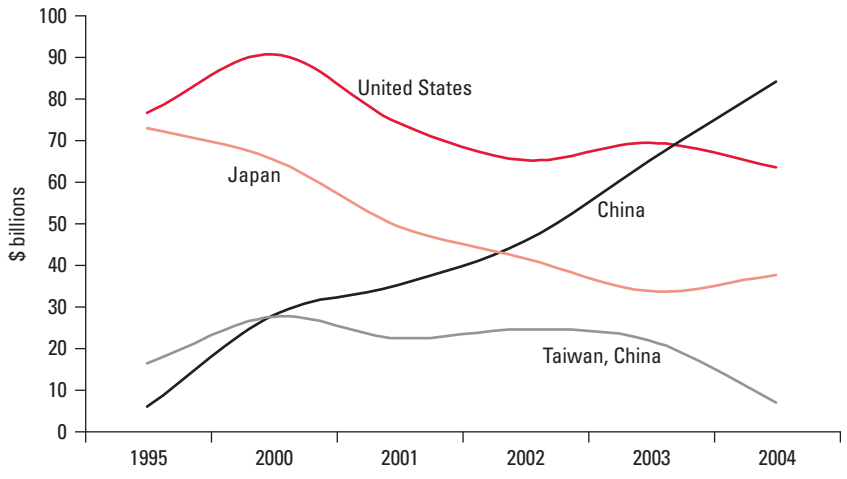
Furthermore, many top Chinese IC companies focus on low-end applications, particularly smart cards. IC cards have been the low-hanging fruit for Chinese IC design firms for several reasons. First, less design capacity is required to produce a basic IC card, so companies without much in-house R&D capacity can still compete. Second, the Chinese government and major state-owned companies are significant purchasers of IC cards, and in some cases, foreign companies are excluded from bidding on the design work for sensitive government projects. As a result, domestic companies are able to win this less-competitive business. However, margins for basic IC cards are limited, so even a substantial IC card business may not generate enough revenues to fund the development of more advanced products. As a result, some of China's early IC design leaders may find it difficult to climb up the value chain.

### **Personal Computer Industry**

China's computer industry has grown at an extraordinary pace over the past decade. Hardware production jumped from \$6 billion in 1995 to \$84 billion in 2004, positioning China as the world's largest computer manufacturer in 2004 (figure 4.2).

Most hardware is produced by multinational computer makers—especially those from Taiwan (China). Taiwan's computer makers began moving component production offshore in the early 1990s in response to rising land and labor costs. Taiwanese companies have established large electronics industry clusters in Guangdong province, the Yangtze River Delta, and the Shanghai and Suzhou areas. After restrictions on doing final assembly in China were lifted in 2001, many original design manufacturers from Taiwan moved to the mainland en masse. Production includes manufacturing for desktop and portable PCs, monitors, motherboards, keyboards, cables, and connectors.

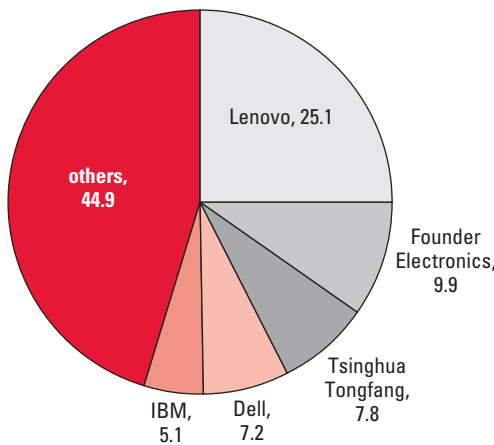
**Figure 4.2 Top Global Producers of Computer Hardware, 1995 and 2000–04**



Source: Reed Electronics Research 2004.

Local firms dominate China’s domestic PC market—especially Lenovo, which in 2004 held a quarter of market share, more than twice that of its nearest competitor (figure 4.3)—and the respective shares of foreign firms such as IBM, Dell, and Hewlett-Packard are decreasing. China’s top three PC makers all have their roots in academia. Lenovo, founded in 1984 with funding by the Chinese Academy of Sciences, purchased IBM’s personal computing division in late 2004 (box 4.3) and is now the top PC vendor in Asia and the Pacific (excluding Japan). China’s second largest computer vendor, Founder Electronics, was formed in 1986 through an investment from Peking University. Tsinghua Tongfang, the third largest domestic

**Figure 4.3 Market Shares of the Top Six Personal Computer Firms in China, 2004 (percent)**



Source: IDG 2005.

**Box 4.3** **Lenovo's Purchase of IBM**

Domestic computer manufacturers have increasingly global ambitions for their business. Lenovo Group Limited, China's top computer maker, bought IBM's personal computing business in December 2004 for \$1.75 billion. This makes Lenovo the third largest PC maker in the world (after Dell and Hewlett-Packard) with shipments of 15 million PCs in 2005. The purchase gives Lenovo the opportunity it has always craved to expand beyond China.

Lenovo, founded by Liu Chuanzhi and 10 colleagues with funding by the Chinese Academy of Sciences, began as a distributor of IT products, launched its first PC in 1990, and has led the domestic PC market in China for seven years. Lenovo's success, like that of other large Chinese companies, has been based on the country's vast labor resources and low production costs. However, Lenovo has traditionally carried out little independent R&D and mostly manufactured low-end systems. While this model worked well for the domestic market, where Lenovo has strong ties to the government, its integration of IBM's PC unit will be a challenge in its quest to globalize. As a result of the IBM acquisition, Lenovo now generates more revenue from overseas than China.

*Sources: The Times 2004; Xinhua Financial Network News 2004.*

computer firm and the youngest, launched an initial public offering on the Shanghai Stock Exchange in 1997 with Tsinghua University as the main shareholder.

The PC industry has followed the pattern of other technology markets in China. Foreign firms dominated the market until domestic companies became competitive, at which point foreign firms abandoned the low-end market and tried to shift into higher-value products. Although foreign firms have fared well in the server market, China Langchao is the market leader, and Lenovo is targeting the market.

A major challenge for China's computer industry will be to expand beyond production of PCs for the domestic market and low-value peripherals and components for the global market. Given the country's strong technical skills and ability to attract foreign investment and technology, it has a reasonable chance of meeting this challenge. Lenovo is moving into software, Internet services, and information appliances; other hardware makers are expanding their scope as well.

## Software

Software is a key pillar of China's information technology (IT) industry. Both the central and the local governments (such as Beijing and Shanghai) are promoting the industry by facilitating funding for software startups and incubators. For example, Chinese software companies do not have to pay taxes during their first two years of operation and receive a 50 percent tax break in the third and fourth years. The industry also benefits from simplified administrative procedures and relatively fast

**Table 4.1 Chinese Software Parks**

Park	Features
Dalian Software Park	<ul style="list-style-type: none"> <li>• Establishment in 1998 by the Dalian city government</li> <li>• Most tenants are multinational corporations from Japan and the Republic of Korea, as well as local companies</li> </ul>
Shanghai Pudong Software Park	<ul style="list-style-type: none"> <li>• Operations began in 1998</li> <li>• Joint investment by China Electronic Corporation and Zhangjiang Hi-Tech Park Development Corporation</li> </ul>
Beijing Zhongguancun Science Park	<ul style="list-style-type: none"> <li>• First state-level high-tech development zone, approved by the State Council in 1998</li> <li>• Largest software development and production center in China, consisting of five science zones</li> </ul>
Guangzhou Software Park	<ul style="list-style-type: none"> <li>• Establishment in 1999 as the software industry base of the National Torch Plan</li> </ul>

Source: IFC 2005.

approval of foreign investment. In addition, preferential treatment is given to research facilities that successfully commercialize their research, and local governments have provided financial support for the construction of software parks (table 4.1).

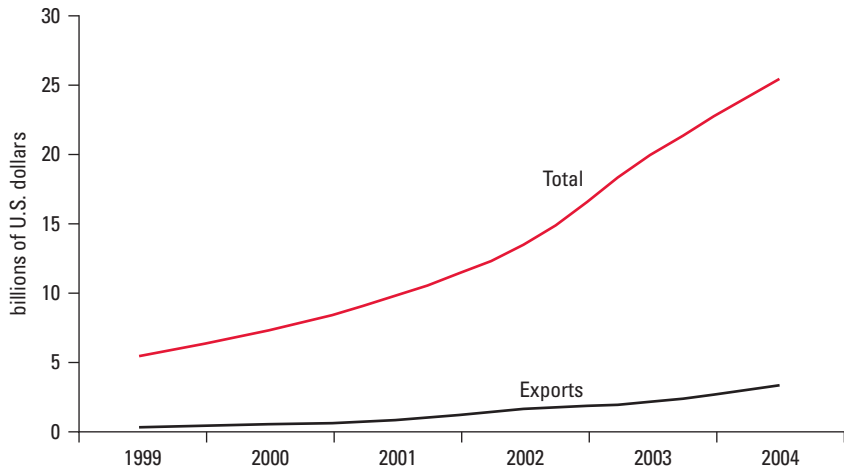
In addition, several aspects of the Chinese economy lend themselves to the software industry’s growth, such as the manufacturing sector (which uses software in computer and telecommunications equipment) and widespread use of consumer electronics products and automated machinery, all of which require software bundling. The country’s 20 million small and medium-size enterprises provide a substantial business-user base for software products.

China’s software industry has grown rapidly in recent years, reaching \$25.3 billion in 2004, according to the Software Industry Association’s forecast—nearly 30 percent more than in 2003 (figure 4.4). Software products accounted for 51 percent of revenue, system integration for 33 percent, and software and IT services for 16 percent. Software exports, including software outsourcing, are estimated to have totaled \$3.2 billion in 2004, accounting for just 1–2 percent of IT industry exports.<sup>3</sup> This reflects China’s comparative strength in IT manufacturing and weakness in software.

By the end of 2005 there were 8,000 software companies registered in China (*McKinsey Quarterly* 2005). Most of these companies are private, foreign, and located in Beijing, Guangdong, Zhejiang, and Shanghai. Although many firms have attracted investment from foreign software companies, efforts are generally limited to product localization and customer services. Most domestic software companies are small, and few have developed commercially successful packages. Large players in the market include China National Computer Software and Technology Service Corporation (CS&S), Shenyang NeuSoft, UF Soft, Kingdee, and ZTE Software Co., Ltd.

**Features**

Three features of China’s software industry are notable: its output, which focuses on products; regional dispersion; and lack of pure-play outsourcers (those with more

**Figure 4.4 China's Software Market, 1999–2004**

Source: IFC 2005.

than 90 percent of revenues from outsourcing):

- *Focus on products.* Many software firms with strong capabilities and business models have a product orientation, leaving the IT services market underdeveloped. Unlike Europe and the United States—where companies such as IBM Global Services, EDS, Accenture, and Cap Gemini offer a wide range of consulting and systems integration services—China has a limited range of providers of IT services. There are several reasons. First, the government restricts foreign companies from offering many of their services in China. Second, Chinese companies are often reluctant to pay for IT services. Third, China's overall economic reforms have focused on agriculture and manufacturing, rather than services.
- *Regional dispersion.* Regions with extensive high-technology infrastructure have more software firms. Among the country's 25 software districts, the top seven (in terms of sales)—Guangdong, Shanghai, Liaoning, Shaanxi, Jiangsu, Shenzhen (where Huawei is headquartered), and Shandong—account for a large portion of companies, workers, and sales (excluding Beijing, which has many firms). Still, software activity is widely dispersed throughout the nation. Although some cities, such as Chengdu (Sichuan province), do not have many software firms, they have at least one that is large and well-known.
- *Lack of pure-play outsourcers.* The Chinese software-outsourcing industry is highly fragmented and lacks large players dedicated to outsourcing. Instead, the largest Chinese software firms engage in a wide variety of businesses besides software outsourcing—notably big-name companies that have recently diversified from product-oriented software development, such as UFSOFT and

Kingdee. Less-known, medium-size pure-play outsourcers in China have yet to achieve scale. DHC, one of the country's largest pure-play software outsourcing firms, has only 1,700 employees and \$33 million in revenues. By contrast, India's top software services firm employs 695,000 people and had revenues of more than \$17.3 billion in 2005, with more than 90 percent of resources devoted to outsourcing (Farrell, Kaka, and Stürze 2005). The Chinese software industry is undergoing consolidation with the expectation that the resulting larger firms will be able to better compete with at least second-level Indian outsourcers.

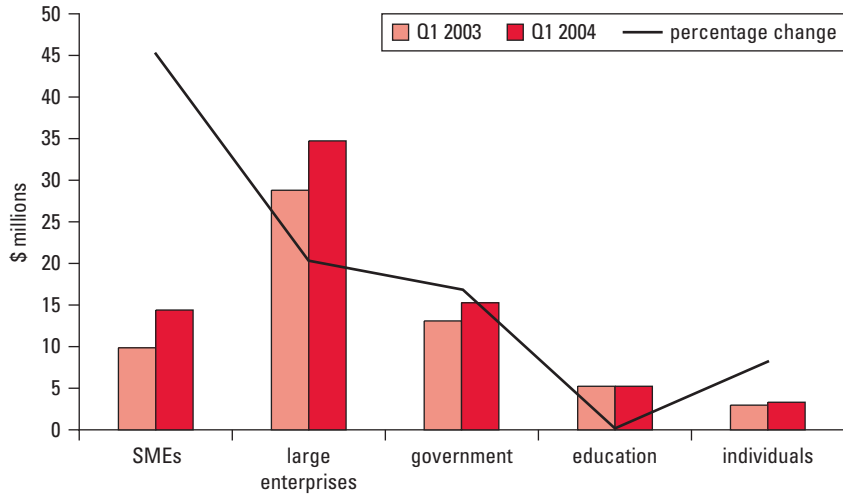
Chinese IT service firms face extensive piracy and intellectual property rights challenges. Although the government has enacted tough anti-piracy laws and conducted publicized crackdowns, piracy rates remain high. About 92 percent of software in China is pirated (IDC/BSA 2003), giving firms little incentive to invest significant R&D resources in the creation of new products. This is a serious concern for China's software vendors and a major barrier to the development of a packaged software industry.

China aims to develop an IT services industry, like India's, that works for foreign firms. In fact, it has attracted a few Indian IT companies to help build its market. However, many Chinese companies lack English language skills, undermining the value of the country's large engineering workforce. In addition, Chinese firms have little or no experience in U.S. or other foreign markets and so have not worked with clients on the front end, writing business process requirements and doing systems architecture and design. The country must develop the long-term human capital required to expand these industries.

Thus China will remain a low-cost location for coding and maintenance and is unlikely to create a software industry that can rival Indian giants for some time. Recently, foreign companies moving their software development operations to China have become a key driver in China's outsourcing market. Whether such development centers are performing software outsourcing in the traditional sense is debatable, since their main customers may be their corporate parents in their home markets rather than third-party customers. Still, such centers create new software export markets and make China a major link in the global software value chain. Expertise developed at these centers will ultimately diffuse into the Chinese market, improving the technical capabilities of domestic software outsourcing firms, which foreign companies may make greater use of in the future.

## Information and Network Security Services

Expanding Internet access, as well as escalating network and computer security attacks, are driving demand for information and network security services in China. According to the first survey of information network security, organized by the Ministry of Public Security and the China Computer Association and conducted by

**Figure 4.5 Network Security Revenue in China's Vertical Markets, Q1 2003–Q2 2004**

Source: IFC 2005.

a. SME = small and medium-size enterprise.

CRC-Pinnacle Consulting in 2003, 73 percent of organizations reported having information network security issues. About 79 percent of incidents involved computer viruses or worms. In addition, 36 percent of users reported problems with spam, and 43 percent reported unauthorized changes to Web pages. In 2003, the information security market reached \$200 million, and by 2007 it is expected to grow to \$670 million. The heavily regulated market for government and the more open corporate market are the two biggest markets for information and network security services (figure 4.5).

Although the government does not invest as much in security as large enterprises do—accounting for about 20 percent of the market—government-backed projects have been a key driver of growth for domestic security firms (box 4.4). For national security reasons, China's government relies exclusively on domestic providers of information and network security products. Moreover, a 2003 government procurement law requires investment plans to receive central government approval. The government has been able to use the approval process to ensure that sensitive security projects are handled by domestic vendors.

Large enterprises lead in IT system implementation in China. A 2003 survey by the State Asset Management Commission and China Computerworld Media Group found that 3,000 large enterprises accounted for 21 percent of national IT investments. As IT systems become more complex and critical to businesses, security has become a key issue. Large enterprises have invested in security measures more actively because of their large overall investments in IT. The telecommunications and finance industries lead investments in network security. Since these industries are mostly state-owned, the government encourages them to use domestic security products.

**Box 4.4** Leading Domestic Security Firms

Aided by favorable government policies, Chinese network security firms have made great strides in catching up with foreign firms in terms of technology, services, and marketing. Measured by revenue, five of the country's top 10 network security product vendors were domestic firms in 2004.

TopSec, the leading Chinese network security firm, has received support from the national and Beijing governments and expanded its business rapidly. In 1999 TopSec's Net Guard firewall system became the first such product recommended by the State Security Bureau. Later that year, the Net Guard line of information security software was also included in a list promoted by the government. In addition, Chinese firms have had success with antivirus software, particularly in the consumer market. Rising Technology, Jiangming, and Kingsoft's consumer antivirus products are widely used domestically. Venus Info Tech's flagship product, Cybervision Intrusion Detection and Management System, is a top brand in China's network security market.

Domestic antivirus companies are now developing more advanced products and offering online services. Rising Technology hopes to capture half of the domestic consumer market in a few years, and Kingsoft is aiming for the enterprise antivirus market, investing \$1.2 million to develop a proprietary product. Over the long term, domestic companies are more likely to succeed if they have strong technology capacity, continue to invest in security-related R&D, and expand beyond government clients.

*Source:* IFC 2005.

Small and medium-size enterprises (SMEs) are behind in use of network security systems. While foreign enterprises spend 4 percent to 5 percent of their IT budgets on security, most Chinese companies spend less than 2 percent. As the Chinese private sector increasingly adopts internal IT management systems, uses e-mail, and establishes Web sites (see chapter 7), it will likely recognize the importance of network security software (such as antivirus and firewall protection) and reach global norms for investment in security products. The Chinese government is urging SMEs to deploy network protection products amid concern that poorly protected IT systems can be a national security issue. The government has begun inspections to confirm whether companies have implemented security software.

The government's growing concern about information and network security is also reflected in other initiatives. The National Computer Network Emergency Response Technical Team and Coordination Center was established in 2000, and an Internet emergency system was established in 2003. An emergency response system for public computer networks has been developed, and a network security monitoring platform focused on international Internet ports has been constructed. Attempts have also been made to manage e-mail security and control spam.

The Chinese government has also implemented controls on the research, manufacturing, and marketing of security-related products through several certificate

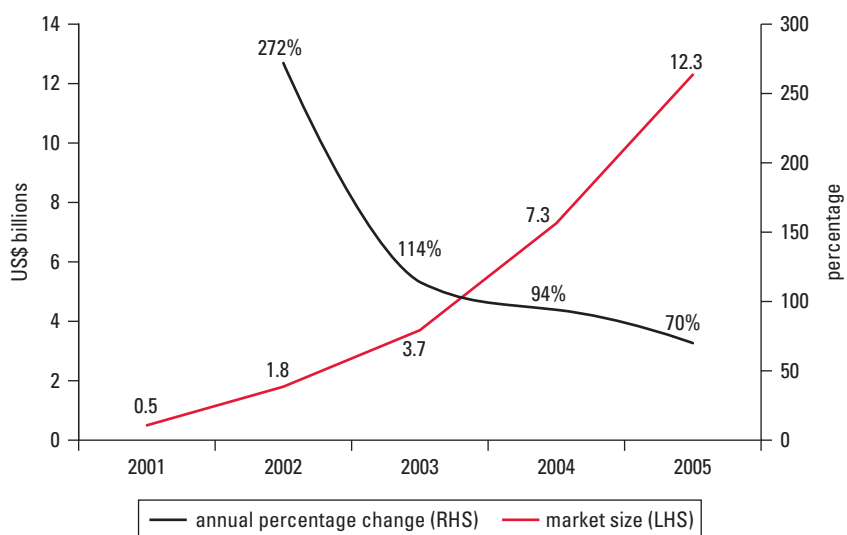
approval processes. All such products sold in China must first be certified by the Computer Information Network Security and Product Quality Supervision Center of the Ministry of Public Security. A certificate for information security products from the Information Technology Security Certification Center is also necessary for products sold in the commercial market. For products of intelligence information systems, manufacturers must receive evaluation and certification from the state secrecy authorities. Encryption products must meet required government regulations.

## Digital Media

The development of digital media has resulted from the growing integration of IT and traditional content industries. Digital media can be wireless or online—including text messages, games, animation, advertising, learning materials, and other applications—as well as Internet Protocol–based television and radio. Digital media has become a large service market in a short period. Between 2001 and 2005, China's digital media market jumped from \$0.5 billion to more than \$12 billion (figure 4.6). The industry is expected to maintain high growth over the next 5–10 years and then gradually enter a period of maturity.

Some segments of the digital media industry have grown especially fast. Mobile messaging services—that is, Short Message Service (SMS) and Multimedia Messaging Service (MMS)—attracted more than 240 million mobile telephone users in 2005, up 49 percent from 2004. Markets for Internet games, online advertising, fee-based e-mail services, and search engines have also grown rapidly. The government has

**Figure 4.6 Size and Growth of China's Digital Media Industry, 2001–05**



Source: IFC 2005.

Note: LHS = left-hand side; RHS = right-hand side

formulated a series of policy measures to encourage and support the development of the digital media industry.

### **Mobile Data Services**

The market for mobile data services opened when China Mobile launched Monternet, its wireless value-added service platform, in 2001. Under this platform, service providers offer content and services (such as ring tones, pictures, and news) to mobile subscribers, and China Mobile collects fees on behalf of the providers through its billing system.<sup>4</sup> Service providers pay China Mobile 15 percent of the revenues collected. China Mobile had agreements with over 1,000 service providers at the end of 2004. China Unicom has launched a similar platform, Uni-Info, with a sharing rate ranging from 10/90 to 40/60 depending on the service provider's scale and performance.

SMS is the most popular wireless data service in China. According to the two mobile operators, SMS traffic totaled 1 billion messages in 2000; this number jumped to 220 billion in 2004. All handsets are now SMS enabled, and more than 70 percent of mobile subscribers use it.

Steady growth in the number of mobile data users and applications has made the mobile telephone an extremely popular form of communication and a new type of media in China. As with other media, the government is enforcing strict management. To ensure that only legal mobile data services are offered, the Ministry of Information Industry (MII) (which regulates the wireless sector) issued in 2004 rules regulating the SMS market. The new regulations require operators and service providers to offer a convenient system for unsubscribing from services, preventing users from being charged for unwanted content. The MII's tightening controls over wireless content will have a mixed impact on the market. Transparent regulations will help wash out unwanted or illegal content from the wireless market, providing a fairer playing field for service providers and promoting greater user confidence. However, stricter controls have also led to lower valuations and reduced investor confidence.

While thus far most mobile content has been focused on text-based platforms, 2.5 and 3G networks offer support for more sophisticated high-speed content. The development of SMS-based content and delays in the introduction of 3G mobile networks have limited China's creation of advanced mobile content. However, given the looming introduction of 3G mobile in the country and the large number of mobile subscribers, advanced mobile content could become a significant industry.

### **Digital Broadcasting**

A number of developments are transforming conventional television broadcasting. Television broadcasting is moving from analog to digital, and new methods are emerging to deliver broadcasting over the Internet and to mobile telephones.

China's digital TV industry is at an early stage, with less than 1 percent of the country's 120 million cable subscribers accessing digital programs. Moreover, a number of pioneering city-level cable operators—including those in Shanghai,

Chengdu, Guangzhou, and Suzhou—report that growth in digital television subscribers has slowed. As a result, operators are now subsidizing set-top boxes to attract new subscribers. Cable networks are also extremely fragmented, which is likely to delay growth. The State Administration of Radio, Film, and Television (SARFT) has tried to integrate city networks within provinces, but progress has been slow.

Telecommunications operators are looking to leverage their large investment in broadband networks by offering broadcast services using Internet Protocol television (IPTV). China Telecom and China Netcom have launched trial services with approximately half a million users at the end of 2005. IPTV faces several bottlenecks including regulatory uncertainty, limited bandwidth, and relatively high costs. SARFT has stated that only broadcast companies can provide IPTV, with the result that the telecommunication companies must collaborate with media companies to provide service. Bandwidth on the operator's broadband asymmetric digital subscriber line (ADSL) networks will need to be increased to provide nationwide IPTV service. The service is also currently significantly more expensive than digital cable television.

Despite a variety of competing standards,<sup>5</sup> a number of mobile operators around the world have launched mobile television services. With the large number of television and mobile users, these services could develop into an attractive market for China. One factor that may help drive the mobile television market is the 2008 Olympics, which will be staged in China.

### Online Games

China's online gaming market has grown strongly in recent years. Its revenues exceeded the country's movie ticket sales in 2003. In 2004 the market size reached \$300 million, according to statistics from the General Administration of Press and Publication. It is expected to be a \$1 billion industry by 2008. An online game connects multiple players (sometimes thousands) at the same time. China's online gaming market is being driven by growing Internet and broadband penetration, the increasing availability of PCs and Internet cafes, and low game fees. The development of prepaid card distribution channels by leading online gaming companies allows payment flexibility.

To reduce their reliance on licensed games—about two-thirds of the titles in commercial operation are licensed from foreign companies, mainly in Japan and the Republic of Korea—and avoid sharing revenue with game developers, many Chinese game operators are investing in in-house R&D capacity to shift the market toward domestically developed content. Although domestic game output is increasing, it remains weak relative to leading foreign markets because the development of core technologies (such as network and graphic game engines) has been slow in China. To bring proprietary games to market more quickly, some domestic companies are seeking to partner with or acquire design houses and development teams.

A talent shortage has also slowed the growth of online gaming companies. Experienced game developers, especially project managers, are rare in China. Moreover, available talent is concentrated in a few top companies—more than half of the

estimated 2,300 game developers in China work for one of the four biggest gaming companies (TQDigital, Shanda, Kingsoft, and Netease). Most leading companies have R&D teams of fewer than 50 people. Weak R&D and shortages of developers will continue to hinder domestic game development.

The government's policies on online gaming are sometimes contradictory, promoting the industry's development while asserting restrictive regulations. This is partially due to the potential negative impact of digital media. Tough regulations have been implemented to punish companies for publishing "inappropriate" content. For example, in September 2004 the Ministry of Culture banned the operation of six online games because of "unhealthy" content. The environment is also complicated by rivalries between the main regulatory bodies over the online game industry. In October 2004 the Ministry of Culture made a formal announcement reemphasizing its authority over the industry. Earlier regulatory announcements had been made by the General Administration of Press and Publication. This situation may continue for some time.

## Strategies for Stimulating Innovation and Growth

The demand from China's large domestic market and foreign export markets offers huge opportunities for its ICT industry. Innovation and R&D capacities are critical for the industry to attract investment, maintain high growth, and become globally competitive. China must address the barriers to more effective innovation by introducing regulatory and policy reforms, encouraging collaboration, and increasing government support. It needs a robust national innovation system that includes the following:

- domestic and foreign enterprises that serve as the backbone of technology development, and that are likely to invest in the development and commercialization of new technologies
- research institutes that serve as engines for innovation
- government agencies that can provide strategic direction and create an environment that fosters innovation, including funding and other support measures
- capital markets and venture capital that can provide investment and support for new technology development.

## Removing Regulatory Obstacles to New Technologies

The government has an important role in facilitating an environment that incubates a virtuous cycle of innovations in products, processes, and practices. This includes ensuring that the legal framework protects intellectual property rights and relaxing restrictions that may inhibit innovation.

Eliminating entry barriers and allowing more foreign direct investment and joint ventures in the ICT market are fundamental to stimulating domestic innovations. Foreign investment not only supports the technical performance of firms in

the short term; it also diffuses advanced technologies to the local economy in the long run.

### **Organizing R&D around Strategic Technologies**

China's R&D capacity must progress much further if the country is to achieve innovations in ICT. China has adopted, absorbed, and used foreign innovations for many years. As a result, it has rapidly developed expertise in manufacturing and become a major producer of ICT products and applications. However, domestic ICT industries rely significantly on foreign technologies, particularly for fundamental technologies. Without greater research in such core technologies, China will continue to lag in the ability to contribute to the development of global technological standards and in the ability to develop its own key intellectual property. Increased R&D and innovation will give China more control over the evolution of its ICT industry, allowing it to respond more rapidly to the dynamic pace of technological flow.

China must also establish strategic directions around technologies critical to its industrial development and future competitiveness. For example, the Republic of Korea invested about \$630 million in TDX (Time Division eXchange) telephone switches, light transmission systems, Code Division Multiple Access (CDMA) mobile technology, and DRAM (Dynamic Random Access Memory) chips. Years later, the market value created was about \$140 billion, or 220 times initial R&D investments (MIC 2002).

To make best use of its resources and competencies, China should focus R&D efforts on core technologies—products and services that have been identified as important for informatization, necessitate extensive customization, or are unique to the Chinese market or where it has strategic advantages. These include areas such as integrated circuits, network security software, telecommunications equipment, and mobile data applications.

### **Improving Academic and Business Collaboration**

China needs to further integrate enterprises, universities, and scientific research institutes to connect skills development and R&D with industrial development, so that technologies can be turned into practical and relevant applications. Industry-university collaboration brings benefits for both: enterprises can provide universities and research institutes with additional funding for targeted research, while the latter have a pool of highly skilled human resources from which to draw. TRILabs in Canada, for instance, is a leading example of multipartner collaboration (box 4.5).

The government should increase financial incentives for academic and business collaboration. This could include outright funding support, as well as tax holidays and interest subsidies for loans. The measures could create incentives for the dissemination of technology, while contributing to the funding of universities and research institutes.

**Box 4.5** TRILabs—An Industry-Led ICT R&D Consortium

TRLabs, a not-for-profit organization, is Canada's largest ICT R&D consortium and one of the most industry-invested R&D vehicles. Its partners include 11 large telecommunications equipment manufacturers and telephone carriers, 34 small and medium-size enterprises, 4 government agencies, and 5 universities. The organization employs 260 researchers, professionals seconded from industry, professors, and students. It drives the competitiveness of western Canada's ICT industry with the supply of brain power and innovative technologies, while balancing the expectations of its three legs—industry, government, and universities.

Through collaboration in research, development, testing, and applications of ICT, the consortium collectively shares the risks of exploring ICT's new horizons but reaps a much greater reward of ideas, new technologies, and highly qualified people. Since its establishment in 1986, it has created 7 companies and had 74 patents issued, with 78 pending. About 30 percent of the 992 technologies developed at TRILabs have been commercialized by industry. In addition, 50 percent of over 800 TRILab student graduates accept employment with its members and apply their practical skills to support the industry.

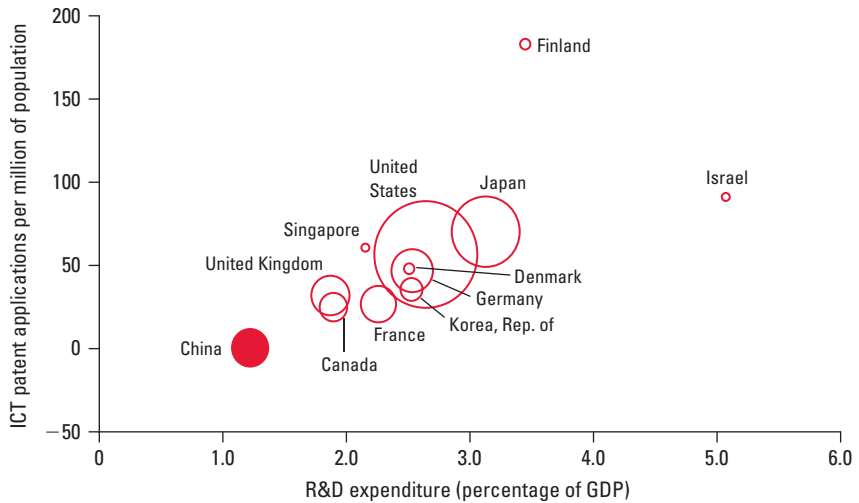
*Source:* TRILabs 2006.

**Stimulating Investment in R&D**

Both government investment and private enterprise R&D investment remain insufficient. China's overall R&D efforts amounted to about 1.2 percent of GDP, much less than in advanced countries (see figure 4.7). On ICT specifically, over the past five years the Ministry of Science and Technology (MOST) invested \$400 million in ICT R&D, and the MII provided an additional \$60 million in research funds each year. In 2002 R&D investment among Chinese ICT-related firms was 2.4 percent of revenues. OECD firms involved in IT and communications, by comparison, invested 9 percent to 10 percent on R&D.

These amounts are relatively small given China's size. As a result, the number of patents granted internationally to Chinese residents remains remarkably low. The U.S. Patent and Trademark Office granted 1,700 patents to Chinese residents in 2004 compared with 3,554 to the Republic of Korea and 20,173 to Japan (see figure 4.7). Chinese firms must still license many of the core technologies developed and owned by foreign enterprises. Securing additional private investment, including new mechanisms such as capital markets and risk investment, will help increase China's capacity to innovate. In addition, given the success of industry clusters, local governments should increase investment in promoting sector development.

Clear incentives are needed to promote innovations and deploy new technologies. Appropriate tax incentives can stimulate R&D. China could draw on successful tax schemes used elsewhere. Some national tax schemes offer a complete write-off of R&D expenditures made during the year. Others provide this only for expenditures

**Figure 4.7 R&D Spending and ICT Patent Applications in Selected Countries, 2004**

Source: World Bank staff analysis based on World Bank (2006c) and WIPO (2005).

Note: Circles reflect relative size of GDP.

exceeding those of the previous year. Some defer tax payments until enterprises show a profit, an arrangement particularly convenient for startup firms (OECD 1999).

### Aligning Standard Development with International Practice

In recent years China has begun to experiment with creating national standards for ICT products. However, relatively few domestic standards or patents have had global success. In 2004 China's ICT-related patents represented just 0.5 percent of the world total.

Despite its large size, China has yet to have a significant impact in international standards bodies. In recent years the International Telecommunication Union (ITU) has reviewed some 4,000 technologies. Of these, just a few Chinese technologies—such as time division-synchronous code division multiple access (TD-SCDMA) and Multi-Service Ring—have been approved by the ITU. Moreover, China has had little input into the Internet Engineering Task Force, and it made no significant contribution to Internet Society image coding standards or to standards set by the Institute of Electrical and Electronic Engineers.

The approval of a standard must also be linked with a commercial strategy to achieve success. In the case of TD-SCDMA, a 3G mobile technology, it has yet to be commercially launched in China or anywhere else. On the other hand, 3G technologies such as wideband-code division multiple access (W-CDMA) and CDMA2000 have been in operation for over half a decade and have a large head start on TD-SCDMA. It is of little use to get acceptance for a standard if the technology resulting from it is not quickly commercialized.

Some of the Chinese government's proposed standards have attracted international attention but have been opposed by foreign firms and governments. For example, in 2003 the Chinese government claimed that the global Wireless Local Area Network (WLAN) 802.11 standard had security shortcomings and announced that it would establish its own standard, called WAPI (WLAN Authentication and Privacy Infrastructure). To sell in China, foreign companies would have to comply with the WAPI standard and work with licensed Chinese partners, giving them access to detailed product blueprints. Intel (a leading U.S.-based IC manufacturer) balked at this demand and said that it would not manufacture its wireless Centrino chips for notebook PCs under such conditions. The U.S. government became involved, and after eight months, the Chinese government indefinitely postponed (but did not revoke) the WAPI regulations.

Government efforts to develop domestic standards could have a serious impact on Chinese firms—giving them an advantage in the domestic market but making it more difficult for them to be successful in foreign ones if they have to develop different export products based on global standards. As noted earlier, domestic standards could discourage international IT firms from investing in China. A better strategy for China would be to use its large and growing market to influence global standards in ways favorable to its firms. For instance, it could encourage the adoption of open versus proprietary standards to reduce royalty burdens on its domestic companies and allow them to develop technological expertise within open technology platforms. It could also promote the use of innovative IT applications that fit domestic needs, encouraging technology vendors to use China as a test market for new standards.

The ICT market is very dynamic, moves quickly, and is truly internationally integrated. China should be cautious about too strong an involvement in driving the selection of technologies that would be inconsistent with globally adopted standards. This will require patience and maturity to continue to work in and through the international standards bodies to get their technologies recognized and resist the temptation to go independent routes. When it comes to standards, strategic engagement is likely to be more successful than isolationism.

### **Improving Links between Production and Demand**

China faces the paradoxical situation of being a leading global hi-technology equipment exporter but not meeting its own domestic ICT needs. Despite its large IC industry, China still imports a substantial amount to meet domestic demand. Lenovo has emerged as the third largest PC producer in the world, yet only around a fifth of Chinese households have computers. Companies such as Huawei and ZTE have emerged as leading global telecommunications equipment exporters and have sold the latest mobile technology to over a dozen developing and developed nations. Yet China has lagged in introducing 3G mobile networks.

The Chinese government should work with local ICT firms to leverage its significant equipment industry to fulfill domestic needs. For example, it could provide

incentives to local computer manufacturers to develop low-cost PCs to increase penetration among lower income households. This could have tremendous export potential since many developing countries face the same challenge of being unable to afford ICT products. The large Chinese market means that producers can achieve significant economies of scale with consequent lower prices. The government should also move more quickly to remove obstacles to the rapid launch of new technological products and services into the Chinese market. This would allow leading-edge technologies to be implemented soon after standards approval, giving China a head start over other countries. Implementation of these measures would produce substantial benefits, enhance sales, and establish China as a showcase for new technology.

## Notes

1. People's Daily Online. [http://english.people.com.cn/200503/23/print20050323\\_177881.html](http://english.people.com.cn/200503/23/print20050323_177881.html).
2. See <http://www.oecd.org/document>.
3. Japan accounts for 61 percent of Chinese software exports, followed by the United States.
4. This has helped spawn a mobile data software industry lead by companies such as Sina, Tom Online, Sohu, Netease, and Tencent.
5. Competing technologies include Digital Multimedia Broadcast, Digital Video Broadcast-Handheld, and MediaFLO, a proprietary technology developed by QUALCOMM.