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Technology Development in the New Millenium: China in Search of a Workable Model

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Preface

Like other East Asian countries, China has been undergoing a process of liberalization and of opening to the world economy. During the last twenty years, economic reforms have slowly moved the country as a whole toward a more open, more market-oriented economy, and science and technology (S&T) policies and institutions have been reformed in a similar spirit. Policy makers gradually dismantled a highly centralized and hierarchical model of technological innovation and began replacing it with a more flexible and "bottom-up" system. Leaders at all levels have moved away from a research and development system dominated by central planning and state-owned enterprises to one that increasingly relies on individual innovation and entrepreneurship, while foreign direct investment (FDI) and multinational corporations both play larger roles in Chinese development plans. The openness to a diversity of actors crucially includes both outside actors--multi-national corporations (MNCs)--and domestic non-state owned corporations. China's entry into the World Trade Organization (WTO), promises to consolidate these trends.

At first glance then, China seems to be part of a larger project of the recasting of technology policy within the region. But ironically, in recent years, China's policy has also evolved in ways that bring it closer to techno-nationalism, at least in some senses of the word. While the Chinese government's hand in technology development is now deployed in a lighter and, on balance, more sophisticated manner than in the past, its motivation is perhaps more explicitly nationalistic than it has been. In part, this is simply because nationalism, in its diverse manifestations, is today a more prominent and important force in China than in the recent past. Many in China today have a strong sense that China is resuming its "rightful" place in the world. Because of China's population, rapid economic growth, and tradition of cultural creativity it is seen as destined to play a prominent role in the global economy. Moreover, now that socialism (and *a fortiori*, communism) has lost most of its ideological and idealistic force in China, nationalism serves as an alternative to justify a continuing role for the government and Chinese Communist Party (CCP) in economic and technology policy.

Economic reform has created a larger role for private businesses in the national economy, and nationalism now provides an underpinning for a government effort to articulate a new government-business partnership. Thus, in 1999, Jiang Zemin initiated the so-called "Three Representative" campaign, which declared the CCP the representative of the "most advanced" sectors of the economy, and of the interests of the nation as a whole. This campaign seeks to de-link the Party from workers in state-owned enterprises (and the proletariat in general). Moreover, "advanced" economic sectors have increasingly been interpreted to include private entrepreneurs and non-state firms. The language of technology policy justifies regime action. But it also, unwittingly, expresses the constraints under which the regime operates; the CCP cannot hope to stay in power unless it is seen to be creating a strong and modern China.

Introduction

"Techno-nationalist" states—like Japan and Korea through the 1980s—were willing to bear economic costs in order to maintain a high degree of technological and economic independence. Techno-nationalist policies in these countries were designed to create independent domestic capabilities in core or critical technologies, supported the establishment of domestic institutions that encouraged the diffusion of these technological capabilities across sectors, and assisted producers and users of these technologies.[1] The central point of this paper is that policy makers in China are indeed forsaking some of the policy tools and institutions traditionally associated with techno-nationalism, especially it's state-run variant; but China is not abandoning the project's larger goal of deepening domestic technological capabilities. If we conceptualize techno-nationalism as a policy orientation toward self-sustained autonomy and independence from other states, rather than a specific set of policies, China remains strongly techno-nationalist.[2] Central planning may be scaled back and the level of support for state-owned enterprises curtailed, but fundamental strategic concerns remain. Chinese leaders continue to worry about autonomy and technological dependence on other countries, especially the United States. These worries express themselves in Chinese policies toward non-state enterprises and MNCs, though the specific policy instruments may change. Indeed, Chinese planners act as if the old, coherent package of MITI-style techno-nationalist policies are simply no longer viable or efficacious, and that they therefore have little choice but to select a few weakly related policies that promise some return in particular instances. If the current policies fail, other policies presumably wait in the wings; the overall pattern of technology development during the reform period has been one of restless change. Luckily for China, the size and diversity of the country might indeed make this a viable improvised strategy.

There are at least three reasons to think that the dynamics for change in China's technology policy reflect uniquely Chinese factors and uniquely Chinese concerns. First, and most simply, China is bigger and more diverse than the other countries under study, so it has the option of maintaining two or more separate, competing, and not necessarily integrated approaches toward technology acquisition. The results are a national mosaic that varies both temporally and geographically. Polices first promoted at the local level may eventually be elevated to central policy. Localities may run competing technology development programs, or try to exploit opportunities implicit in national policies in ways that are not necessarily consistent with the spirit of national policy. The southern province of Guangdong is considerably more advanced than other Chinese regions in developing a technology policy based on human resource development, and inter-firm

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[1] Richard Samuels, *Rich Nation, Strong Army: National Security and Technological Transformation in Japan* (Ithaca: Cornell University Press, 1994).

[2] All economic nationalisms specify a direction for foreign economic policy away from an "other", and lead governments to interpret their economic dependence on some states as a security threat. See Rawi Abdelal, *Economic Nationalism After Empire: A Comparative Perspective on Nation, Economy, and Security in Post-Soviet Eurasia* (Ithaca: Cornell University Press, forthcoming)

technology cooperation. Other regions may rely more on government-sponsored research and extension efforts.
With diverse outcomes in different localities, central policy makers can choose among existing policy experiments. Faced with challenges in different policy arenas and with the need to balance the interest of various state and non-state actors, decision makers can look to regional outcomes to judge the ultimate feasibility of different policy packages. Regional decentralization thus aids policy innovation. The success of one province emboldens others, at both the regional and central level, to adopt the same or similar policies.

Within this general pattern of diversity and flexibility, there remains – precisely because of China's size – a hard core of continued central government sponsorship of R&D (largely for military purposes) and a strong central government role in setting the parameters of technology policy. It is not that decentralization and regionalization drives the entire system; rather, a degree of decentralization in interaction with a continued central government role, creates one of the most crucial dynamics of the system.

Second, China is still in the process of reforming its economy, in particular the industrial management system, and the old science and technology system. The agreement with the US on the terms on which China will enter the World Trade Organization will provide a powerful impetus to further reforms and help reshape the domestic economy. The Asian financial crisis had important effects on China's economy, and brought substantial costs, but the impact has been less than that of the successive phases of domestic reform. Whatever new system of innovation ultimately emerges in China, the scope and scale of that process will be significantly shaped by the trajectory of changes in the broader economic system.

Finally, and perhaps most important, China's technology acquisition policies interact with military and strategic issues in ways different from the other Asian economies. Because of its size and history, Chinese leaders act on the understanding that China will assume great power status some time in the near future. Larger than all the other East Asian countries put together by population (China is 65 percent of East Asian population), China's economic capabilities are still modest, accounting for only 10 percent of East Asian GDP.[3] Military capabilities lag still further behind, and relations with the U.S., Japan, and Taiwan have recently soured over a range of political and technological issues. China is clearly *more* concerned with national defense and defense-related technological development today than a few years ago. In all states, certain sensitive areas or projects are simply circumscribed and kept out of the general liberalization stream. In China, because great power pretensions are more significant, and strategic interactions (the "security dilemma") more immediate, these sensitive areas are likely to remain proportionately more important than in most other East Asian states. Areas directly related to security still remain tightly connected to central budgets, planning, and policy. More broadly, globalization combined with the perceived

[3] Measured at exchange rates. Purchasing power parity calculations would promote China to a 36 percent share of East Asian GDP, about the same as Japan. Purchasing power parity calculations based on World Bank, *World Development Report* 1996, pp. 188-89.

overwhelming predominance of the U.S. is seen to create important threats to national sovereignty. In response, a discussion on the nature of "economic security" has been prominent in Chinese media over the last several years.[4] These concerns temper and modify the general trend toward greater openness.

In addition, there has been an increasing willingness of the center to attach the language of techno-nationalism to policies that might also be consistent with techno-globalism. The central government has moved to diversify technology policies and relax controls over many areas of the economy. With the failures of more traditionally interventionist policies, and the success of relatively *laissez-faire* technological approaches such as that of the United States, central leaders are looking for new ways to enhance the nation's technological autonomy. This has meant the embrace of actors that before were ideologically suspect. What matters now for a national champion is not that it is state, collective, or privately owned, but that it is Chinese.

The existence of these strategic issues and of a core of state-led R&D activities along with the promotion of relatively *laissez-faire* technological approaches suggests that at times the language of technology policy may be different from the logic of policies on the ground. But the two are not completely decoupled. The desire to be a modern, powerful country is deeply rooted, and the mastery of technology is a key symbol of success. No matter how closely Chinese technology policy comes to resemble that of its neighbors, it continues to reveal a historically rooted concern with technological autonomy. Chinese techno-nationalism remains regionally distinct because the Chinese are so clearly concerned about dependence on the United States.

The rest of this paper illustrates these tensions with a discussion of contemporary Chinese technology policy, including several case study examples. We begin with an overview of Chinese technology policy from the start of the reforms until now. This overview not only traces the most important secular trend--the evolution of a more market-friendly approach—is also shows that each shift in technology policy has been a reaction to the preceding phase, and reflects some dissatisfaction with what was achieved in an earlier phase. This perspective prepares us for contemporary technology policy, which since about the time of the Asian financial crisis, has shifted to a distinctly stronger emphasis on small firms, and on technological creativity, while simultaneously articulating a more clearly nationalistic rationale for the policy. It is not inconsequential that this shift occurred around the time of the Asian crisis, but, as we shall see, the change grows primarily out of domestic imperatives and the retrospective evaluation of technology policy over the previous two decades. In the following section, we examine some of the ways in which China's strategic pretensions affect its technology policy, and then conclude with an attempt to assess the complex cross-currents in contemporary Chinese technology policy.

[4] For an example, see Fang, Ning; Xiaodong Wang and Qiang Song (1999). *Quanqiuhua Yinyingxia de Zhongguo zhi Lu [China's Path Under the Influence of Globalization]*. Beijing: Zhongguo Shehui Kexue.

Reform Through the Early 1990s

The reform process, begun in 1979, was a huge break from the past, but initially it also revealed the government's unquestioned assumption that it must continue to control the overall process of technology development. Marketization occurred rapidly, transforming the economy, but marketization was most rapid precisely in the most "low tech" parts of the economy: rural enterprises, agriculture, and petty commerce. High technology seemed to the majority of planners to fall into the area that most needed direct government involvement, and so the government's presence remained fairly strong in the higher technology parts of the economy. Policy makers consistently stressed the need for two simultaneous processes: the absorption of advanced technologies from abroad and the development of the domestic capacity to absorb and digest technology, whatever its origins. The balance between the two—which we will label technology import and technology development respectively—has changed over time, but the two are intimately connected. Over time, policies focused on technology transfer from abroad have led to much greater roles for MNCs and foreign investment, while policies focused on developing an indigenous capability have gradually broadened from an exclusive focus on public research institutes and state-owned enterprises to one that embraces individual entrepreneurs and private (or semi-private) firms. Neither of these processes, however, has been linear.

From the very beginning of the reform process, the need to accelerate the pace of technology import was put forward as a key argument for reform. In March of 1978—even before the triumph of the reformers in December of that year—Deng Xiaoping argued that

> Profound changes have taken places and new leaps have been made in almost all areas. A whole range of new sciences and technologies is continuously emerging...we have lost a lot of time as a result of the sabotage by Lin Biao and the Gang of Four...Backwardness must be recognized before it can be changed.[5]

Initially, lacking a coherent central government approach to technology, some control over technology import was decentralized to localities and parceled out to central government ministries. Localities generally were given authority to import technology under a certain financial ceiling. Feeling a sense of urgency to get into fast-developing new sectors, and acutely aware of their own limited ability to analyze and absorb technologies, local governments generally opted to import technology-embodying machinery and production lines. The result was a rush of machinery import—the central government gave away whatever bargaining power it might have had vis-à-vis foreign machinery suppliers.

As the 1980s proceeded, the central government reasserted its own important role in the technology import process. Seeking to shift the emphasis of technology import from new plant construction to the renovation of existing medium and large-sized state-owned enterprises, the government established an important role in brokering technology import

[5] Deng Xiaoping, *Selected Works 1975-1982*, pp. 103, 106. See also Barry Naughton, *Growing Out of the Plan: Chinese Economic Reform, 1978-1993*. New York: Cambridge University Press, 1995, pp. 62-74.

projects. The State Economic Commission—which had responsibility for enterprise renovation—coordinated an approval process for 3,000 renovation projects, including 1,550 for machinery, 296 for conversion of defense industries, and 1,200 for light and textile industries, primarily with Japanese firms.[6]

Foreign investment also began to be encouraged, but was still very much limited to various enclaves defined by the Chinese government. Local officials could approve individual cases of foreign investment (again under a given value ceiling), but foreign investors were generally denied access to the domestic market, were required to export, and had to balance their own foreign exchange needs. When access to the domestic market was granted, it generally followed an individual case-by-case determination by the relevant Chinese authorities that production involved technologies that China needed and could not replicate on her own. Typically, this would involve extended negotiations with a Chinese ministry, which often arranged competing bids among different MNCs in an effort to pick a single foreign partner who would serve as the main technology partner. Thus, with respect to incoming FDI, the Chinese side tried very hard to set the terms of the technology bargain. It was precisely in "high tech" fields where the strength and influence of central government ministries remained strongest, and where the central government retained a significant degree of monopoly power confronting MNCs.

Telecommunications equipment provides an excellent example. The Ministry of Post and Telecommunications initially sought a technology partnership with AT&T (in the late 1970s and early 1980s), and subsequently Nortel. AT&T—preoccupied with its impending judicially-ordered break-up and a perceived need to focus on the domestic United States marketplace—declined to be elected. Nortel also dropped out of the competition. Both AT&T and Nortel were subsequently penalized for their lack of enthusiasm: they were placed in the "penalty box" and completely frozen out of competition for the domestic equipment market. They discovered that the Ministry had a long memory and was quite unforgiving. Ultimately, the Chinese side was able to persuade ITT Belgium (subsequently acquired by Alcatel) to play the role of preferred partner. In exchange for substantial technology commitments, Alcatel was given not just market access guarantees for its Shanghai Bell joint venture manufacturing facility, but also the ability to sell imported telecommunications switches to Chinese clients. This policy, known as "combining direct import with technology acquisition," was implemented across a range of industrial sectors as a way to overcome MNC reluctance to invest large sums of money and technology in the unproven China market. Monopoly control over market access was used to develop multi-dimensional bargains with foreign technology suppliers.

In domestic technology development policy, China also carried out significant initial decentralization, but gradually, during the mid-1980s, and particularly in 1985-86,

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[6] Ding, Jingping (1997). "Using imported technology to transform existing enterprises in China" and Jiang, Xiaojuan (1997). "Chinese government policy towards science and technology and its influence on the technical development of industrial enterprises". Both in *Chinese Technology Transfer in the 1990s: Current Experience, Historical Problems and International Perspectives*. Ed. by Charles Feinstein and Chrisopher Howe. Cheltenham: Edward Elgar**:** Pp. 109-111, 142.

developed a range of new indirect, long-term plans for the economy, trying to replace the old-style discredited highly centralized plans. One, the 863 Project (named for its approval date of March 1986) targeted industries in the areas of biotechnology, new materials, lasers, energy, information, robotics, and space. The program--which continues today--brings together specialists in many fields on cross-disciplinary products such as computer integrated manufacturing systems. The 863 Project introduced the concept of peer review and a mixed method of project selection for the first time to technology plans in China, and researchers focused on predominantly (but not entirely) civilian technologies.[7]

Another new plan, the 1988 Torch Plan, hoped to develop China's high technology manufacturing capabilities, focusing especially on R&D and the commercialization of new technologies in state-owned enterprises. Rather than having the central government arrange the delivery of commodities and allocating funds to research projects, the Torch Plan was the first large S&T plan originating from the center that was not prescriptive.[8] Central funding for the Torch Plan has been limited and administered by the Torch Development Center under the former State Science and Technology Commission (SSTC), which acts more like a fund-raiser and broker than like an investor itself. Initial SSTC investments totaled only 100 million RMB, but by 1992 investments reached 4.4 billion RMB (in United States dollars going from $40 million to about $800 million).[9] The Torch Plan also included the creation of high technology development zones. Chinese policy makers intended to recreate the experiences of Silicon Valley, Route 128, and other science parks locally through a policy of locating universities and high technology firms in the same area and combining research and education with production. Subsequent elaborations described preferential policies in five areas: taxes, finance, imports and exports, pricing, and personnel policy.[10]

If we are to characterize policy through the 1980s succinctly, we may say that China was trying to carry out a form of techno-nationalism in which the chief agents were to be large state-owned enterprises (SOEs) and government research institutes. Chinese policy-makers looked enviously to Japan and Korea and sought to replicate their perceived success, but with SOEs emerging as the Toshibas and Hyundais of China. Where MNCs were to play an important domestic role, they were to be partnered with

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[7]"High Tech R&D Program (Project 863) Surges Ahead" *Zhongguo Keji Luntan*, no. 5, 18 September 1989, pp. 8-10 in *Joint Publication Research Service-China Science and Technology* [hereafter, JPRS-CST] 4 January 1990, p. 1. On the organization of the 863 program, its roots in the past, and its difference from earlier defense-oriented critical technologies programs in China, see Evan Feigenbaum, "Soldiers, Weapons and Chinese Development Strategy: The Mao Era Military in China's Economic and Institutional Debate," *China Quarterly*, 158 (June 1999), pp. 285-313; and "Who's behind China's high technology 'revolution'? How bomb makers remade Beijing's priorities, policies, and institutions," *International Security*, 24:1 (Summer 1999).

[8]Qin Shijun, High Technology Industrialization in China: An Analysis of the Current Status," *Asian Survey* vol. 32, no. 12 (December 1992): 1129.

[9]Deng Shoupeng, "The Torch Plan Facing the Nineties," *Renmin Ribao*, 19 November 1990, p.3, in JPRS-CST 30 November 1990, p. 25.

[10]The list is from the 1992 State Basic Policy for High-Tech Industrial Development Zones. Shao Zhengqiang, "Present Policy to Govern High, New Tech Industrial Development Zones," *Zhongguo Keji Luntan* no. 4, July 1992, pp. 14-16,54 in JPRS-CST 16 December 1992, pp. 5-8.

strong domestic SOEs. But Chinese capabilities at this time fell short of those in Japan or Korea a few decades earlier: government "technology brokers" had less familiarity with world trends, and Chinese corporations were still only partially liberated from the bureaucratic strictures of the planned economy.

By the late 1980s, it became clear that there were inherent limitations to both technology import and technology development strategies. The 863 Project has had (and continues to have) limited success in bringing new products to market. Research institutions participating in the programs had few official connections with enterprises, and enterprises had few incentives to look to these institutions for new innovations.[11] Moreover, the government was too anxious to achieve dramatic results with limited resources in a short period. As a result, from 1988 to 1994, the average research fund for every 863 Project researcher was only about US $5,000 because government funds were spread over an average 1,044 research programs annually.[12]

The Torch Plan made more progress in commercializing new technologies and supporting the growth of high technology industries, but it also had problems. There were too many so-called high-tech industrial parks all over the country, some with only a few enterprises. Many firms that entered the parks did so only to take advantage of the preferential tax policies and export subsidies, and never developed any new technologies. Moreover, much of the program funding went to medium and large state-owned enterprises rather than the smaller, more technologically innovative firms.

The technology transfer policies of the 1980s were also perceived to be falling short by the early 1990s. Decentralized import of technology by local decision-makers had numerous problems, and the overall record of absorption was not good.[13] At the central level, while the State Economic Commission tried to act like MITI in Japan or the Economic Planning Board in Korea and coordinate technology imports to renovate older factories, the SEC lacked significant institutional capabilities. In many cases, ministries chose which technologies to import with little understanding of the technologies themselves, the needs of particular sectors within China, or the long-term implications of their choices. Ministry officials tended to chase after the "highest", most-advanced technologies. In Korea, by contrast, government research centers were more finely tuned to the needs of domestic enterprises, informing firms about the available technologies and thus enhancing their bargaining positions with the MNCs.

The strategy of selective partnering with MNCs was not producing exceptional technological success. Delays and disputes plagued many of the big showcase projects. In a bilateral monopoly situation, both sides were capable of exploiting their position, and

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[11] CAS Accomplishments in High Technology Development Reviewed," *Xiandaihau* 23 January 1990, 10-12, in JPRS-CST 23 July 1990, pp. 2-5.

[12] The average was 22,000 renminbi per researcher. Chen Chunbao*, Zhongguo Jishu Chanye Fazhan yu WaimaoJjingzhengli (Development of High-tech Industries in China and China's Competitiveness in Foreign Trade),* China Northeast Caijing University Press, 1998, P. 64.

[13] Ho, Samuel P.S. (1997). "Technology Transfer to China During the 1980s--How Effective? Some Evidence from Jiangsu." *Pacific Affairs* 70(1): 85-106. See also Jiang Xiaojuan, op. cit., fn. 10.

projects became increasingly complicated and delayed, and rarely resulted in rapid "leaps" in technological capability. A number of areas which had been designated the highest priority by the Chinese government displayed the slowest development. In the automobile industry, the large centrally controlled producers were authorized to seek joint venture partners for passenger car production in the mid-1980s, but it took them a decade to get these ventures into production. In the meantime, locally run producers in Shanghai and Tianjin worked out quicker and more successful strategies, with the result that centrally-run passenger car producers have never been profitable.[14] Expensive, high profile projects to import semiconductor fabrication technology ran into repeated delays. The result was that the technology gap separating China from the rapidly advancing world technology frontier probably widened in the area of semiconductor fabrication.[15] Furthermore, expanded marketization was undermining some of the presumptions embedded in the complex bargains the Chinese government sought with MNCs, bargains that were predicated on monopoly control of key sectors. For example, in telecommunications, in the early 1990s, Alcatel found that newly empowered local telecom authorities were unwilling to buy high-priced imported switches, and aggressively sought alternative lower-price supplies. The bargain between the ministry and Alcatel had to be recast in order to save the project.

The limited success of the mainstream national approach to technology policy also contributed to divergent regional outcomes. Guangdong province, which had been allowed to really carve out its own independent policies with respect to foreign participation in the economy (and thus, de facto, with respect to technology import), was having remarkable success. Guangdong allowed corporations much more independence in structuring their businesses internally and externally. Corporations in Guangdong could gain access to foreign firms much more easily (through Hong Kong), and had more freedom to craft cooperative business and technological relationships with foreign firms. In this environment, a new technological growth pole grew up in Guangdong by the mid-1990s. Ultimately, Guangdong's success was to pave the way for a shift in national policy.

Policy Shift: More Open, More Players

In the early 1990s, China underwent a significant shift to a more radical, less controlled version of technology policy. The change is most clearly marked with respect to technology import, because of the massive surge in foreign direct investment that

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[14] Jin Chen and Takahiro Fujimoto, "Different Behaviors of Chinese Auto Maker in Technology Introduction and Assimilation" University of Tokyo Discussion Paper CIRJE-F-10 (June 1998), Tomoo Marukawa, "WTO, Industrial Policy and China's Industrial Development" IDE-JETRO International Symposium, *China Enters WTO: Pursuing Symbiosis with the Global Economy*. Chiba, Japan, January 17, 2001.

[15] Yuan Zhijia, "Semiconductor Industry: Industrial Development under Government initiative [in Japanese]," in Marukawa, Tomoo, ed., *Iko-ki Chugoku no Sangyo Seiasaku [China's Industrial Policy in Transition]*. Chiba: Institute of Developing Economies, 2000. pp. 407-437. See also the earlier discussion in Barry Naughton, *The China Circle: Economics and Technology in the PRC, Taiwan and Hong Kong*, Washington, D.C.: The Brookings Institution, 1997, p. 26 and *passim.*

emerged after Deng Xiaoping's "Southern Tour" in 1992. While this political event triggered a much bolder approach to market transition overall, its impact was especially apparent with respect to foreign investment. In its wake, China became much more reliant on incoming foreign direct investment (FDI) than Japan or Korea have ever been. The shift in 1992 was especially clear because the Tiananmen Incident of 1989-90 had caused three years of stagnation in FDI. During the period of stagnation, the key change was a reshuffling of foreign partners. Some MNCs reduced their involvement in China, and China faced potential isolation from Western partners. Meanwhile, though, other "contrarians" (such as Motorola in Tianjin) who were willing to make investment commitments in the aftermath of the Tiananmen incident, emerged as competitors to first round technology partners.

Similarly to Japan's experience in the 1950s and 1960s, the benefits of having multiple competing foreign technology sources began to seem increasingly obvious to the Chinese side. At the same time, the success of Guangdong's more open approach was becoming obvious. Export manufacturers from Hong Kong and Taiwan had been moving labor-intensive stages of production to the China mainland. The scale of exports from foreign invested enterprises (FIEs) was increasing, surpassing 20 percent of total exports in 1992 (from only 1percent in 1985). Even more striking, FIE exports, which had originally been predominantly clothing and toys, began to include a substantial share of electronics assembly and other production associated with high technology sectors. These developments encouraged a dramatic liberalization of the investment regime in 1992-93. After 1992, FIEs had much more domestic market access than before, and both they and FIE exporters faced a much more favorable policy regime. The result was a flood of foreign investment, much of it in medium to high technology sectors. Figure 1 shows the volume of three important flows associated with technology import. The top line shows investment goods (nearly all of it machinery) imported as part of foreign investment projects; the middle line shows capital equipment imported by domestic firms and reported as technology import; and the bottom line shows funds expended for licenses and other technology fees. Clearly, there is no exact dollar equivalence between these different types of flows, each represented by data coming from different sources.[16] Equally clearly, though, while foreign investment was roughly equivalent to domestic firm technology acquisition in importance through 1991, beginning in 1992, foreign investment quickly dominated domestic machinery purchase, and almost certainly emerged as the dominant source of technology import through 1997. Investment poured into China.

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[16] In Figure 2, foreign invested enterprise (FIE) investment goods are taken from Customs statistics, as reported in General Adminsitration of Customs, *China's Custom's Statistics,* annual December issues. Annual figures are affected by the fact that imports of FIE investment goods were tax exempt through 1996, after which time tax exemptions were scaled back. As a result, there may be some overstatement for 1996 (as firms rushed to get in machinery before some tax exemptions expired) and some understatement for later years (since the incentive to report fully has diminished). Data on domestic enterprise technology acquisition is from State Statistical Bureau and State Science and Technology Commission, eds., *Zhongguo Keji Tongji Nianjian [China Science and Technology Statistical Yearbook]*, Beijing: Zhongguo Tongji, 1992, p. 329 and 1998, p. 200; MOFTEC (1999). *Zhongguo Duiwai JIngji Maoyi Baibishu [White Book on China's Foreign Economics and Trade]*. Beijing: Jingji Kexue, p. 85-86, 131. Definitions of these series "drift" in different years as well, and should be used only for a general assessment of large-scale trends.

The massive flow of foreign investment into China was in many respects an enormous success. As Figure 1 shows graphically, the overall pace of inward technology transfer stepped up dramatically after 1992. The reliance on FDI inflows—which since 1993 has surpassed 5 percent of GDP--was such that China in this respect came to resemble a Southeast Asian country more than a more traditionally techno-nationalist northeast Asian country. MNCs were playing a dominant role in overall technology import. (The share of total exports produced by FIEs continued to grow as well, reaching 47 percent in 1999).

As the approach to technology transfer shifted to a greater reliance on foreign investment, so technology policy targeted at indigenous capabilities expanded to include more forms of ownership. For the first time, the center took steps, albeit tentative, to promote and support non-state technology enterprises. The 1993 "Decision on Several Problems Facing the Enthusiastic Promotion of Non-governmental Technology Enterprises" recognized and encouraged these firms. The Decision declared that non-state enterprises would have a role in developing a new innovation system based on market-oriented technology firms as well as changing an S&T system dominated by public institutions to one that embraced organizations of various ownership structures. [17] These "non-governmental" firms, often founded by entrepreneurial individuals from the Chinese Academy of Sciences or Beijing University, existed in a space between "private" and "public" ownership. Start-up capital came from friends or savings; the initial technology and office space were often located in state-funded research institutes.

Meanwhile, the inflow of FDI has also had significant implications for domestic firms. Non-governmental companies like Legend Computer (discussed further below), frequently excluded from bank lending, have been able to raise significant capital by forming joint ventures with foreign firms. Cooperation with foreign producers also allowed Legend access to an already established global network of foreign partners to market their joint venture products. In addition, working with foreign enterprises allowed Legend to learn and experiment with new management structures.

In 1995 the Communist Party and the State Council also issued a "Decision on Accelerating S&T Development." While calling for the strengthening of government leadership in basic technology research, the Decision accepted that the development of applied technologies should be left to the market. Scientific research institutes were to have full autonomy in choosing R&D projects, and they should try to form joint ventures with domestic and foreign partners. Moreover, the Decision pointed out that non-state companies were an important force in the high-tech field and worthy of encouragement. This point implicitly revised the previous priority given to large state-owned enterprises,

[17] "Guanyu Dali Tuidong Minying Keji Qiye Fazhan Ruogan Wenti de Jueding," in Xi'an Science and Technology Commission, *Keji Fagui Xuanbian* [Selected S&T Laws and Regulations] (Xi'an: Xi'an Kexue Jishu Weiyuanhui,1996):390-398.

while also implicitly recognizing that policy up through 1995 had continued to favor large state-owned enterprises (SOEs).[18]

The policies surrounding high technology parks also became more highly attuned to the needs of non-state enterprises. Within already established parks, local officials began creating small business "incubators."[19] Officials in the Xi'an International Business Incubator, for example, established a venture capital fund for smaller firms and helped individual entrepreneurs apply for bank loans and Torch Program funding.

The success of Legend Computer illustrates the growing role and importance of these non-governmental companies in the new economy. Legend was founded in 1984 by a group of scientists from the Institute of Computing Technology at the Chinese Academy of Sciences; the Academy provided the initial start-up capital in the form of a 200,000 RMB loan.[20] The company's first product was a Chinese language card-- an electronic card inserted in PCs to convert English key strokes into Chinese characters—and in 1988 Legend introduced its own PC in the domestic market. By late 1996, Legend's PC was outselling all of its foreign and domestic competitors in the Chinese market. From 1993 to 1997, Legend's annual income almost quadrupled from 3.2 billion to 12 billion RMB (in US dollars, tripling from c. 500 million to 1.5 billion).

Legend's organizational structure also came to resemble the modern enterprises that would underpin the "new innovation system" described in the 1993 Decision. The company grew from 20 to 4,200 employees, and from one office to six departments, including offices for scientific development, finance, subsidiary companies, and production, as well as divisions for specific technologies including networks, software, and microelectronics.[21] In 1988, Legend established a holding company in Hong Kong and issued shares on the Hong Kong stock market.[22] In 2000, Legend officially ended its ambiguous "non-governmental" status, formally becoming a joint stock company, with the Institute of Computing Technology as one of the largest shareholders.[23]

Despite substantial successes, there were significant problems and tensions associated with the FDI-led program of technology acquisition. First, China found that in many sectors, MNCs moved rapidly and aggressively to establish strong market positions. Moreover, many MNCs proved quite capable of maintaining effective control over

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[18] There is an excellent discussion of this document at the U.S. Embassy website: see http://www.usembassy-china.org.cn

[19] Jing Junhai and Jin Hui, *Keji Qiye Chengzhang yu Qiye Fuhuaqi [The Growth of Science and Technology Enterprises and Business Incubator*s] (Xi'an: Xibei Gongye Daxue Chubanshe, 1998)

[20] For a history of the Legend, see Chen Huihu, *Lianxiang Weishenma*,[Why Legend] (Beijing: Beijing Daxue Chunbanshe, 1997)

[21]Lianxiang Jituan [Legend Corporation], company prospectus, no date. Interview, Legend Corporation, Beijing, June 26, 1997.

[22]"Sitong Gupiao Niandi Shangshi," [Stone to go on the Stock Market at the end of the Year] *Keji Ribao*, [*S&T Daily*]October 22, 1988.

[23] Hu Yanping, "Lianxiang/Jisuansuo – Ziji de Lihun Bieren de Piping" [Legend and The Computer Science Institute-Our Divorce, Other people's criticism] http://www.sina.com.cn/news/review/2000-01-18/15840.shtml.

proprietary technologies, either by resisting joint venture partners and operating wholly owned subsidiaries, or by structuring relations with partners to segment the technology. The latter was particularly easy when joint venture partners were slow moving traditionally structured state-owned enterprises.

There were many features of the Chinese system that limited the spillover benefits from FDI. An unsatisfactory level of intellectual property protection and doubts about the willingness of Chinese entities to abide by contractual agreements hampered China's efforts to receive and localize imported technology. Foreign companies were reluctant to engage Chinese enterprises as partners to develop their best technology for the Chinese market. In their eyes, there was a substantial risk that the Chinese partner would bring the product to market on its own or transfer the technology to other unauthorized partners.[24] Foreign investors had both the incentive and the ability to keep technological capabilities closely guarded within the firm.

Second, the trade and investment regime had characteristics that inadvertently discouraged technological learning. FIEs often operated in an externally-oriented enclave economy, with limited links to the rest of the Chinese economy. FIEs were encouraged to export, and to bring in advanced technologies. In order to facilitate the transplantation of export networks to China from elsewhere in East Asia, China adopted an extremely open export-processing regime, under which inputs could be imported duty-free, as long as production was exported. While this policy was effective in encouraging movement of producers to China, it also encouraged producers to maintain supply and sales links with external businesses, and thus inadvertently discouraged the growth of supply networks based on domestic Chinese firms.

An example of this is the hard disk drive (HDD) industry, which has grown rapidly in China in recent years. Chinese plants (all foreign-owned or joint ventures) now assemble hard disk drives (10 percent of world output in 1998), and also produce some of the components of HDDs, especially labor-intensive components such as heads. Yet all the components are imported, and all the heads, and all the assembled disk drives, are exported. Indeed, 100 percent of output is exported even though many of the heads are ultimately assembled into drives in China, and many of the drives are ultimately installed into personal computers in China.

Why are these drives exported and then re-imported? Because for exporters to continue to operate under the liberal export processing regime with minimal restrictions, they must export all output. Otherwise, imported inputs would be subject to duties, and value-added taxes (VAT) would be charged on a portion of output value. Even local suppliers of low technology inputs (cleaners and solvents, furniture, office supplies) are uncommon, and the HDD plants sit in a kind of splendid isolation in clean, greenfield technology parks. The supply and sales chains of these plants all lead across Chinese borders. Technology spillovers are, to date, quite modest or non-existent.[25]

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[24] Maskus, Keith and Sean Doughterty (1998). "Intellectual Property Rights and Economic Development in China." Chongqing, Sino-U.S. Conference on Intellectual Property Rights and Economic Development.
[25] Industry interviews, Shenzhen, June 21, 1999; Wuxi, August 24, 1999.

Thus, by the late 1990s, Chinese policy-makers were facing new dilemmas. The economy had become much more open to incoming investment, and in that sense had swung out of the ambit of the government-steerage and techno-nationalist policies characteristic both of the planned economy and of Japan and Korea in earlier decades. While the benefits of the incoming FDI were considerable, there was a widespread sense that technological spillovers had been disappointing.[26] Perhaps this was inevitable. The policy swing that permitted the flood of investment had been sudden, and had certainly not been calibrated with policies to foster technology absorption and diffusion. Moreover, Chinese capabilities in both the organizational and technological realm were growing, but were still limited. Investment in the assimilation and absorption of purchased technology regularly ran behind what economists estimated was efficient.[27] There was clearly scope for more effective government action.

But in which direction? In this hybrid environment, government policies and institutions obstructed the type of technological spillovers that would occur in a pure market environment, because profitable activities such as out-sourcing to local suppliers, subcontracting, and licensing were discouraged. And while government policies still attempted to squeeze technology concessions out of MNCs as a condition for operating in the Chinese market, these policies were neither systematic nor professional enough to provide really substantial technological benefits to the Chinese economy. In this environment, there were really two choices. The first was to move systematically to a techno-nationalist policy similar to the carried out by Japan and Korea in previous decades; the alternative was further liberalization. In the case of movement toward a Japanese or Korean-style industrial policy, China's gradually developing technological sophistication and administrative capability would be harnessed to a more systematic and sophisticated industrial policy. Incoming FDI might well be reduced, but more technological benefit would be squeezed out of each incoming dollar. Indeed, there were initiatives in this direction. An automobile industrial policy in 1994 announced a moratorium on new producers (thus restricting incoming FDI). It also promised state support for the first producers who reached an annual 100,000 passenger car output, combining elements of a tournament with strong incentives to consolidate. The similarity to Japanese automobile industrial policy in the 1960s is overwhelming.[28] Minister Wu Jichuan, head of the telecommunications system, clearly favored an approach to telecommunications that stressed a vigorously nationalistic industrial policy. Yet, ultimately, these initiatives were not followed up. None of the other industrial policies promised in the wake of the automobile industry policy ever appeared. The ground was being laid for a different type of policy, and when the shift came, it was in the direction of greater liberalization.

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[26] See, for example, the discussion in Wang Chengxu*: Kejiao Xingguo (Science and Education for a Prosperous China)*.

[27] Chinese economists have repeatedly raised the fact that Chinese organizations on average allocated resources for technology absorption equal to about 50 percent of technology purchase price, compared to 200-300 percent in Korea and Japan. See Xu 1997.

[28] Murakawa, op. cit.

New Millenium, New Technology Policy?

In the late 1990s, the context for technology development changed once again. The impetus for the subsequent shifts in policy was both external and domestic. The Asian financial crisis deeply affected elite opinion by showing the limitations and weaknesses of Korean-style model of large enterprise led (chaebol) dominated industrialization. For many Chinese, the *chaebol* had been an important model of what the most successful state-owned enterprises might become. Proposals to create one hundred or more "enterprise groups" out of the stronger state firms have circulated for years. The revelation of extensive problems within the *chaebol* groups in the course of the financial crisis discredited policies to build up national champions out of SOEs, and strengthened the hand of those like Premier Zhu Rongji who had been known to be skeptical about such programs.

Yet the Asian crisis, exploding in mid-1997, followed in the wake of a set of Chinese domestic policy changes that had already altered the economic context in which technology and industrial policy choices would be made. A series of reforms during 1993-95 had changed the institutional foundations of the economy. Tax reform placed enterprises on a more nearly level playing field; labor reforms gave enterprises the right to lay-off surplus workers; and financial reforms gave the banking system some insulation from pressures to prop up unsuccessful firms. As a result, the pace of credit creation and monetary growth slowed, and the economy began to move away from an inflationary shortage economy, and toward a much more competitive economy.[29]

From the beginning of 1997, China's inflation rate dropped into the single digits, and Chinese economists proclaimed a successful "soft landing." Meanwhile, steady increases in production capacity—some created by FDI inflows—combined with consistent restraint in aggregate demand has led to enormous increases in the degree of competition in domestic markets. Increased competitiveness has been used to drive an impressive shrinkage of the public enterprise sector. Urban publicly-owned industrial enterprises shed almost half of their labor force between 1992 and 1999, dropping from 81 million to 41 million total employees.[30] With these changes, the ability of the central and local governments to prop-up public enterprises or subsidize their technological expenses has been severely curtailed.

Moreover, during the course of 1997 political changes were underway that strengthened central leaders like Zhu Rongji, and ensured that they were better positioned politically to follow up on their pro-market policies, and on their skepticism towards extensive promotion of "national champions." These political changes culminated in the 15th Party Congress in November 1997 and the installation of Zhu as Premier in March 1998—after several years in which he had been the de facto economic "czar"—shifted the balance of forces in the national government. Committed to the substantial downsizing of the state

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[29] For an earlier, more detailed, account, see Barry Naughton, **"**China: Domestic Restructuring and a New Role in Asia**,"** in T. J. Pempel, ed., *The Politics of Asian Economic Crisis.* Ithaca: Cornell University Press, 1999. Pp. 203-223. In this case, the Japanese analogy is to the Matsukata deflation.

[30] *Zhongguo Tongji Zhaiyao [China Statistical Abstract] 2000*, Beijing: Zhongguo Tongji, p. 38. This includes both state-owned industrial enterprises and urban collectives.

sector, Zhu helped initiate massive layoffs at SOEs and a significant shrinkage and restructuring of government organs. The number of ministries was reduced, and ministerial level personnel cut by 49 percent.

These reforms helped private and non-governmental enterprises. The now weakened industrial ministries had advocated solutions that stressed protection and new resources for their subordinate enterprises. The Economics and Trade Commission favored engineering centers. Advisers at the State Science and Technology Commission (now renamed the Ministry of Science and Technology) had always supported policies that were favorable to start-ups, small firms, and venture capital. [31]

Moreover, the impact of the Asian crisis and the changed perception of the *chaebol*, were just part of a broader shift in views about the nature of a successful economy that could be competitive internationally. The dramatic explosion of the Internet and related digital technologies in China has received significant coverage in the popular press, and it has also significantly influenced how Chinese leaders think about innovation. Small smart-up companies appear to have been the engine of this wave of innovation in the West, and Chinese leaders are anxious not to miss out on the benefits of rapid technological change, as they had in the 60s, 70s, and 80s. Especially significant has been the fact that many Chinese scientists and engineers have played a significant role in the most recent wave of innovation and are particularly prominent in Silicon Valley. The striking role of these entrepreneurial engineers has elicited policies designed *both* to reverse part of China's serious brain drain, and to make government policy more friendly to innovation and the creation of new businesses. Numerous localities have begun setting up special centers offering free rent and other benefits to lure young entrepreneurs home. Beijing, for example, has announced the establishment of a Silicon Valley recruitment center in a bid to attract students to return to China.[32] Taiwan's experience with initial brain drain leading to later technological prowess and creativity has been carefully studied.

These factors, as well as accumulating doubts about the previous polices, have led to important changes in the state's relationship to non-state enterprises and innovation. First, and crucially, there has been a generous expansion of the type of Chinese domestic enterprises that are deemed worthy of support. Instead of favoring large SOEs, the government now supports virtually all technologically advanced enterprises, including small, private start-ups, and technology-intensive spin-offs from schools and research institutes. This reflects the important ideological changes made at the 15th Party Congress in September 1997, which fully acknowledged the legitimacy, contribution, and equal rights of private enterprise for the first time. Simultaneously, it reflects an important shift of perception. Instead of seeing private firms as rivals with publicly-owned enterprises, these firms are now viewed as "national" enterprises: non-state firms can also be the national champions that compete with foreign firms.

Second, the nature of support has changed. Government ministries have been reduced in manpower and mandate, and non-state firms were never subject to the same degree of

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[31] We thank Wenkai He for bringing this point to our attention.

[32] "Beijing Targets High-tech Ex-pats," *South China Morning Post*, January 11, 2000.

government direction as SOEs were. Thus, the ability of the government to manage the process of selecting and importing technology directly has been substantially reduced. Instead, the government provides a kind of across-the-board support for 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.

Third, China has gradually shifted the emphasis of technology absorption policies, encouraging the less tangible forms of technology transfer (i.e. licenses, consultancy, etc.) rather than "hardware" in the form of equipment imports. This shift in orientation, combined with delegation of decision-making to more entrepreneurial organizations, may be yielding some results. As Figure 1 (at end of paper) shows, intangible import of technology in 1998 and 1999 registered significant increases over previous years, while machinery imports declined, due to weak domestic demand.

In these circumstances, a new technology orientation has been shaping up that attempts to address some of the specific needs of the contemporary environment. Venture capital and private firms, in particular, have received unprecedented attention. This policy direction has been crystallized by a late 1999 Decision that puts forth a set of practicable policies to foster domestic technology development.[33] In contrast to the vagueness in the 1993 and 1995 State Council Decision, the 1999 Decision calls for concrete measures to foster high-tech industries and services:

- A fund to support S&T innovation by small and medium-sized enterprises;
- Preference for domestic high-tech products and equipment in government and enterprise procurement;
- A partial tax deduction for R&D expenditures;
- A tax exemption for all income from the transfer or development of new technologies and related consulting and technical services;
- A preferential 6-percent value-added tax rate for software products developed and produced in china;
- Complete deductibility of payroll expenditures for software development and manufacturing companies;
- Complete VAT exemption and subsidized credit for high-tech exports;
- Preferential tax treatment for imports of cutting-edge technologies and equipment not available in china;
- Listing new high-tech companies on the Shanghai and Shenzhen stock exchanges.

In addition, the state will support each year, through interest subsidies, a few technological restructuring projects by large and medium-sized state-owned enterprises that are deemed to be profitable, of strategic significance and merited on scientific grounds. Clearly, the Chinese government does not intend to take a "hands off" attitude

[33] The account in following pages is take from the website of the State Council Development Research Center, http://www.drcnet.com.cn or from http://www.vcchina.com.cn.

toward technological development: they will continue to support favored firms aggressively.

Policies are also being altered to make it possible for technologically inventive entrepreneurs to reap large rewards for their contributions. Inspired by the great success of the alliance of S&T workers with venture capitalists in developed countries, especially in U.S. high-tech industry, the decision called for developing venture capital companies and funds. To stimulate venture capital, China has changed accounting regulations on how registered capital is calculated, and begun to address problems of public sale of companies (or listing on stock markets) in order to provide an exit option for initial investors. Chinese Company Law formerly decreed that a maximum of 20 percent of an enterprise's registered capital could be granted for the contribution of intangible "technology." Originally developed to increase the bargaining power of Chinese firms negotiating with technology-rich MNCs, the 20 percent cap became part of domestic company law as well. The limit has already been abandoned in practice, although new regulations have not yet been issued. Plans for a "growth enterprise market," like NASDAQ in the US, have been approved, but implementation has been put off until after regulatory reforms that will restructure the existing Shanghai and Shenzhen stock markets.

Connected to this focus on non-state actors in technological development is the belief that foreign direct investment will continue and even accelerate in the wake of China's entry into the WTO. In some respects, the focus of contemporary policy is less on maximizing the flow of technological capabilities into China than it is on maximizing the extent to which Chinese domestic firms will be able to master the technologies that are expected to flood into China. This may be realistic, and the pattern of government policy and firm response can be illustrated by recent events in the telecommunications equipment industry.

One of the most impressive Chinese firms to have emerged out of the recent liberalization is a telecommunications equipment manufacturer named Huawei. Huawei was started in an interior city, but moved to the Shenzhen Special Economic Zone in order to take advantage of the greater freedom to source foreign components, travel abroad, and collaborate with foreign firms that the Zone offered. Huawei is an entirely Chinese firm with a national reach. Its 1999 revenues reached US $1.8 billion, almost entirely from selling switches and other infrastructure equipment to provincial telephone authorities (there are almost no consumer products). Huawei is an employee-owned corporation—not a "collective," but a joint-stock company with over 90 percent of its shares held by employees, including the founders and top managers. The right to purchase shares is carefully parceled out as an incentive device, but about 80 percent of employees own shares. Huawei has substantial capabilities: 85 percent of total employees have college degrees, and the average age is 27; in 1998, R&D expenditures were 18 percent of total revenues. Company managers report that there is no government policy favoring them in procurement, but readily acknowledge that Chinese network operators like to purchase from them for emotional and patriotic reasons.[34] Industry analysts in Beijing assert that

[34] Company interviews, Shenzhen, June 20, 1999.

provincial telecom operators have been told that in addition to whatever foreign-invested or foreign suppliers they use, they must also have at least one domestic Chinese supplier. The policy seems to be working: Huawei sold 6.5 million lines in 1998, for a 33 percent market share, and foreign companies respect them as formidable competitors with strong technology and aggressive prices.

Similar policies, with more mixed outcomes, are in evidence in the mobile phone industry.[35] A number of Chinese firms have decided that assembly of mobile phone handsets is a business in which they can compete, particularly in the lower end of the market. The most aggressive entrants have typically not been specialized telecommunications firms, which would have in the past been those selected for government assistance. Instead, the firms are those that manufacture consumer durables, especially color televisions. Prominent examples at Konka and TCL, both diversified and successful consumer electronics firms. These companies purchase chips from Lucent and Siemens, respectively, so they do not seek to replicate core technologies, but instead seek to leverage competitive advantage in assembly, design, and systems engineering into a competitive position in the market. These are not mere "assemblers" — both companies invest substantial sums into firm-level R&D and purchase of intellectual property rights from abroad. Government policy supports these firms through a series of channels. Direct financial subsidies are estimated to have reached 1.4 billion RMB (US $169 million) in 1999, and regulatory favoritism is also evident. Foreign firms have to jump through a number of hoops to establish that their phones reach quality standards and that component imports are all legal. Domestic firms are generally untroubled by such regulatory obstacles.

These measures are still in their early stages, and may not be effective. As of September 1999, 91 percent of mobile phone handsets sold in China was made by the big four foreign producers (Nokia, Ericsson, Motorola and Siemens). Chinese competition had brought down prices, without yet making dramatic inroads into market share. Perhaps more significant, though, Chinese policy, while still attempting to shape market outcomes, is now to a significant extent itself shaped by market processes. The government did not choose the competitors, but elected to support aggressive competitors once they emerged. Moreover, the government dropped its scruples about supporting non-state or mixed ownership firms. The broad categories of “domestic” firms are all deemed worthy of support.

The most successful parts of China’s technological development in recent years appears to be precisely the areas where innovative domestic firms are closely related to FIEs, but engage in complex relations of supply, cooperation and competition. For example, in electronics, Chinese domestic firms have quickly found niches in which they could cooperate with MNCs. Although their initial entry has typically been in relatively low-tech, labor-intensive assembly phases, these firms have been in a position to move

[35] Lester Gesteland, “Chinese Cell Phones Unpopular Despite Strong Official Backing,” *China Online*, December 15, 1999; “Chinese Cell Phone Makers Poised to Take on the Foreign Giants,” *China Online*, December 6, 1999; “The End of Price Wars in China’s Cellular Phone Market,” *China Online*, December 16, 1999, all at www.chinaonline.com/industry/telecom/currentnews.

gradually but steadily into slightly higher technology stages of the complex electronics production chains. This seems to have led to rapid "indigenization" of technological competencies, even while government policy heretofore has stressed the "upgrading" of technological levels at FIEs, only to find that the competencies are bottled up in ventures controlled by foreign-based MNCs.[36] The shift in policy seems to recognize the successes that are being achieved by China's more entrepreneurial domestic firms, and could position China well to take a larger share of the ongoing technological revolution.

A Big Emerging Market and Big Security Concerns

In the background of much of the above discussion about how China has veered from techno-nationalist to techo-globalist policies while promoting an increasingly nationalistic discourse is the fact that China is the largest country in this study. What difference does it make that China is such a big country? First, China's technological development cannot be separated from military and strategic concerns. In the view of Chinese policy-makers, China's earliest defense technology successes –the atomic and hydrogen bomb, and intercontinental ballistic missiles—were key to maintaining autonomy in relation to the states China viewed as the primary threats to its security, first the United States, then the Soviets. The link of technology to military needs and strategic goals is no less clear today. Even before the Kosovo and Taiwan Straits crises, the government increased spending for military research and development under the premise that the Peoples Libertarian Army (PLA) must develop sophisticated weapons to maintain territorial integrity. These concerns have only been heightened by increased tensions with the United States over the last several years. During the last Taiwan crisis, Jiang Zemin reportedly linked a "sound base in technology and national defense" to the success of the mainland's reunification enterprise.[37] Economic and foreign policy concerns may also overlap at the level of sanctions or the use of other economic weapons. In its purchase of 28 aircraft valued at $1.8 billion from European consortium Airbus, China was seen as using checkbook diplomacy to drive home displeasure with US policy over Taiwan.

As noted above, the Chinese self-perception is that it deserves a broad, well-lit place on the world stage. A recurrent theme in Chinese strategic writing is the idea that those with strength will (and should) use it; thus, weak states will be humiliated, and therefore military strength is indispensable.[38] Moreover, since people are forward-looking, it follows that existing powers—like the US--will resist the dilution of their current predominant position and try to block China's emergence. Chinese policy-makers

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[36] The precise contrast between indigenization and upgrading is from Greg Felker, "Malaysia's Industrial Technology Development: Firms, Policies, and Political Economy," in Greg Felker and Jomo K.S., eds., Malaysia's Industrial Technology Development. London: Routledge, 1999; See also Barry Naughton, "Technological Development, Production Networks, and IPR: How the Global Revolution in Electronics Affects China's Optimal Technology Policy," National Bureau of Asian Research Working Paper, March 1999.

[37] Willy Wo-Lap Lam, "Jiang Boosts Defense Funding," *South China Morning Post,* December 1, 1999

[38] For an interesting discussion, see Johnston, Alastair I. (1996), "Cultural Realism and Strategy in Maoist China," in Peter J. Katzenstein, ed., *The Culture of National Security: Norms and Identity in World Politics.* New York: Columbia University Press.

believe that they will be forced to develop a substantial degree of technological self-sufficiency because real technology dependency will inevitably provoke attempts by the United States and others to exploit that dependency when a backlash develops against China's rise. At the same time, though, Chinese military planners have absorbed many of the same lessons that Chinese economic planners have absorbed: the determinants of security are no longer to be found solely or even primarily in the big-ticket deterrent weapons, but increasingly depend on sophistication in the information revolution. Yet such sophistication is hard to purchase with government dollars, and requires a flexible and innovative civilian economy.[39] Undoubtedly, such views encourage more adaptable civilian technology policies; but at the same time, such a worldview certainly will not foreswear government-direct technology initiatives, either. Though we do not discuss the military-technology complex in this paper, there is no doubt that it retains an important role in China.

A second implication of China's large size is that the emerging scope of China's domestic market gives technology policy an additional element of leverage. In the first place, domestic Chinese firms could have substantial long-run advantages because of their intimate knowledge of the large and growing Chinese market. As that market increasingly comes to define its own technological standards (as has already happened, for example, with VCDs, a product in which China claims the bulk of the world market). Chinese firms will emerge in better position in subsequent decades than they have experienced heretofore.

A more pointed implication is that the Chinese government can use the advantage of market size to influence the process of standard-setting in the information economy. Like the rest of us, Chinese policy-makers have taken note of the importance of market size and lock-in effects in determining which technological standards predominate—and of the fact that "ownership" of the dominant standards confers competitive advantage. This point may be best illustrated by the government's promotion of software companies like Red Hat working on Linux operating software and of its advocacy of domestic users adopting the operating system over Microsoft. Linux's open source code makes it easy for local users to modify and customize to local conditions. Moreover, China is currently unable to compete in the domestic market for Windows-related software. Chinese computer programmers and companies, however, could play a much bigger role in the Linux world.[40]

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[39] For some of the most interesting examples of current Chinese thinking on military and technology issues, see Qiao Liang and Wang Xiangsui, *Chaoxianzhan: Dui Quanqiuhua Shidai Zhanzheng yu Zhanfa de Xiangding [Unrestricted Warfare: Thoughts on War and Strategy in the Era of Globalization]*. Beijing: Jiefangjun Wenyi, 1999; and Zhang Zhaozhong, *Xia Yige Mubiao Shi Shei? [Who is the Next Target?]*, Beijing: Zhongguo Qingnian, 1999. Exerpts from these works are translated on the U.S. Embassy website, www.usembassy-china.org.can/english/sandt/unresw1.html

[40] G. Pierre Goad and Lorien Holland, "China Joins the Linux Bandwagon," *Far Eastern Economic Review*, February 24, 2000. Some important concrete steps have followed, including IBM's agreement to pre-install Redflag-Linux OS 2.0 in its large-scale S/390 computers in China. See "IBM, Redflag-Linux team on Linux development." *China Online*, August 24, 2000, reporting on an article from *Zhongguo Jingji Shibao*.

Promotion of Linux may also ease Chinese fears of dependence on Microsoft and the United States. The Chinese government suspects that Windows has "back doors" that allows the company or the US to spy on users. In an editorial on "information colonialism," the People's Liberation Army Daily argued that China must develop its own software since "without information security, there is no national security in economics, politics, or military affairs."[41] According to one official, "maintaining independence and keeping the initiative over our own operating system will be the 'Two Bombs and One Satellite (i.e., intercontinental missile) of the new era."[42]

A similar example may be unfolding with respect to mobile phone standards. Globally, two digital telecommunications standards have been in competition since the mid-1990s. Worldwide, GSM, the European standard, has maintained a lead over CDMA, the US standard, despite the technological superiority of CDMA, because GSM was first to market, and has been supported by a steady stream of consumer-friendly product innovations. GSM is now well established in China, while CDMA has never quite been able to break into the Chinese market, despite successful demonstration projects as early as early 1994, and the adoption of the CDMA standard by Korea in the fall of 1993.[43] The internal mechanics of Chinese decision-making with regard to digital telecommunications standards remains opaque to even the best-informed industry observers, but one suspicion has seemed increasingly likely in recent months. The suspicion is that Chinese policy-makers intentionally slowed down the introduction of CDMA because they were unwilling to support the emergence of still another globally dominant US-based technological standard.

In this interpretation, Chinese policy-makers were willing to delay China's adoption of so-called "second generation" digital wireless standards in order to increase their influence over the configuration of the subsequent "third generation" (3G) digital wireless standards, which were just becoming operational during the second half of 2000. This may not be wishful thinking: in early 2000, China surpassed Japan as the second-largest mobile phone market in the world, with 51.7 million users.[44] While all 3G standards mix elements of GSM and CDMA, there is still competition between 3G standards that are backwards-compatible with existing GSM operations (so-called wideband CDMA of WCDMA) and those that are backwards-compatible with existing CDMA operations (CDMA 2000), supported by European and US firms respectively. China's determination to play a role became clear when it announced its own 3G standard, called TD-SCDMA, for which it achieved approval by the International

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[41] Chen "Guanzhu 'Xinxi Zhimin Zhuyi' Xianxiang," [Concerning Information Colonialism] *Jiefangjun Ribao* [*PLA Daily*], February 8, 2000.

[42] "China to Ban Government Use of Windows." Reuters, January 6, 2000. Officials at the Ministry of Information Industry later denied the ban, but the point, and the worry is the same.

[43] Barry Naughton and John Norton, *Qualcomm in China: A Telecommunications Licensing Negotiation Exercise in Two Parts*. San Diego: University of California, San Diego Graduate School of International Relations and Pacific Studies, Revised Edition, 2000.

[44] "China succeeds Japan as largest cellphone market in Asia-Pacific region," *China Online,* August 23, 2000, reporting on *Zhongguo Xinwen She.*

Telecommunications Union (ITU) in August 2000.[45] The standard was developed by a Chinese SOE, Datang Telecom, in conjunction with a research institute of the Ministry of Information Industry, with technical assistance from Siemens. The standard is, no surprise here, closer to WCDMA than to CDMA 2000, and promises backward compatibility with GSM operations. Industry technical experts consider it too little, too late, but do not rule out the possibility it can have an impact on the overall standard-setting process.

What is of interest in this case is the way that techno-nationalism has been elevated to the global plane and given a strategic dimension, in the sense that behavioral interactions with other global players are incorporated. The contrast with Korea's strategy is significant: Korea moved aggressively to be an early adopter of CDMA, paying a high price in royalties and license fees, but successfully establishing an equipment industry with strong export competitiveness. Korean planners chose a fast-follower strategy, accepting (or gambling) that the technological superiority of CDMA would lead to US predominance.[46] By contrast, China, even though its manufacturing capabilities are much weaker than those of Korea, has been emboldened to play a global strategic role because of its confidence in the current--and especially future--importance of the Chinese market.[47]

The promotion of technical standards in which Chinese producers may have a future advantage is a good example of how China's future technology policy may be techno-nationalist in spirit, even if specific policies diverge from those found in past techno-nationalist programs. The promotion of the open Linux operating system is motivated by both economic and security concerns. Government leaders hope that Chinese companies can play a dominant role in a new market, and reduce the country's dependence on U.S. multinationals. But many of the companies the government hopes will lead the charge are non-state enterprises. Red Flag, for example, is backed by the Chinese Academy of Sciences and the Founder Group, a company spun off from Beijing University. The government is no longer concerned that a company is from the public sector, just that it can compete on international markets and that it is Chinese.

Conclusion

Notions of techno-nationalism are still relevant in China, even as it moves towards reduced government steerage of the economy. China's size gives it a strategic sensitivity, as it worries about the impact of its own size and growth on the attitude of outside

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[45] "International telecom union adopts China's TD-SCDMA 3G mobile standard," *China Online*, August 15, 2000, reporting on August 11, 2000 *Caijing Zazhi[Finance Magazine]* report. At www.chinaonline.com/topstories/000815/1/c00081107.

[46] Korean critics of that decision now abound, and they point to China's stance as a tougher, more nationalistic policy that they feel Korea should have followed. In that sense, China's stance has re-legitimated hardball policies to some sections of the Korean public.

[47] In the case of telecommunications standards, the exogenous technological trends may be pushing the competing standards together into a consolidated or hybrid standard. To the extent this turns out to be true, we expect China to become more enthusiastic about CDMA, and simply use its own standard as a bargaining point in discussions about royalties.

technology suppliers. But at the same time, because of its size, China has an impact on global standard-setting that certainly can be used to its advantage. Moreover, the Chinese government is constantly casting about for factors that justify its continuing hold on power and its extensive involvement in the economy. Chinese policy-makers long ago gave up on the idea that they could steer and shape the entire economy. But worldviews that legitimate continued government intervention in the economy—even if those interventions are selective—serve a useful domestic political purpose. This is especially true when the Chinese government actively promotes a view of itself as the strong defender of China's national interests and pride. Ironically, under current conditions such a worldview can also be used to justify a much more market-oriented policy towards domestic enterprise and domestic private ownership. China must privatize, precisely because only privatization can assure a strong national economy. For all these reasons, techno-nationalism lives in China.

But the continuing vitality of techno-nationalist views in China also needs to be seen in context. That context includes the failure of large government-sponsored business groups to succeed on any significant scale. It includes an increasingly broad-based view that the key actors in the next phase of technological development are likely to come from a rich entrepreneurial seed-bed rather than nurtured national champions. The future context will also have to factor in compliance with WTO provisions that further limit the ways the government can intervene in economic processes. In summary, the future is likely to display the continuing salience of techno-nationalist attitudes, but without the coherent, tightly integrated policy package that supported techno-nationalism in Japan during the 1950s through 1970s. China will select bits and pieces of preferential policies, designed to advance techno-nationalist ideals within the context of a fiercely competitive and fairly open domestic economy. Such policies will often seem to lack intellectual coherence, and represent purely adaptive, opportunistic policies of "muddling through." In the past, though, "muddling through" has been a fairly effective approach for policy-makers trying to cope with China's diversity and dynamism. Perhaps it will be in the future as well.