TRENDS IN CHINA'S TRANSITION TOWARD A KNOWLEDGE ECONOMY

Ernest J. Wilson III and Adam Segal

Abstract

This essay identifies critical trends in the evolution of information technology sectors in China. Chinese policymakers will have to make decisions in four areas that will shape the knowledge economy and may help transform China from being a technology market taker to a market maker.

During the past decade, China has arguably placed more importance on reforming and modernizing its information and communication technology (ICT) sector than any other developing country in the world. Under former Premier Zhu Rongji, the Chinese leadership was strongly committed to making ICT central to its national goals—from transforming Chinese society at home to pursuing its ambitions as a world economic and political power. In one of his final speeches, delivered at the first session of the 10th National People's Congress in 2003, Zhu implored his successors to "energetically promote information technology (IT) applications and use IT to propel and accelerate industrialization" so that the Chinese Communist Party (CCP) can continue to build a "well-off society."[1]

The current leadership under President Hu Jintao and Premier Wen Jiabao continues to devote massive material and political resources to what it terms *xinxihua* "informatization" (the application of modern ICT tools to other economic sectors) as a key strategic element for advancing the twin goals to

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1. "Chinese Premier's Government Work Report 1997–2002—Official Version," BBC Monitoring International Reports, March 20, 2003.

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which the CCP is committed: the measured transition from a communist to a market economy and, more reluctantly, the continued shift of the CCP from a revolutionary to a ruling party.

This essay identifies critical trends in the evolution of the Internet and other information and communication technology sectors in the People's Republic of China. Within the next one to two years, China's leadership under Hu Jintao will have to make several important policy decisions that will shape domestic and possibly global ICT performance and will affect a variety of other key matters like economic efficiency, growth rates, international competitiveness, and patterns of political participation for many years to come.

These critical decisions fall within four areas; within each area Beijing must find an economically efficient and politically tenable equilibrium that also accelerates technological innovation. Chinese policy makers must find optimal balances between domestic hardware and software production; domestic and export markets; centralization and decentralization; and top down, state-directed industrial policy and more indirect "innovation strategy." Together these new balances may help transform China from being a technology market *taker* to a market *maker*.

Extent and Significance of the ICT Sector

Although there are significant questions about how data on technology in China are measured and collected, a few statistics give a sense of the remarkable size and direction of change in Chinese ICT sectors. China's Ministry of Information Industries (MII) predicts that the ICT industry will continue to grow more or less as it has, at about 20% annually, or around three times the growth rate of gross domestic product (GDP). The China Center for Information Industry Development (CCIID) estimates that China's personal computer (PC) industry will grow 11.5% in market sales annually from 2004 to 2010.[2] CCIID estimates that China's PC industry will reach a value of US$25 billion by 2010.[3]

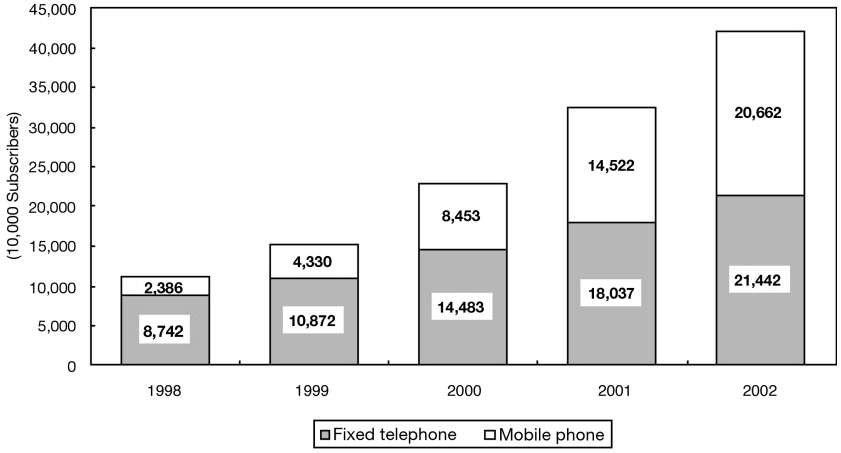
From 2001–04, China added 322 million new telephone subscribers, one-quarter the Asia-Pacific regional total, with a compound annual growth rate of 23%. China's total number of telephone subscribers exceeded 645 million in 2004; on average, nine million new subscribers are added every month. No other country has gained so many telephone subscribers in so brief a period. China now ranks first in the size of its mobile telephone market (330 million in 2004) and first in fixed lines (312 million).[4] MII expects that fixed lines will

2. "China to Surpass Japan in Market Size in Value Terms for Cellular Terminals in 2005, PC in 2006," June 14, 2005, Nomura Research Institute <http://www.nri.co.jp>.

3. "Briefing—Asia Information Technology," *Asia Pulse*, April 2, 2003.

4. "Asia-Pacific Telecommunication Indicators 2002," *International Telecommunications Union*, November 2002, <http://www.itu.int>.

FIGURE 1 *Fixed-line v. Mobile*



SOURCE: Post and Telecommunication Services 2003, National Bureau of Statistics of China, <http://www.stats.gov.cn/english/statisticaldata/yearlydata/yarbook2003_e.pdf>.

TABLE 1 *Fixed-line and Mobile Growth Rates*

	2001 (%)	*2002 (%)*
Fixed line growth rate	24.1	19
Mobile growth rate	69.8	42.4

SOURCE: Post and Telecommunication Services 2003, National Bureau of Statistics of China, <http://www.stats.gov.cn/english/statisticaldata/yearlydata/yarbook2003_e.pdf>.

add 32–35 million new subscribers until 2006, an annual growth rate of almost 13%.[5] Much of this unprecedented growth has been driven by expansion in the mobile phone market. The mobile to fixed line ratio is currently 107:100, markedly up from 27:100 as recently as 1998.[6] Mobile subscribers outnumbered fixed line users by 2003 (see Figure 1 and Table 1).[7]

5. Hui Yuk-min, "Forecast Fixed-Line Growth Rate Raised to 13 Percent a Year," *South China Morning Post* (Hong Kong), p. 24, March 27, 2003.

6. "Number of Mobile Phone Users in China Nearly Equal to That of Fixed Phone Users," Xinhua, March 17, 2003.

7. "Asia-Pacific Telecommunication Indicators 2005," *International Telecommunications Union*, June 2005, <http://www.itu.int>.

Internet

Despite having only 40.3 computers for every 1,000 people,[8] China is still set to surpass Japan as the world's second-largest Internet nation (after the United States).[9] In 2004, China's 16.3 million host computers (an 82% increase over 2001) were used by China's 94 million Internet users (a 178% increase over 2001).[10]

In terms of ICT exports, China dominates the low-end market and has recently started to compete in medium-end technology. In 2001 China's high-technology exports grew 25.4% to $46.46 billion, and total high-tech product trade reached $110.57 billion, accounting for 21.7% of the country's foreign trade total. Its high-tech trade volume increased $9.4 billion or 55.5% of total export growth of $16.95 billion. About 90% of China's high-tech exports were electronic- and computer- and telecommunications-related products.[11] Still, China's IT export sector consists predominantly of processing and assembly of imported components for re-export.

The MII has set a goal for the export of electronic products in 2005 to $240 billion, 20% over the 2004 goal. IT-related products and electronics accounted for 34% of total export volume in 2004.[12] This estimation is based on the previous Five-Year Plan period (1996–2000), during which software, electronics, and IT manufacturing industries grew more than 30% each year.[13]

Political and Institutional Changes

Although President Hu has solidified his authority fairly smoothly and the reforms of the ICT sector have generally followed the direction laid out by Hu's predecessors, there is still a great deal of uncertainty about how committed policy makers are to making the sector more transparent and more market-oriented. The leading administrative institutions in the ICT sector may be subjected to further reform or simply to cosmetic administrative shuffles.

Despite this uncertainty, several important points can be made. First, it has been widely reported that the new generation of paramount leaders are technocrats—many are engineers and all possess university degrees in technical subjects. It has been less widely noted that the next generation of leaders, those

8. World Bank, *World Development Indicators: 2002* (Washington, D.C.: World Bank, 2002).

9. Paul Chan, "Asian Internet Sector Rocks in the North; China Is Set to Overtake Japan; S Korea Is the World's Leading Broadband Nation," *Business Times Singapore*, January 2, 2003.

10. China Internet Network Information Center, 12th Statistical Survey of Internet Development in China (July 2003), <http://www.cnnic.net.cn/download/manual/en-reports/12.pdf>.

11. "Rapid Growth of China's High-Tech Exports," Xinhua, January 11, 2002.

12. "China Exported 140 Million Mobile Phones Last Year," *People's Daily Online*, January 20, 2005, <http://english.people.com.cn>.

13. "Summary of the Tenth Five-Year Plan (2001–2005)—Information Industry," MII (translated by the Telecommunications Research Project of the Center of Asian Studies at the University of Hong Kong), <http://www.trp.hku.hk/infofile/china/2002/10-5-yr-plan.pdf>.

right below Hu and the other members of the Politburo Standing Committee—the source of real power in the Party—exemplify new leadership trends in the economic bureaucracies. These leaders comprise what Barry Naughton calls "true technocrats," individuals with higher-education specialization in the professional fields in which they have made their careers. These individuals "are technocrats not simply by virtue of a generalized background as technically educated individuals but rather in the sense that they are genuinely specialized, well trained, and experienced in economic and technological issues."[14]

Second, in addition to leadership changes, China is undergoing a process of administrative reform expected to make the functions and capabilities of the Chinese state more compatible with a market economy. The changes are designed to significantly strengthen the government as a regulatory authority and reduce direct government management of businesses. Among the important changes that emerged from the National People's Congress in March 2004 were the renaming of the State Development Planning Commission as the State Development and Reform Commission, the creation of a new Ministry of Commerce that brings together foreign and domestic trade regulation, and the establishment of the China Banking Regulatory Commission and the State Asset Management Commission.

Third, despite the fact that ICT is a high political and economic priority, the decision making process in its industries suffers from many of the weaknesses that characterize other areas of the Chinese polity. The political and economic institutions involved in ICT decision making are fragmented, segmented, and stratified; struggles occur within and among ministries, provinces, and localities for information, resources, and status.[15] Over the years, policy making has become increasingly pluralistic, involving a greater number of officials from various Communist Party and government departments.[16] Overlaying these institutional divisions at the center are important ideological differences. Edward Steinfeld, for example, argues that more interventionist approaches to industrial policy are fiercely contested by those who prefer that the market plays a more central role.[17]

Perhaps the most important division is between the center and the localities. Local officials play an extremely important role in determining how central

14. Barry Naughton, "Government Reorganization: Liu Mingkang and Financial Restructuring," *China Leadership Monitor*, no. 7, Hoover Institution, Stanford University (Summer 2003), <http://www.chinaleadershipmonitor.org/20033/bn.pdf>.

15. Michael Oksenberg and Kenneth Lieberthal, *Policymaking in China: Leaders, Structures, and Process* (Princeton, N. J.: Princeton University Press, 1988), p. 3.

16. Susan Shirk, *The Political Logic of Economic Reform in China* (Berkeley: University of California Press, 1993), pp. 111–12.

17. Edward Steinfeld, "Chinese Enterprise Development and the Challenge of Global Integration," in Shahid Yusuf, ed., *East Asian Networked Production* (World Bank: Washington, 2004), pp. 255–97.

ICT policy initiatives are interpreted and implemented. Under central government auspices, local governments have expanded decision-making authority and a greater ability to retain the revenues earned locally. As a result, localities have promoted local development, often while implementing a local industrial policy that ignored national objectives. The degree to which a local government complies with the dictates of Beijing may be the most important factor determining actual policy.[18] Policies first promoted at the local level may eventually be elevated to central policy. In the end, China can maintain two or more separate, competing, and not necessarily integrated approaches toward key ICT issues like technology acquisition.

In the past, Beijing has tried to overcome all of these bureaucratic barriers to policy coherence through a big push from above. The pattern is for the top party leaders to rein in a big ministry from above and to force the reluctant minister to change policies and organization. This often happens through a high-level super-committee that knocks heads together below and imposes some competition on former monopolies. This has happened several times in the ICT industries, as State Council committees imposed new directions on ministries like the MII.

This top-down, campaign style of creating industrial policy is becoming more difficult to employ as both domestic political associations and foreign multinationals exert a greater degree of influence over decision making. As Scott Kennedy argues, today, firms influence policy directly through the lobbying of regulators and indirectly through business associations and other intermediaries. The success of these firms is based on their ownership type, size, and technological sophistication.[19]

The impact of domestic and foreign firms on ICT policy was clearly demonstrated over a six-month period when Beijing stepped back from the use of technology standards, uneven taxes, and government procurement policies that would have restricted the competitiveness of the wireless, semiconductor, and software industries. In April 2004 Beijing suspended the implementation of wireless local area network (LAN) authentication and privacy infrastructure (WAPI) as a wireless encryption standard that would replace the dominant standard of Wi-Fi; in July China ended the value-added tax (VAT) on semiconductors; and in August Chinese officials distanced themselves from regulations that would require government offices to buy software only from local companies.

18. Adam Segal and Eric Thun, "Thinking Globally, Acting Locally: Local Governments, Industrial Sectors, and Development in China," *Politics and Society* 29:4 (December 2001), pp. 557–88.

19. Scott Kennedy, *The Business of Lobbying in China* (Cambridge: Harvard University Press, 2005).

What explains China's retreat? A preliminary answer is foreign pressure, overlapped with internal debates. In the case of WAPI, the American government maintained consistent pressure on Beijing while foreign producers managed to fight the impulse to defect and cut a separate deal with China.[20] Intel in particular resisted the measure strongly, declaring that it would not substitute WAPI for Wi-Fi and that it would end the sale of all products that included wireless communications technology in China.[21] At the same time, Chinese domestic producers have not been completely unqualified supporters of a technology standards strategy. Depending on their level of development, some companies may find that new technology standards are likely to raise costs and create confusion.[22] Technology enterprises that are already tightly linked to American or European markets are not likely to support the development of a China-only standard that cuts them off from these markets.

New Priorities and Uncertainties

Four critical issues represent important and sometimes subtle shifts in emphases likely to have significant consequences for the future evolution of China's ICT sector. These issues are (1) the shift toward more high-level attention to software, not just hardware; (2) the move from a discourse emphasizing domestic ICT markets to greater attention to ICT exports; (3) a shift away from centralized structures in administration and markets toward more decentralization; and (4) a shift in the nature and scope of technology policy from quantity to quality or, in other words, from top-down state-directed programs to those more focused on creating an environment supportive of innovation and entrepreneurship.

More Attention to Software

As all economies become more knowledge intensive, software becomes increasingly important, a kind of critical intermediate good in the emerging digital economies. Adequate access to appropriate software is imperative for continued economic growth and international competitiveness. It is also central for successful e-government initiatives. However, it is certainly not imperative that software be locally produced in all cases. Most countries import much if not

20. This unity may have been fragile. There were reports, later denied, that Texas Instruments was willing to cooperate in the development of WAPI. See Daniel Shen, "TI and Atheros Ready to Support China's WAPI," February 14, 2004, <*DigiTimes.com*>, <http://digitmes.com>.

21. Scott Kennedy, "Holey Protectionism," *China Economic Quarterly*, Q3, 2004, pp. 24–28.

22. Richard Suttmeier and Yao Xiangkui, *China's Post-WTO Technology Policy: Standards, Software, and the Changing Nature of Techno-Nationalism*, National Bureau of Asian Research Special Report, no. 7 (May 2004), <http://www.nbr.org/publications/special_report/SR7-China_Tech_Policy/ChinaTechPolicy.pdf>.

most of their software needs. Yet, a domestic software industry can, under the right circumstances, promote innovation and positive spread effects within and beyond the ICT sector of the economy.

A contrast with India is instructive here. China is ahead of India along a number of dimensions relevant to software development but clearly lags in software production. For example, from 1981 to 1995 China had 537 scientists/engineers in research and development (R&D) per million against India's 151. China leads India in personal computers 3-to-1 and enjoys a 4-to-1 lead in Internet usage. Yet, in 2001 India produced $8.4 billion of software, while China only produced $6.8 billion for its substantially larger economy. According to Li and Gao, using data from the Organization for Economic Cooperation and Development (OECD), "The percentage of hardware expenditure in China was significantly higher than that of India, 88% vs. 62%."[23] India shows a much greater expenditure on IT services, 32%, versus China, at only 7.3%. Today, in China most consumers buy their software embedded in their hardware, not in separate packages.

Policy makers are clearly worried about China's failure to develop software standards. At a November 2003 conference, MII Vice Minister Gou Zhongwen labeled software a "strategic industry" and described five areas in need of reform: government procurement, customs regulations, financial system, government support and guidance, and market stability. According to Gou, government purchases account for 14.1% of the domestic market, but without formal policies, government procurement does not help promote national producers. Given the size of the domestic market (and the dominance of Microsoft Windows), policy makers have spoken of encouraging a software industry based on Linux.[24]

Li and Gao place the blame for China's underperformance largely on a failure of leadership at two levels. Within the firms, executives fail to recognize that software design is not just individual craft work but is mainly an engineering process requiring meticulous adherence to international standards. Within government, strong national-level champions have failed to emerge and insist on more aggressive software promotion policies. A 2000 State Council Document (no. 18) encouraged the listing of software firms on stock markets, standardization of tax policies, and creation of venture capital funds. Another State Council Document (no. 47), issued in 2002, identified a series of specific targets for the software industry, including development of a domestic soft-

23. Li Mingzhi and Ming Gao, "Strategies for Developing China's Software Industry," *Information Technologies and International Development*, no. 1 (Fall 2003), p. 6.

24. "Guojia Jiang Fazhan Ji Yu Linux Ruanjian Ye" [China should develop a Linux based software industry], *Zhonggua Gao Xin Jishu Chanye Baodao* [China High-Tech Industry Herald, hereafter ZGXJCB], November 6, 2003, <http://www.chinahightech.com/chinahightech/News/View.asp?NewsId=6313237303>.

ware market valued at $30 billion, 20 large software companies with revenues of $1 billion yuan ($120 million), 100 Chinese software brands, and software exports of $1–2 billion by 2005.[25]

From Production Mainly for the Local Market to More Production for Export

Despite an International Finance Corporation report that China will increase its share of global electronics production from 8% to 14% by 2005, foreign invested firms tend to dominate the export market.[26] According to a report by Lehman Brothers, a U.S.-based investment bank, the number of foreign-funded corporations among the top 100 largest exporters in China rose to 53 in 2004 from 48 in 2003.[27] Chinese-owned firms manufacture ICT products mainly for the domestic market. Again, a contrast with India is illustrative. Of the $6.8 billion worth of software China produced in 2000–01, $6.4 billion was sold domestically and only $400 million exported. By contrast, India sold software worth $2.2 billion at home and $6.2 billion abroad. For India, this constituted 10% of GDP growth.

Foreign firms are deeply involved in all aspects of production and development. Foreign invested enterprises (FIE) account for roughly two-thirds to four-fifths of China's electronics exports. This percentage actually increased from 1996 to 2001, and U.S. firms, along with Taiwanese, Japanese, and Korean companies, are among the sector's biggest players: it remains dominated by FIEs. Exports of computer equipment, for example, jumped from $716 million in 1993 to $41 billion in 2003, with the FIE's share rising from 74% to 92%; China's electronics and telecom exports grew from $13 billion in 1993 to $89 billion in 2003, with the foreign share of exports moving from 45% to 74%.[28]

Companies like the giant computer manufacturer Lenovo (formerly Legend) slowly turned their attention to foreign markets for exports during the beginning of the century, even though the firm only exported 7% of its production in 2003. The company announced its intention to increase exports to 25%–30% of total sales by 2006.[29] Few analysts believed Lenovo was going to meet that goal, and the April 2005 purchase of IBM's PC division was motivated in

25. See Suttmeier and Yao, *China's Post WTO Technology Policy.*

26. American Electronics Association, "Tech Trade Update 2003," <http://www.aeanet.org>, accessed January 2004.

27. Flor Wang, "Taiwan Major Force in Funding Chinese Export Sector: Report," Central News Agency (Taiwan), August 15, 2005.

28. George Gilboy, "The Myth behind China's Miracle," *Foreign Affairs* (July/August 2004), pp. 33–49.

29. Keith Bradsher, "Chinese Computer Maker Plans Push Overseas," *New York Times*, February 22, 2003.

part by the desire to overcome Lenovo's weaknesses in international markets and achieve an instantly recognizable global brand. It is still too early to tell if Lenovo can compete on more than low-cost manufacturing.

From Centralization to Decentralization

The shift away from higher to lower levels of centralization in the administration and in economic affairs (i.e., the "market") has been occurring since the beginning of the reform period in 1978 and has included the decentralization of authority for R&D and production from the central state to lower level actors including provincial and municipal governments, universities, research institutes, enterprises, plus individual scientists and entrepreneurs.[30] As noted above, the center has granted greater decision-making authority to local governments that often pursue their own objectives.

Administrative decentralization has also been accompanied by market decentralization, the deliberate dismantling of monopoly and monopsony—the presence of only one buyer in the market—conditions by the central government, although this has been a process characterized by bureaucratic foot-dragging and conflict. Real competition is emerging, even if it is limited by the attempts of China Telecom to preserve its predominant position. The Ministry of Posts and Telecommunications (MPT) managed long distance services until China Telecom was incorporated in 1995. After considerable bureaucratic battling, China Unicom was created in 1994 as an alternative carrier for voice, with ownership spread across multiple shareholders—the Ministry of Electronic Industries, the Ministry of Railways, the Ministry of Electric Power, and 12 state-owned enterprises (SOEs). Jitong was established as an alternate provider of data services. In addition to Unicom, by 1998 the MPT also had to deal with the entry into the cell phone market of the People's Liberation Army (PLA) through the franchise awarded to China Great Wall. Netcom—backed by the State Administration for Radio, Film, and Television—was authorized in 1999 to provide Internet access, telephone services, and high-speed data transfer.

In April 2000, further decentralization occurred when China Telecom was split into three entities: China Telecom for fixed lines and data transfer, China Mobile, and China Satellite Telecommunications Group for satellite communications and high-speed Internet delivery. In May 2002, China Telecom was again split into China Telecom (which operates in 21 southern and western provinces) and China Netcom Group (operating in 10 northern provinces). The central government also ordered China Netcom Group to merge with broadband service providers China Netcom Corporation and Jitong. But more than a year later, the three are still operating independently, although in June 2003

30. Adam Segal, *Digital Dragon: High-Technology Enterprises in China* (Ithaca, N.Y.: Cornell University Press, 2002), p. 27.

China Netcom announced a 481.9 million yuan ($59.6 million) offer to acquire all of Jitong's state-owned shares.

Telecoms reform was not on the agenda at the 10th National People's Congress. The creation of a "State Telecoms Regulatory Commission" to replace MII (which was created in 1998 and incorporated functions previously exercised by the MPT, Ministry of Electronic Industries [MEI], and Ministry of Radio Film, and Television) was not discussed, but telecoms reform is still apparently on course.

There continue to be rumors that MII will be weakened in the future; China's State Council is reportedly considering three different proposals for restructuring the ministry: (1) creating a regulator modeled after the U.S. Federal Communications Commission responsible for regulating and supervising the telecoms industry, including telecom networks, broadcast TV networks, and computer networks; (2) dividing MII into provincial regulatory agencies along the lines of the People's Bank of China; or (3) a hybrid of the above two.[31] Of all the decisions to be taken in the short term, none is more important than dilution of the power and authority of the telecoms regulator.

From Industrial Policy to Innovation: How Far Will It Go?

A shift in the nature and focus of Chinese technology policy is already occurring. The early phase of development in China focused on the physical deployment of ICT infrastructure. Development was based on a top-down, "big push" economic model associated with state planning, as well as the more successful roll-outs of mainlines and telephones. During the late 1990s, Chinese decision makers began to shift their focus from more extensive to intensive development—this move has been reflected in the proliferation of government policies more supportive of entrepreneurial and innovative activities. Richard Suttmeier has described this as a move "from S&T (science and technology) policy to innovation strategy."[32]

This emerging strategy consists of three parts.[33] First, influenced by the experience of small, private innovative firms in the West and in Silicon Valley in particular, policy makers moved to support all types of advanced enterprises—

31. MFC Insight, *MFC Insight Update*, December 23, 2002, <http://www.mfcinsight.com/products/iframe/article/021122/news.html>.

32. Richard Suttmeier, "Globalization, Structural Change, and the Role of Government in China's Search for a National Innovation Strategy," forthcoming in a volume on innovation in developing countries, edited by Gu Shulin, to be published by the United Nations University.

33. These are discussed in Barry Naughton and Adam Segal, "China in Search of a Workable Model: Technology Development in the New Millennium," in *Crisis and Innovation in Asian Technology*, eds. William Keller and Richard Samuels (New York: Cambridge University Press, 2003), pp. 160–87.

non-governmental, private, and small spin-offs—rather than just large SOEs. This embrace of non-state actors also reflected important ideological changes made toward private enterprises. In January 2000, a minister at the State Development Planning Commission announced that the government would "eliminate all restrictive and discriminatory regulations that are not friendly toward private investment."[34] And during a speech marking the 80th anniversary of the founding of the CCP on July 1, 2001, former President Jiang Zemin announced that the Party would now accept private business people as members. This is reinforced by permitting some greater leeway for semi-autonomous bodies like business and professional associations—such as the China Electronic Commerce Association—to emerge.

Second, cuts in state agency manpower and mandate have inhibited the government's efforts to select specific technologies for support. Now, the government provides broad support to all domestic enterprises designated "high-technology." This support can take the form of access to low-interest credit lines, preference in procurement decisions, or other kinds of regulatory preference or relief, but it is focused on the larger environment of innovation, not specific policy support. The third and final part of the strategy was to encourage the less tangible, "software" forms of technology transfer (i.e., licenses, consultancy, etc.) rather than "hardware" in the form of equipment imports.

These three strands are reflected in a late 1999 Decision.[35] Included in this Decision were funding support for S&T innovation by small- and medium-sized enterprises, a tax exemption for all income from the transfer or development of new technologies and related consulting and technical services, a preferential 6% value-added tax rate for software products developed and produced in China, and complete VAT exemption and subsidized credit for high-tech exports.

Chinese policy makers have also tried to make it easier to reward technologically inventive entrepreneurs for their contributions. The 1999 Decision called for the development of venture capital companies and funds. Plans for a "growth enterprise market" like NASDAQ in the United States and GEM in Hong Kong have been approved, but implementation has been put off until after regulatory reforms that will restructure the existing Shanghai and Shenzhen stock markets.

Implications

Each of these four critical uncertainties on its own has big implications for other critical downstream aspects of Chinese social structure and dynamics.

34. James Kynge, "Support Planned for Private Sector," *Financial Times*, January 5, 2000.

35. State council decisions are regulatory documents, not law, but they may under certain conditions be legally binding. They can be described as opinions with de facto regulatory effect. Thanks to Zhen Liu. Discussed in Naughton and Segal, "China in Search of a Workable Model," pp. 178–79.

Taken together, interacting, their impacts will be multiple and complex. Some impacts will be narrow and institution-specific, others broader and more inclusive. Some will occur mainly within the ICT sector, while others will affect political reform, institutional reform, China's regional relationships, and Sino-American relations.

ICT Sector: From Market Taker to More of a Market Maker

One way to interpret the aggregate impacts of these four uncertainties is to speculate whether and how fast China is moving from being mainly a market taker to becoming a market maker. That is, while China in the past had to accept the current market conditions of pricing, demand and supply, locating R&D facilities and other aspects of the dynamics and structure of the multi-trillion-dollar global ICT market, the country is arguably shifting toward a new position wherein it can have an independent impact on selected aspects of the global market as well as on large national markets that are central to the global market.

Looked at from the China side, the export picture reveals interesting supply trends that underscore the uncertainties of the country's impacts on the dynamics and structure of the global industry. China's exports are clearly having a big impact on the world's largest market, the U.S. It appears that China's ICT hardware exports, while still based in low- or mid-range value-added products, are starting to push out Mexico and Japan as top suppliers to the U.S. market and are creating substantial shifts in the production profile of ICT powerhouse Taiwan.

On the demand side, Japan—the second largest personal computer market in the world after the United States—is close to being eclipsed by China, a shift which will continue to shape the strategies of global manufacturers. A future key issue will be China's strategy for selecting particular industry standards for telecoms and value-added services. Standard setting in China—relative to other existing standards—could have major impacts on global markets for important services and goods if companies worldwide must manufacture products with China-specific standards.

Another potential but still murky impact on global markets lies in the globalization of R&D. Most major ICT firms have chosen over the past several years to locate some R&D facilities on the mainland—over 200 foreign R&D centers and labs were established from 1990 to 2002—but their rhetorical ambitions and actual performance vary substantially.[36] Some of the largest companies claim their research campuses are charged to innovate not just for the

36. Kathleen Walsh, *Foreign High-Tech R&D in China: Risks, Rewards, and Implications for U.S.-China Relations* (Washington, D.C.: The Henry Stimson Center, 2003), pp. 73–77.

mainland market but for the companies' regional and global value chains as well. Some observers believe that foreign firms will be reluctant to make major intellectual property investments in the country while huge risks remain that their products will be pirated: the software/content piracy rate in China is well into the 90% range. In an interview, an executive of a Beijing-based U.S. trade association reported to us that foreign companies seem to be putting just enough money into R&D to pretend to demonstrate to their Chinese policy maker audiences that they are really serious about contributing to the future of informatization in China as a platform for global innovation, but in reality they are not and cannot invest resources at that level unless and until substantive change occurs in intellectual property rights protection.

Political Reform

The first generation of writing and research on the political impact of ICT in China assumed that the rapid and widespread diffusion of these technologies would inevitably prompt a greater flow of information, a more open (though still state-controlled) media, and eventually, more political transparency and competition among organized interests. It is certainly true that groups both in and outside of China have been able to use the Internet, satellite broadcasts, and mobile phones to disseminate restricted information, coordinate new forms of organization, and publicize opposition to the regime. More recent studies, however, have concluded that there is no easy one-to-one equivalence between Internet diffusion and use, and the growth of democracy. In the short term, the state has had unexpected success in controlling the political impact of openness, developing an effective multi-layered strategy to control Internet content and monitor online activities at every level of Internet service and content networks.[37] This control is built on a mixture of legal regulations and blocking, filtering, and surveillance technology. Longer-term it is possible that power may shift from the state to individual citizens, but there is not enough evidence now to substantiate this claim.[38]

Still, focusing on the lack of organized resistance to the CCP and eventual democratization overshadows the degree to which the Party increasingly feels it must respond to the freer flow of information in Chinese society. Zhu Rongji's public apology in March 2001 for misleading the country about the cause of an explosion in a school in Jiangxi was a remarkable example of ICT

37. Michael S. Chase and James C. Mulvenon, *You've Got Dissent: Chinese Dissident Use of the Internet and Beijing's Counter-Strategies* (Santa Monica, Calif.: RAND 2002), pp. 49–56; Shanthi Kalathil and Taylor C. Boas, *The Internet and State Control in Authoritarian Regimes: China, Cuba, and the Counterrevolution*, Carnegie Endowment for International Peace, Working Paper, no. 21 (July 2001), pp. 4–6.

38. Nina Hachigian, "China's Cyber Strategy," *Foreign Affairs* (March/April 2001), pp. 118–33.

forcing greater transparency at the top. It is still too soon to guess the long-term impact of the 2003 Severe Acute Respiratory Syndrome (SARS) crisis; movements toward greater media transparency have been accompanied by censorship, and ownership of the media remains firmly in the hands of the Communist Party. But the environment in which decisions are made and justified has certainly changed. Decision makers must bear in mind that Chinese citizens not only have greater *access* to foreign sources of information but they can also *distribute* that information widely and rapidly using new technologies such as text messaging. For example, in Guangzhou, a cell phone text message, "There is a fatal flu in Guangzhou," was re-sent 40 million times on February 8, 41 million times the next day, and 45 million times on February 10, according to the *Nanfang Zhoumo* newspaper.[39]

Institutional Reform

The Internet and other ICTs have started to affect institutional rules and dynamics inside and outside the sector. The first phase of telecommunication reform consisted of breaking up the telecommunications monopoly and reducing the state's role in the ICT market. Now, China must develop new institutions to regulate competition—among domestic and foreign players and in several regulatory issue areas—in an extremely rapid time frame. The state must define the scope of competition, regulate industry structure, and clarify current relations among commercial and legal grey areas. New leaders must also cooperate increasingly with non-state actors in developing legal and institutional frameworks, although privatization is not a major element of regulatory evolution in China. How successful China will be in developing these regulatory capacities remains a critical uncertainty, especially because power and authority have been devolved away from central ministries.

At a more micro level, there are new stresses on the overlapping systems and organizations involved in technological invention and innovation. These systems typically consist of actors in four sectors: the public sector, private sector, research institutions, and civil society. These are the key actors that design, negotiate, and subsequently implement the architecture of the national systems of innovation including ICT innovation.[40]

In China, the reform process has been defined in part by the expansion and empowerment of new actors. The impetus for innovation has moved from the industrial ministries to research institutes like the Chinese Academy of Sciences and academies like Tsinghua University and Beijing University as pro-

39. Xiao Qiang, "SARS Impact on Media Control and Governance," testimony before the U.S.-China Economic and Security Review Commission, June 5, 2003, <http://www.uscc.gov/qiates.htm>.

40. Ernest J. Wilson III, *The Information Revolution and Developing Countries* (Cambridge, Mass.: MIT Press, 2004), ch. 5, pp. 223–97.

duction and development of new technologies have gradually shifted from SOEs to non-state enterprises like Lenovo and Founder.

The reform process will require not only new institutions and new regulations but also new forms of elite interaction. The sometimes heavy-handed direction of Party or state enterprise bosses will need to give way to alternative modes of social relations that encourage innovation by relying more on consultation and knowledge sharing, and less on top-down authoritarian instructions. Government, private, research, and non-profit elites will need to interact continuously in a four-sided arrangement that elicits the contributions of each to ICT diffusion and innovation. The challenge for the Party is that such innovation-friendly autonomy risks reducing Party allegiance.

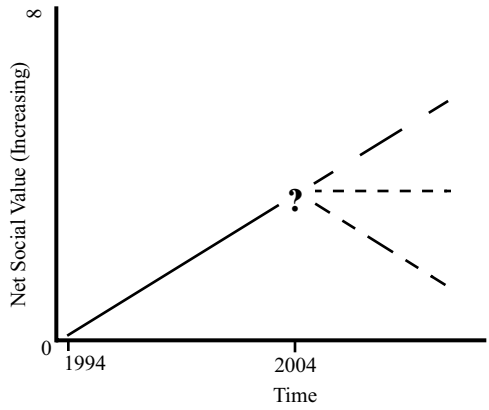
China has moved a great distance over the past 20 years, but it continues to face great challenges over the medium term. Developing the types of institutions required to move China up the product cycle, especially in software, has two kinds of highly significant implications, especially upstream. The first is that building a viable and internationally competitive software industry will require some restructuring of the social pipeline that produces software engineers, software managers, salespersons, systems integrators, and so forth. This pipeline extends from the recruitment of talented youngsters in high school and the first years of tertiary education to systems of reward, retention, and lifetime learning for older and more experienced workers. China will need to step up dramatically the throughput of that pipeline.

Second, the shift from hardware to software could involve more subtle political changes. It is not clear that authoritarian practices and a constricted societal environment can command software writers to "be more creative." Authors like Ronald Inglehart argue that when a society reaches a certain threshold of modernization and as the number of white-collar workers rises (propelled by education, income, job types, etc.) then their worldview and expectations shift, and they start to demand greater personal and professional autonomy.[41] It is under these circumstances (and perhaps only under these circumstances) that modern knowledge workers will produce innovative and high quality work.

Thus, while it is undeniable that China over the past decade achieved truly astonishing progress in its ICT sector, there are no guarantees that these same trends will continue over the next decade. Commanding compliance in hardware manufacturing and infrastructure build-out using top-down management structures yields better results than commanding innovation or commanding more competitive knowledge management strategies in the software or ICT service sector. Commanding creativity is a contradiction in terms. If the current

41. Ronald Inglehart, *Modernization and Postmodernization* (Princeton, N.J.: Princeton University Press, 1997).

FIGURE 2 *IT's Contribution to Social Value: Alternative Scenarios*



political and professional constraints remain, then the large number of well-trained potential innovators may not live up to their promise; some will continue to underperform in antiquated systems at home; others will vote with their feet and emigrate to more open societies in Asia or the West.

The following illustration in Figure 2 captures this dynamic. Let us call the diagonal vertical dimension "net social benefit," which when viewed over time shows a clear sharp upward trend through mid-decade. The broken lines represent possible scenarios or trends in the evolution of net social value of IT to Chinese society. By 2006 the economy hits a "knowledge wall" as top decision makers begin regularly to confront choices between either retaining centralized political and administrative controls from Beijing or permitting greater decentralization in markets and R&D activities. Simply put, new conditions press these officials to choose between maintaining one unit of control or securing two units of social and technological innovation. At least three scenarios come to mind, as indicated in Figure 2. First, if centralized restrictions are not relaxed, then innovation-based net social value can plateau or, secondly, decline. Alternatively, innovation might flourish if centralized controls are relaxed.

Regional Relations

Over the next three to five years, decisions made in China will increasingly affect telecommunications and other ICT conditions in other countries in the region. The ICT dynamic in China will affect different countries differently in terms of investment, production, and demand patterns. From high-end producers and exporters like Singapore and Taiwan to low-value-added countries like

Vietnam that are simply trying to enter ICT mass production, producers in the region will feel the effects of China's choices about its future ICT strategies.

The most interesting regional impact by far will be on China's big next-door neighbor, India. The two Asian giants are competitors economically and politically and now pursue ICT strategies that are diametrically opposed. In the sharpest, starkest formulation, China now concentrates on the domestic market for ICT goods and services, while India focuses mainly on exports. China has put the lion's share of resources and senior level attention into hardware production, while Indian elites emphasize software. Of course, similarities exist too, especially as China (pushed by Taiwan investments) expands its export base across the economy; but the strategic foci do differ.

Will these two neighboring giants retain the main thrusts of their strategies and push their achieved comparative advantage as far as they can, or will they shift course? If on the whole each retains its unique focus, even as they converge somewhat through greater production and sales diversification, we can anticipate one set of impacts for their bilateral relations. Greater complementarities are likely to yield greater cooperation, ceteris paribus. If, on the other hand, the government and private sector elites in the two countries choose to move aggressively into one another's current areas—i.e., China more toward software for export, India more toward hardware exports—then we might anticipate greater conflict. Such conflict is unlikely to spill over into serious clashes at the state level but might help contribute to more edgy bilateral relations. For the moment, interviews with the National Association of Software and Service Companies concluded that there is no potential threat or competition in the global software market and that one should view China as a market, not a competitor. Still, private conversations with senior Indian and Chinese leaders reveal continuing nervousness about the others' capabilities and intentions.

Other countries in the region, both high- and low-value-added producers, will also be affected by ICT decision making in China. China will start to compete more with Singapore as a regional R&D hub. Malaysia is a major exporter of assembled electronics products and has an ambitious R&D and production project under way, the Multimedia Super Corridor; it too will feel the pressure as China's increased exports threaten to push down Malaysia's earnings and undercut its longer-term strategy. Though they lack robust R&D infrastructures, Thailand, Vietnam, and other countries want to compete with China on labor costs. These countries are likely to ramp up their export production as more ICT products become commodities, in turn putting pressures on China's cheap hardware strategy over the medium to long term.

China clearly sees the political impact of these economic changes and has mounted a sustained diplomatic campaign to convince Southeast Asia that it is a responsible neighbor. China is assuming a more assertive role in the regional economy, successfully securing an Association of Southeast Asian

Nations (ASEAN)-China free trade agreement, while Japan and the United States watch from the sidelines. While China continues to receive some development assistance from Japan and the international financial community, it has become a donor country within Southeast Asia.

One of the most important evolving relationships will be the PRC's ICT ties to Taiwan. On the one hand, cross-strait investment and commercial ties are growing more robust and routine. At the same time, cross-strait relations are so contentious and politically charged that ICT ties could easily be engulfed in the fallout of an erupting political crisis. In the view of some Taiwanese, relocating high technology production to China is part of what an advisor to Taiwanese President Chen Shui-bian has described as "Beijing's grand strategy to digest Taiwanese industry."[42]

It is also possible that the continued and increasingly rapid economic integration of Taiwan and China will draw the two sides closer together, possibly moderating political difference and reducing the risks of military conflict. On the positive side, Taiwanese firms in the 1990s began moving the most labor-intensive stages of electronics production to the China mainland, beginning with assembly of keyboards, mice, and monitors. The simplest assembly processes were transferred at the beginning stages, but the movement gradually expanded to include nearly all assembly operations. According to the Institute for Information Industry's (III) Market Intelligence Center, located in Taipei, by the first quarter of 2002 the share of Taiwan's IT hardware actually produced in Taiwan was only 38% (down from 47% in full-year 2001), while the share produced on the mainland was 49% (up from 37% for 2001). By 2004, the share of Taiwan's IT hardware actually produced in Taiwan was only 15.6%, while the share produced on the mainland was 71.2%.[43]

To continue competing globally, Taiwanese industry has to make two changes. It needs to move up the product cycle, innovate, and establish brand recognition in new markets; and Taiwanese producers must reduce foreign investment transaction costs and expand production and transport ties with the mainland.[44] In a perfect world, Taiwan would follow both of these strategies, attracting overseas capital and skilled manpower as well as expanding ties with the mainland.[45] Both of these strategies are dependent on maintaining positive political relations

42. Haung Tien-lin, "Taiwan's Silicon Shield Must Be Maintained," *Taibei Times*, March 17, 2002.

43. Tim Culpan, "IT Hardware Manufacturers Storm into Mainland," *South China Morning Post*, April 30, 2002.

44. Gary Jefferson, "Like Lips and Teeth: Economic Scenarios for Cross-Strait Relations," paper prepared for the Seminar on Cross-Strait Relations and the United States at the Turn of the Century, Center for Strategic and International Studies, Washington, D.C., September 1999.

45. Mark Clifford, "Taiwan's Misplaced Dread over China," *Business Week Online*, January 29, 2002, <http://www.businessweek.com/bwdaily/dnflash/jan2002/nf20020129_2252.htm>.

with China. Shifting manufacturing to China clearly depends on cross-strait stability and even the attraction of more sophisticated product makers and high-end functions like advanced R&D to the island requires stable relations with China.

Sino-U.S. Relations

Clearly, technological issues already have and will continue to spill over into commercial, security, and other U.S. bilateral relations with China. Will Foster argues that the U.S. now shares a big border with China—in cyberspace—and we have already seen hackers attack those shared virtual borders from both sides.[46] So far, hacker attacks have been largely symbolic (defacing the other nation's websites, for example) and a nuisance. They have the potential for becoming more worrisome, and there currently are no agreed-upon procedures for resolving contentious cyber conflicts.

Technological competition could also provoke trade conflict. Beijing has come under increasing criticism for having a large trade surplus—$162 billion in 2004—and unevenly implementing its WTO commitments. U.S. manufacturers have argued that manufacturing capability is migrating to China with the help of an undervalued yuan. China's movement into relatively more capital-intensive and high-technology industries, coupled with rising unemployment in the U.S.'s high tech sector, could trigger political frictions between the two nations, especially with American congressional and presidential elections approaching. Cisco's lawsuit against Huawei for illegally copying software and supporting documentation is probably only the most recent in what will be a string of intellectual property rights cases involving U.S. and Chinese firms.

China's movement up the product cycle also entails security challenges. The shift of ICT manufacturing and R&D to China is seen by some to threaten reliable access to high-end chips from trusted producers and thus to raise serious U.S. national security and intelligence concerns.[47] There are also worries about the transfer of dual-use technologies through joint ventures and foreign direct investment. Many of the technologies involved in commercial projects can be used to improve military command, control, communications, computers, and intelligence, surveillance, and reconnaissance infrastructures (C4ISR).[48] Before the PLA's divestiture from commercial enterprises in 1998, the Chinese army had access to ICT through a joint venture between a unit of China Telecom and the General Staff Department's China Electronic System and

46. Quoted in Wilson, *The Information Revolution*, pp. 110–11.

47. Senator Joseph Lieberman, *White Paper: National Security Aspects of the Global Migration of the U.S. Semiconductor Industry* (June 2003), <http://www.senate.gov/~lieberman/semi.pdf>.

48. James Mulvenon and Thomas Bickford, "The PLA and the Telecommunications Industry in China," in *The People's Liberation Army in the Information Age*, eds. James C. Mulvenon and Richard H. Yang (Santa Monica, Calif.: RAND, 1999), pp. 245–57.

Engineering Company. The resulting company—China Telecom-Great Wall Communication—assumed a dominant position in the domestic market. After divestiture, many of the minor PLA players have been removed, but the major players remain involved.

Another dual-edged issue of concern to some is the continuing influx—and outflow—of Chinese students in U.S. professional and graduate schools, especially in engineering and the sciences. American security analysts fear that some of these highly trained individuals could return to China and provide their expertise to military industries. Yet, any policy response would have to balance the multiple benefits and contributions these individuals make to American industry and education, as well as familiarizing Chinese young people with American society.

Conclusions

Chinese leaders, whether in Beijing or at the enterprise level, face a set of critical choices that will significantly affect China's own internal ICT development and its position in the rapidly evolving global ICT industries. These choices will help shape the distribution of political authority and economic efficiency within China as well as Beijing's place in the regional economy and its relations with the United States.

Because ICT is so central—and the stakes so high economically and politically—decision makers will have a difficult time ahead deciding where the optimal balance lies in the four key areas discussed above: between domestic hardware and software production; between domestic and export markets; between centralization and decentralization; and between top-down, state-directed industrial policy and more indirect "innovation strategy." Indeed, many of the trends described here toward greater administrative decentralization, demonopolization, and market competition mean that the tools now available to government decision makers have become more complex and less predictable. Policy tools, while perhaps greater in number, are more remote and less subject to immediate manipulation. The resulting economic and administrative diversity may buttress more pluralism in civil society and provide more diverse levers for more groups to try and influence economic policy. For outside observers, this greater administrative and market pluralism may be normatively desirable but it is probably no easier to understand. Transparency may be gained in ICT sectors, but complexity and confusion may grow as well.

One should not underestimate the impacts these reform processes can have on the definition and resolution of the substantive challenges that confront the Chinese decision makers. The reforms will change the old players and introduce new ones into policy making, and will create brand new incentives within the already complicated processes of negotiations over technology policy.