Patterns of Chinese Policies on Technology Transfer

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High-technology issues have dominated U.S.-China relations in the last years of the twentieth century. In sectors related to national security, allegations of compromising transactions and thefts of proprietary American commercial and military technology plagued bilateral ties in the late 1990s. The apparent transfer of sophisticated space-launch information prompted a congressional investigation of two major U.S. multinationals, Hughes Electronics and Loral Space and Communications. Then, allegations of Chinese espionage at U.S. nuclear weapons laboratories produced a bipartisan Select Committee, chaired by Representative Christopher Cox (R-Calif.), charged with scrutinizing all aspects of U.S.-China technology relations, from corporate technology transfers to academic exchanges of scientific personnel between the two countries.

In the economic realm, even as China negotiated its entry into the World Trade Organization (WTO), technology bureaucrats defied trends in the global high-tech economy by announcing their intention to impose new restrictions on foreign investment in high-growth, high-profit technology industries. The November 1999 agreement on China's entry into the WTO appears, for the moment, to have reversed these policies. But implementation and compliance remain important question marks. Moreover, the sheer persistence of such restrictions twenty years into China's process of economic internationalization is astonishing. In the weeks leading up to the November 1999 WTO agreement, China's powerful minister of the information industry, Wu Jichuan, reaffirmed a long-standing ban on foreign equity participation in both Internet service and content providers. This defies a world reshaped by venture finance and reinforces a commitment to regulatory roadblocks in China's telecommunications industry at a time when Web-based communication and electronic commerce have mushroomed in China. Predictably, the restrictions became a major point of contention in U.S. talks with Beijing over China's entry into the WTO. While China's trade bureaucrats bargained in October and November 1999, Wu's ministry also hinted at a major new program of state subsidies, incorporating new protections, to Chinese cellular handset manufacturers. Absent the WTO agreement, the government flirted

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with introducing strict market-share ceilings for the three major brands in the Chinese market, all of them foreign: Motorola (U.S.), Nokia (Finland), and Ericsson (Sweden).

Despite its aspirations to become a global leader for technological innovation and manufacturing, then, many of Beijing's policies continue to defy accepted wisdom about the borderless world of technology and the utility of unfettered markets. Technology has radically transformed the Chinese economy. Yet in at least some top-priority areas, it seems to have had little impact on the state's *political* relationship to the marketplace. So much for the borderless world.

For more than two decades, China's broad-ranging efforts at economic reform have reserved an important role for foreign trade and joint venture arrangements. Notwithstanding the government's restrictions in high-tech industries, foreign direct investment (FDI) has played a significant part in the drive toward economic modernization since the death of Mao Zedong in 1976 and the promulgation of a new national economic strategy in 1978.

Most accounts of China's reform process have focused on this large-scale shift of economic development strategy. They suggest—rightly—that the policies associated with China's effort to "open up" (*kaifang*) to the outside world since 1978 represent one of the most sweeping breaks with the country's Maoist past (1949–76). After the Sino-Soviet split of 1960, after all, Chinese leaders pursued "self-reliance" (*zili gengsheng*) as a matter of state policy. Even before the Sino-Soviet split, at the height of bilateral cooperation in 1958, Chairman Mao asked rhetorically: "If we should unduly stress reliance on Soviet aid, let us ask on whom the Soviet Union depended for its help?"[1] This presaged a drift toward autarky that accelerated after the withdrawal of Soviet assistance in 1960.

Despite the scholarly emphasis on a break after Mao, important continuities explain the persistence of industrial-policy thinking in China today. These continuities are specific to technology policies and industries. But they comprise an important part of China's economic policy choices from 1978 to the present. In addition to the obvious profit motives, restrictions and subsidies in sectors now acknowledged by Beijing to thrive in a borderless world can be attributed to two central tenets of Chinese technology policy over the last five decades:

"Whatever they have, we must have too." Since the establishment of the People's Republic of China (PRC) in 1949, Chinese leaders have struggled to overcome three centuries of pervasive technological backwardness (*luohou*). Beijing has employed a variety of national policy

1. Mao Zedong, "Speech at the Group Leaders Forum of the Enlarged Conference of the Military Affairs Commission," *Chinese Law and Government* 1 (Winter 1968/69), 16.

instruments—domestic investment, overseas purchases, legal and tax advantages for licensing and co-production with foreigners, and so on—to acquire technologies deemed by the leadership's technical advisors to be of an international "standard" (*biaozhun*) and of "strategic" (*zhanlüe*) importance to the state. China has, essentially, sought all technologies possessed by the great industrial and military powers (*daguo*), from military to industrial process systems.

Management consultants term this process "benchmarking." Yet it has required that a backward China leapfrog many basic mid-range technologies to seek the most advanced systems. As economists who study China have pointed out, working from the top downward rather than vice versa is a curious way to build a technology base.

"Indigenize to avoid external dependence." Since 1949, Chinese leaders have sought to indigenize what government advisors have deemed "essential" technologies—products and processes considered indispensable to Chinese national security or economic competitiveness. Beijing has always supported purchases from abroad or co-production of technologies with foreigners. This was true under Mao and remains true today. The government has, however, held freedom from external dependence as an absolute, consistent, and unwavering aim. This "technonational" impulse flies in the face of China's growing integration into the global economy. And it contains built-in contradictions, since China must *further* integrate into international manufacturing, finance, and commerce in order to gain access to many of the technologies it seeks to indigenize.

It is this contradiction that defines much of the PRC's struggle to modernize. China's technology and economic policies have long reflected a deep-seated nationalist impulse. But technological backwardness has repeatedly forced policymakers to compromise these principles. In effect, the Chinese government must square a circle. To build a strong nation requires compromises that further integrate China into the very international system that crude variants of Chinese nationalism so distrust.

What follows is a descriptive summary of several principles that have defined China's technology acquisition strategy since the mid-1950s. How these principles shaped important aspects of policy and behavior in China's most sweeping acquisition effort under Mao—the Sino-Soviet technology relationship of the 1950s—is the subject of the second section. Finally, I describe changes since Mao's death in 1976 and note how fundamental principles continue to shape aspects of technology transfer behavior amidst the wide-ranging transformations associated with economic globalization.

The key themes are policy continuity—what economic historians term "path dependence"[2]—and the persistence among certain Chinese policy constituencies of ideas rendered increasingly anachronistic by globalization. Although dramatic changes in Chinese economic and technology policy since the late 1970s are well documented,[3] less clear are the assumptions and state-led development strategies of a bygone era that continue to define Chinese attitudes. The political economy of Sino-Soviet technology relations in the 1950s—an economic arrangement made possible by a strictly political alliance between strategic and ideological partners—could not possibly be more distinct from the world that has brought U.S. auto negotiators and the representatives of major multinationals to China in the 1980s and 1990s. And yet continuities across both periods explain why so many Chinese companies and bureaucracies still pursue blatantly nationalistic policies of technology indigenization. They may also reveal why China continues to face enormous obstacles in its effort to absorb technologies essential for infrastructure and production modernization.

Essential Principles

China's Communist leaders came to power in 1949 deeply committed to broad-based modernization of the country's strategic industries. These included capital-intensive heavy industries, such as iron, steel, mineral mining, and petrochemicals, as well as military-related industries, from aircraft to electronics to ordnance. Three facts best illustrate this commitment:

First, despite the peasant revolution that brought the Chinese Communist Party (CCP) to power, post-revolutionary policy squeezed the rural sector to develop a heavy industrial base. As the sociologist Mark Selden notes, "With the establishment of the People's Republic [PRC],

2. Douglass C. North, *Institutions, Institutional Change, and Economic Performance* (Cambridge, England, 1990); Paul A. David, "Clio and the Economics of QWERTY," *American Economic Review* 75 (1985), 332–37. See also Robert D. Putnam, *Making Democracy Work: Civic Traditions in Modern Italy* (Princeton, N.J., 1993).

3. On foreign investment, see esp. Margaret M. Pearson, *Joint Ventures in the People's Republic of China: The Control of Foreign Direct Investment under Socialism* (Princeton, N.J., 1991) and Nicholas D. Lardy, *China and the World Economy* (Washington, D.C., 1994). On key shifts in Chinese technology policy during the post-Mao transition, see Office of Technology Assessment, U.S. Congress, *Technology Transfer to China* (Washington, D.C., 1987); Richard P. Suttmeier, *Science, Technology, and China's Drive for Modernization* (Stanford, Calif., 1980), chap. 1; Denis Fred Simon and Merle Goldman, eds., *Science and Technology in Post-Mao China* (Cambridge, Mass., 1989); and Evan A. Feigenbaum, *The Military Transforms China: The Politics of Strategic Technology from the Nuclear to the Information Age* (Ph.D. diss., Stanford University, 1997), 290–377.

the focus of the party's development policy and priorities shifted from the countryside to the city and from agriculture to industry."[4] This was accomplished by "price scissor" policies, in which the state held the price of rural outputs at low levels while raising prices for agricultural inputs, such as machinery, film mulching technology, and fertilizer.

Second, the shift away from the countryside to capital-intensive heavy industry was reflected in Chinese allocation priorities in the early years of the new regime. Instead of investing in the peasant constituencies that had catapulted it to power, the CCP prioritized heavy industry to an extent greater than even its Soviet counterpart, particularly during the first and second Five Year Plans.[5]

Third, Chinese leaders relentlessly pursued advanced technology, even in areas considered too esoteric for developing countries. And they sought technologies in areas where leadership rhetoric belittled the importance of the mere possession of the hardware. In the first category, Beijing in the late 1950s pursued an array of delivery systems for nuclear weapons that were so expensive that Chinese planners had to divert priority monies from more realistic projects. The 1958 decision to acquire a nuclear-powered submarine was made at a time when China faced several pressing development needs and possessed little physical or human infrastructure to develop such a technology. The effort consumed enormous expenditures from the late 1950s to the 1970s.[6] In the second category are boosted-yield and thermonuclear weapons. Chinese leaders, particularly Mao Zedong, routinely dismissed nuclear weapons in public statements as "paper tigers" that were "unable to decide wars."[7] But Beijing's relentless pursuit of advanced, boosted-yield weapons after rudimentary systems were acquired in 1964 indicates a private faith in the nuclear option.

Such a strong commitment to industrial modernization compelled China, with little technical infrastructure of its own, to acquire technology from overseas. But the Communist victory, particularly after the Sino-Soviet treaty of friendship of 1950, destroyed most of China's

4. Mark Selden, *The Political Economy of Chinese Development* (Armonk, N.Y., 1993), 11.

5. K. C. Yeh, "Soviet and Chinese Industrialization Strategies," in Donald W. Treadgold, ed., *Soviet and Chinese Communism* (Seattle, Wash., 1967), 326–63.

6. The story is well told in John Wilson Lewis and Xue Litai, *China's Strategic Seapower: The Politics of Force Modernization in the Nuclear Age* (Stanford, Calif., 1994).

7. On the "paper tiger" theme, see Alice Langley Hsieh, *Communist China's Strategy in the Nuclear Era* (Englewood Cliffs, N.J., 1962), 131. Mao made his well-known remark about nuclear weapons being "unable to decide wars" in the wake of the U.S. atomic bombings of Japan in August 1945. See "The Situation and Our Policy After the Victory in the War of Resistance Against Japan" (13 Aug. 1945), in *Selected Works of Mao Tse-tung*, 5 vols. (Beijing, 1961–77), 4:21.

ties with its pre-1949 trading partners. The result was a politicization of technology acquisition policy marked by three principal elements: *Technology policy as foreign policy:* The government would compensate for a lack of traditional forms of international intercourse by pursuing technology transfer as a matter of foreign policy. *A pivotal role for the center:* A pivotal role would, thus, be played by the state, particularly by the central government apparatus, not simply by state enterprises or provincial or local authorities. *Technology bundled into grand strategy:* With intimate central government involvement, technology acquisition would be tied to the *strategic* aims of the Center.

The result, as I have argued elsewhere, was a close connection between technology and strategy that privileged military programs.[8] Ultimately, this produced a Chinese variant of what historian Walter McDougall has termed "technonationalism," or "technological nationalism." Chinese leaders came to regard technology acquisition as primarily a political, rather than an economic, matter.[9] Technology, many Mao-era leaders believed, would have obvious and important economic effects. But first and foremost were implications for Chinese national power. China's leaders came to regard technology investment as an intrinsically strategic undertaking, serving the explicitly political end of enhancing relative national power and wealth on the global stage. Indeed, early Chinese efforts to acquire, nurture, and diffuse technology focused on advanced systems central to capital-intensive, heavy and defense-oriented industrialization.

Beijing did not ignore other programs. Agricultural machinery, for example, became a particularly important focus of Sino-Soviet cooperation in the 1950s. But military and capital-intensive sectors absorbed much of the investment that could have been devoted to more basic technologies, such as rural and light industrial equipment and machinery. The early Communist state never espoused the commercial goals so essential to the Japanese variant of technonational development ideology.[10] Thus, although assistance from the Soviet Union—

8. Evan A. Feigenbaum, "Soldiers, Weapons, and Chinese Development Strategy: The Mao Era Military in China's Economic and Institutional Debate," *China Quarterly,* no. 158 (June 1999).

9. See, for example, Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York, 1985). I have also borrowed from the political scientist Richard J. Samuels. See his *Rich Nation, Strong Army: National Security and the Technological Transformation of Japan* (Ithaca, N.Y., 1993). Richard P. Suttmeier, a political scientist writing on China, uses the term "technological nationalism" to evoke a similar idea. See his "Conclusion: Science, Technology, and China's Political Future—A Framework for Analysis," in Simon and Goldman, 378.

10. Samuels, *Rich Nation, Strong Army.*

China's major source of technology from 1949 to 1961—had an impressive and important impact on rural and light industrial sectors, military priorities and facilities devoured nearly one-third of all Soviet technical aid. Fully 30 percent of the approximately 250 industrial facilities made available by the Soviets to the Chinese had military applications. Forty-one of the 156 "key industrial facilities" offered under an initial 1953 Sino-Soviet technical accord were connected to weapons production. Most of the more than U.S.$2 billion in credits extended to Beijing by Moscow during the 1950s was used for weapons purchases.[11] And Chinese leaders forcibly switched nearly all Chinese students pursuing technical subjects at Soviet institutions to military-related disciplines.[12]

National Security and "Late" Development: Two Sides of a Coin

The rapid militarization of China's technology transfer policy during the 1950s reflected two principal policy concerns. The first was national security, particularly protection of the new Communist regime. Military power deterred foreign efforts to reverse China's revolution, either through direct subversion or via support to the Guomindang in Taiwan. Meanwhile, China's first and second Five Year Plans in the 1950s made rapid industrialization a national priority. Militarization and late industrialization thus became intimately linked in Chinese trade and technology transfer policies.

Such a linkage is hardly novel. It derives both from mercantilist theory and later efforts to tie economic nationalism to defense and manufactures. In his 1791 "Report on Manufactures," Alexander Hamilton linked the concept of "infant" national industry to autarky.[13] Several decades later, German economist Friedrich List identified national power as the primary concern of economic policy.[14] Political and economic theorists, from Barrington Moore to Alexander

11. Sergei Goncharov, John W. Lewis, and Xue Litai, *Uncertain Partners: Stalin, Mao, and the Korean War* (Stanford, Calif., 1993).

12. Nie Rongzhen, *Nie Rongzhen huiyilu* (Memoirs of Nie Rongzhen), 3 vols. (Beijing, 1983–86), 3:chap. 24.

13. Edward Mead Earle, "Adam Smith, Alexander Hamilton, Friedrich List: The Economic Foundations of Military Power," in Peter Paret, ed., *Makers of Modern Strategy: From Machiavelli to the Nuclear Age* (Princeton, N.J., 1986), 234.

14 "The object of the economy," List wrote, "is not only wealth as in individual and cosmopolitical [*sic*] economy, but power and wealth, because national wealth is increased and secured by national power, as national power is increased and secured by national wealth. Its leading principles are therefore not only economical, but political too." Ibid., 247. As Edward Mead Earle has argued, although List did link power with welfare, his primary intellectual orientation was to mercantilism.

Gerschenkron, have shown how the development of infant industries in late-comer societies, such as Germany and Russia, became linked to hegemonic forms of state power and militarization. The same was true of China under Mao. But the immediacy of China's national security threat during the 1950s accentuated the military rationale for industrialization to a greater extent than in other late-developers, including China's Asian neighbors. Like their Japanese counterparts, Chinese policymakers came to view economic policy as a strategic enterprise. But this had no substantive commercial underpinnings in China. The Maoist state had little interest in developing markets, and its leaders worried throughout the 1950s about state survival in the face of external subversion.

In practice, Chinese technology acquisition policy thus became tied not just to national political goals but to the immediate problem of national security. So long as military concerns held priority, freedom from dependence on foreign partners remained critical. At the height of Sino-Soviet technical collaboration, Chinese leaders, not least Mao himself, stressed the need to avoid "blind faith in foreigners."[15] And the extraordinarily strong sense of betrayal felt after the Sino-Soviet split of 1960 instilled in an entire generation of Chinese technology policymakers a desire for complete indigenization/self-reliance even in a partnership or alliance. Marshal Nie Rongzhen, leader of China's strategic weapons programs and civilian high-technology efforts, told Politburo colleagues in January 1960 that the Soviets were determined to "maintain their superior position" (*baochi lingxian diwei*). The Soviet strategy was "always to keep [China] two or three steps behind" (*yongyuan luohou ta liang san bu*).[16] Likewise, in 1964, Beijing described all Soviet aid as a reflection of Moscow's own self-interest and encumbered by strings designed to keep China in an inferior position. Moscow would have never extended nuclear aid, the Chinese argued, had the Soviets not sought Chinese mineral resources for their own strategic weapons programs.[17]

China ultimately became isolated from potential technology and trade partners, both capitalist and Communist. It is easy in retrospect to confuse China's "self-reliance" and "independent development"

15. Mao Zedong, "Speech at the Group Leaders Forum," 18.

16. See Nie, *Nie Rongzhen huiyilu*, 809.

17. See "Letter of the Central Committee of the CPC of February 29, 1964 to the Central Committee of the CPSU," in *Seven Letters Exchanged Between the Central Committees of the Communist Party of China and the Communist Party of the Soviet Union* (Beijing, 1964), 21–41. In fact, as I have argued elsewhere, the Chinese overstated their case, and Nie severely misinterpreted the reasons behind Moscow's refusal to provide certain types of military technological aid. See Feigenbaum, *The Military Transforms China*, 57–58.

(*duli zizhu*) with autarky. But autarky was never Beijing's intention. Rather, larger political events—a Sino-Soviet split dependent as much on politics, nationalism, and clashing security concepts as on ideology—forced China's technology system into a state of nearly complete "self-reliance."

Zili gengsheng referred, first to the relationship between the state and economic development, for in practice, "self-reliance" meant that China would acquire external technologies while planning for a future, potentially far down the road, free from the shackles of dependence. China needed an indigenous high-technology research and development (R&D) system. But it would have to follow a series of preliminary stages involving partnerships, licenses, co-production arrangements, and direct foreign aid. Although the long-term goal was freedom from dependence, the initial Chinese variant of technonationalism thus placed considerable emphasis on external assistance.

Policy and Practice in the 1950s, Change and Reorientation in the Early 1960s

Because this Chinese technonationalism made an explicit connection between technology, national security, and relative economic welfare, China's most significant early technology transfer relationship—its partnership with the Soviet Union—emphasized technologies relevant to a broad array of capital-intensive industries (metals, chemical composites and synthetics, fuels, military industries).

Soviet assistance was crucial to China across the board.[18] Indeed, the most active era of Sino-Soviet exchange was characterized by the acquisition of complete technology "systems." This meant interest in all types of transfers—complete physical plants, education and training for Chinese personnel, advisory assistance by foreigners on the ground in China, and a supply of blueprints and knock-down kits to facilitate Chinese learning from the bottom up. This emphasis on both hardware and software acquisitions is significant. After the Sino-Soviet split in the early 1960s, the Chinese mostly abandoned their em-

18. See, for instance, Li Debin, "Wushi niandai wo guo yinjin jishu shebei de wenti" (The issue of our country's importation of technology and equipment during the 1950s), *Beijing daxue xuebao* (Beijing University Journal), Philosophy and Social Science Series (April 1985). While condemning Moscow's betrayal, the Chinese admitted even after the Sino-Soviet split that Soviet assistance had been extraordinarily important and useful. See "Letter of the Central Committee . . . ," 24. See also Goncharov, Lewis, and Xue, *Uncertain Partners,* which clearly disproves older accounts that argued that the Soviets *actively* refused to assist China's technological ambitions.

phasis on software in all but the strategic weapons sector[19]—nuclear weapons, strategic missiles, nuclear submarines, satellites, and auxiliary areas such as supercomputing.

Most significant in Sino-Soviet technology relations was the mutual frustration produced by China's technonational rationale. Beijing condemned its "ungenerous" partner and Moscow fumed at Beijing's "ingratitude." China's linkage of technological ambition with strategic concerns for national wealth and power destroyed the Sino-Soviet technology relationship. It may also have contributed to the collapse of the alliance.

The Soviets, for example, offered generous nuclear and missile aid, including training for fifty Chinese rocketeers at the Moscow Aviation Institute,[20] and a full "Soviet Army missile battalion with two R-2 missiles and their associated launching equipment." The battalion reached China in December 1957. Beijing subsequently redubbed the missile "1059," purchased twelve more, and received blueprints and technical documents (totaling 10,151 volumes) relevant to the manufacture, testing, and launch of the missile.[21] This transaction was one of the most important items on China's wish-list, and it followed a broad-based transaction agreement on "new technologies" (a euphemism for strategic weapons and auxiliary electronic systems) signed in October 1957.[22]

But this did not satisfy Beijing, which sought complete indigenization of strategic technologies as quickly as possible. Prob-

19. The existence of political guarantees—enforced at the top of the political and military systems—provided "space" for innovation and experimentation in the strategic weapons sphere. This is a major theme of Feigenbaum, "Soldiers, Weapons, and Chinese Development Strategy." The strategic weapons experience—China's "highest" tech sectors from 1955 to 1985—provides a stark contrast to the rest of the Chinese R&D system, where intellectual and human resources came under enormous political pressure throughout the period of Communist rule. The continuing emphasis on software as a means to innovate and thus produce hardware also contrasts with the increasingly hardware-focused paradigm that governed the rest of the Chinese R&D system after 1960.

20. On Chinese engineering students and the priority of missile-related subjects, see Nie's recommendations to Prime Minister Zhou Enlai, "Jiaqiang wo guo yanzhi daodan wenti de baogao" (Report on how to strengthen our country's missile research and development), 25 Oct. 1956, in *Nie Rongzhen junshi wenxuan* (Selected military works of Nie Rongzhen) (Beijing, 1992), 409–11.

21. John Wilson Lewis and Hua Di, "China's Ballistic Missile Programs: Technologies, Strategies, Goals," *International Security* 17 (Fall 1992), 8.

22. This so-called "October 15th Agreement" (*shiyue shiwuri xieding*) was the most important Sino-Soviet technology pact. See Nie, *Nie Rongzhen huiyilu,* 807–8; Song Renqiong, *Song Renqiong huiyilu* (Memoirs of Song Renqiong), 2 vols. (Beijing, 1994), 1:341–43; and Xiao Jingguang, *Xiao Jingguang huiyilu* (Memoirs of Xiao Jingguang), 2 vols. (Beijing, 1988–90), 2:173–75.

lems arose, therefore, with technologies that China sought to indigenize but which Moscow was unwilling to either provide outright or to demonstrate how to build. The Khrushchev politburo refused, for example, to share nuclear submarines (SSBN) in any form.[23] It offered the benefits of this technology—sea-based protection from the Soviet nuclear-propelled Pacific fleet, and diesel propulsion data—without the opportunity for China to acquire the hardware or know-how. In light of the connection between technology and strategic concerns (both military and economic), the Chinese reaction was fiercely nationalistic.[24] The disjuncture between Chinese ambitions for complete indigenization and Soviet unwillingness to oblige gradually intensified. And they forecasted more current problems China has experienced with foreign partners unwilling to relinquish proprietary control over, or the intellectual property associated with, advanced technology systems.

The collapse of the Sino-Soviet relationship spurred two principal changes in Chinese technology policy: all-out indigenization of "strategic" technologies and a predominantly hardware-focused acquisition policy. Even as Chinese science and technology circles became isolated from international discourse in the early 1960s, Chinese strategic weapons technicians enjoyed open access to foreign materials and technical journals. An elaborate information network was created, including collection, indexing, translation, and abstraction bureaus. As Chinese science drifted toward autarky, only in strategic weapons circles was a concerted political effort made to compensate, an effort sustained by support from the very apex of power.[25] The same circles equally valued hardware. But compared to most of the post-1960 Chinese R&D system, software retained its emphasis as the first step toward hardware acquisition. In fact, had strategic weapons not constituted such an important part of Beijing's interest in technology, Chinese technonationalism after the Sino-Soviet split might have veered toward an exclusive focus on hardware. But the Cultural Revolution

23. See the account in Lewis and Xue, 12–18.

24. See, for example, Mao Zedong, "Tong Sulian zhu Hua dashi Long Jin de tanhua" (A discussion with the Soviet ambassador to China, Yudin), 22 July 1958, based on a meeting transcript, in Ministry of Foreign Affairs and Central Documents Research Section of the Chinese Communist Party, eds., *Mao Zedong waijiao wenxuan* (Selected diplomatic works of Mao Zedong) (Beijing, 1994), 322–33.

25. Feigenbaum, "Soldiers, Weapons, and Chinese Development Strategy," 299–303. See also John Wilson Lewis and Xue Litai, *China Builds the Bomb* (Stanford, Calif., 1988), 55; and Yuan Yaojun, "Guofang keji qingbao shiye de huigu yu zhanwang" (The past and future of China's defense science and technology information cause), in Nie Li and Huai Guomo, eds., *Huigu yu zhanwang: Xin Zhongguo de guofang keji gongye* (Retrospect and prospect: New China's defense science, technology, and industry) (Beijing, 1989), 514–16.

destroyed virtually all technology programs except those in strategic weapons. Interest in gross output or hardware was derailed. And by 1967, strategic weapons represented the only major program of technological construction that enjoyed high-level state support.

Through political guarantees to the weapons programs, the high political priority attached by Mao to strategic weapons, and the physical isolation of program facilities in China's remote northwest and southwest,[26] the military promoters of these programs continued to stress software acquisition in China's ultimate ability to develop hardware, including bombs, guided missiles, and satellites. They also succeeded in extending at least some degree of physical protection to program technicians from the mass violence of the Cultural Revolution.

The emphasis on strategic weapons in the latter part of 1960s and early 1970s, in other words, guaranteed the continued importance of software issues—the protection of key personnel, training, and mentoring—in Chinese efforts to indigenize leading-edge technology. Paradoxically, a set of command programs organized around mobilization principles became the last bastion of experimental method and managerial flexibility under Mao. Technicians were given free rein to explore design ideas, competition determined winning designs, risk was encouraged, and failure was accepted (provided that technicians went immediately back to their drawing boards to satisfy state goals anew).

In stark contrast to the continuing emphasis on software in strategic weapons, Chinese technology planners in other parts of the system shifted toward a predominantly hardware-focused acquisition policy after the Sino-Soviet split. Some acquisitions, primarily the transfer of whole plants and equipment, came from capitalist countries in the first half of the 1960s.[27] But little attention was paid in these trans-

26. This physical isolation was created, in part, by the "Third Line" (*sanxian*) policy of the 1960s that sought to build a complete and self-sufficient industrial base in China's strategic rear. Mao first declared the need for such an industrial base in an important 1964 speech, and for the next seven years, Chinese planning agencies allocated between one-half and two-thirds of all national investment to Third Line regions in the southwest and northwest. There is excellent work in English on the Third Line by the economist Barry Naughton. See especially his "The Third Front: Defence Industrialization in the Chinese Interior," *China Quarterly* no. 115 (September 1988). For good Chinese overviews of Third Line construction, see Yan Fangming, "Sanxian jianshe shuping" (A review of third line construction), *Dangshi yanjiu* (Research in party history), (no. 4, 1987); Peng Min, *Dangdai Zhongguo de jiben jianshe* (Contemporary China's capital construction) (Beijing, 1989), vol. 1; and Xie Guang, *Dangdai Zhongguo de guofang keji shiye* (Contemporary China's national defense science and technology cause), 2 vols. (Beijing, 1992), 1:62–64.

27. Office of Technology Assessment, 40.

actions to the type of software issues that had become so crucial to the Sino-Soviet technology partnership. Training and advisory services were downplayed, even as they continued to receive emphasis in top-priority military programs seeking complete indigenization in the absence of Soviet assistance. Not surprisingly, this made assimilation difficult. And it hampered long-range indigenization. It may explain why much of the technology that China has successfully reverse-engineered from imported prototypes remains backward by the standards of the original hardware providers.

Dramatic FDI Policy Shifts

The most dramatic changes in Chinese technology policies followed the death of Mao Zedong in 1976. Most important has been fundamental economic change, in particular the rise of market forms and the emergence of entrepreneurial behavior among individual Chinese economic agents. In official circles, since 1978, priorities have shifted from the capital-intensive, heavy industrial emphases of the Mao era toward light industrial and service sectors. In more recent years, government investment has targeted China's telecommunications and other infrastructure.

New sources of growth and patterns of behavior have been accompanied by dramatic changes in state-economy relations. The relationship is marked increasingly by regulation, rather than direct state ownership or intervention. State enterprises remain an enormous component of the economy (and a tremendous drain on its efficiency). And reform of this sector, and the financial system, is a paramount policy goal for the next five years.[28] But the Chinese reform process has not been characterized by ownership change—as in Russian and East European–style privatization—but by the massive entry of new firms. Few such entrants boast old-style state ownership. More often, they are either corporate hybrids—melding diverse ownership forms, —or they are private firms.[29]

Thus, the relationship between state and economy in post-Mao China increasingly revolves around what economic historian Richard Vietor has termed "market structuring." "Government regulation," he argues, "shapes the structural characteristics of the market in which a firm does business. Such changes, in turn, create vested interests in protecting or changing the regulatory status quo, and these interests

28. See, for example, Nicholas R. Lardy, *China's Unfinished Economic Revolution* (Washington, D.C., 1998); and Edward Steinfeld, *Forging Reform in China* (Cambridge, England, 1999).

29. See, for instance, John McMillan and Barry Naughton, "How to Reform a Planned Economy: Lessons from China," *Oxford Review of Economic Policy,* 8 (1992).

organize and compete analogously in the political arena. For the regulated firm, then, there are two related environments in which it must operate effectively: the market and the political arena, both of which are shaped by regulation."[30]

This regulatory aspect of the reform era has been intimately tied to the emergence of market competition in technology sectors in the PRC. Monopolies have been shattered, new entrants have emerged (particularly in the telecommunications sector), and competition is as political as it is economic. For instance, a new cellular phone service provider, such as China's upstart second company, *Liantong* (Unicom), founded in 1993–94, may have a market advantage in digital clarity and low rates. But as *Liantong* discovered in its initial years of operation, penetration of the national market can become a political issue as soon as government regulation and market obstruction (*hangye baohu*) by rival providers makes it impossible for the new company's customers to communicate with those using handsets of rival companies. This is what happened in China's newly opened telecom market in the mid-1990s.[31] And it had an important impact on technology transfer, for "better" technology—often meaning imported technology—became a weapon in the war for market share.

Economic change, then, invites change in technology transfer issues. Since 1978, Chinese technology planners have stressed the kinds of software issues (know-how and training) that fell off the agenda in the 1960s. As an early U.S. government survey noted in 1987:

> Modes of technology that offer more intimate interactions with foreign technical personnel have come to be preferred. A wide variety of instruments of transfer, including licensing, joint ventures, cooperative ventures, wholly foreign-owned ventures, compensation trade, and the use of consultants and the procurement of technical services are being used. Much emphasis is being placed on foreign provision of training in contract negotiations of Sino-foreign technology transfer. As a result of this change, a much greater proportion of the technology imported since the end of the 1970s has been 'unembodied' technology, or pure know-how.[32]

Government spending on imports has also increased significantly. In the first half of the 1980s, the sixth Five-Year Plan (1981–85) allocated U.S.$9.7 billion to foreign technology imports, some 15 percent

30. Richard H. K. Vietor, *Contrived Competition: Regulation and Deregulation in America* (Cambridge, Mass., 1994), 21.

31. For some context, see Feigenbaum, *The Military Transforms China,* 499. For this specific case, see also Henny Sender, "Wrong Number," *Far Eastern Economic Review,* 9 Jan. 1997, 74–76.

32. Office of Technology Assessment, 41.

of plan investment funds. This facilitated over 1300 technology import contracts with foreign firms. And the spending level has increased in the succeeding decade and a half.[33]

Perhaps the most important new trend in technology transfers is a widening of the circle of technology importers. Where technology acquisition decisions were once highly centralized in state planning agencies, the proliferation of firms and the diffusion of decision-making to a wide variety of central and subcentral agents have broken the monopoly of the Center.[34] Most government bureaucracies have had import-export agents since the earliest years of the PRC. But direct overseas investment by Chinese firms in the 1990s created alternative points of access to foreign ideas, experience, and technology. Local firms today are in a far stronger position than in the past to negotiate their own terms with potential foreign partners. This is because most can now negotiate of their own accord, without exclusive reliance on the intermediary agency of central foreign trade corporations and ministry bureaucrats.

Technology acquisition through imports is also intimately tied to improvements in China's creaking production system and physical infrastructure, including industrial plant and machinery. More recently, this effort runs parallel with the modernization of China's commercial infrastructure, in telecommunications, air traffic management, and electronic finance.

Continuities: A Reconfigured (But Recognizable) Technonationalism

Despite these dramatic changes, old ideas and behavior patterns persist. Specifically, two assumptions retain force in Chinese economic and technology policy. First, indigenization remains the ultimate goal of economic integration with foreign partners. At the governmental level, at least, Beijing feigns little interest in the liberal underpinnings of economic globalization. Rather, Chinese leaders take a mostly instrumental view of technology transfer and commercial cooperation. This was evidenced in the 1950s when Moscow offered advanced technology aid in return for implicit Chinese support for Soviet leadership of the Communist bloc. Today, this trade takes place in a market context. But Chinese transfer policy calls for acquisition for as little cost as possible and with few long-term guarantees.

Second, China continues to stress the strategic underpinnings of

33. Ibid., and Denis Fred Simon, "Technology Transfer and China's Emerging Role in the World Economy," in Simon and Goldman, 299.

34. A good survey is provided by Simon, "Technology Transfer," 300.

technology and economic policy, even as it enjoys its most peaceful external environment for nearly a century-and-a-half.[35] The same technonational rationale that fueled indigenization in the 1950s and 1960s continues, in large part, to drive Chinese technology programming and spending. Why, many foreign observers ask, do the Chinese so often seem dead-set on "reinventing the wheel" in so many areas? Why try to develop indigenously a system that is already commercially available elsewhere?

Technonationalism remains important because the lessons of dependence from the 1950s still inform critical Chinese goals. As the Chinese eye more advanced foreign systems, they recognize the dangers of reliance on foreign imports, the availability of which depends on the whims of foreign governments. They may also produce a more subtle form of dependence: on parts, labor, and the supply of technical knowledge.

This is the technonational rationale that once spurred China to indigenize even those technologies that the Soviet Union was willing to provide. Today, "strategic" technology planners argue that Chinese R&D will languish if advanced systems can only be acquired from abroad. By this logic, "reinventing the wheel" has enormous software benefits. Chinese engineers may be building something that foreign producers already have, but if they did not, the domestic knowledge base would not advance. Chinese planners in Wu Jichuan's Ministry of the Information Industry desperately seek an indigenous software industry. Meanwhile, Chinese supercomputers may be slower than those from Silicon Graphics. But, the planners argue, if China purchased all of its supercomputers abroad, its indigenous knowledge base and capacity for innovation would atrophy. For the Chinese, then, freedom from dependence may have little economic justification in the short-term. But for a country whose R&D base remains far behind the advanced industrial countries, these long-term political rationales are critical.

Even as a private technology sector emerges, then, "new era" strategic technology programs continue to consume a large share of current state spending in the form of government seed money. In such programs, competitively selected contractors bid for the right either to indigenize an existing technology and help build the domestic R&D base, or they try to create something new that is compatible with broad state goals.[36]

35. For extensive treatment of this theme, see Evan A. Feigenbaum, "Who's Behind China's High Technology 'Revolution'? How Bomb-Makers Remade Beijing's Priorities, Policies, and Institutions," *International Security* 24 (Summer 1999).

36. Ibid., 115–16.

Continuing Faith in Hardware, Growing Emphasis on Software

Despite the dramatic changes in the Chinese economy during the past twenty years, many Chinese policymakers and industrialists retain an extraordinary faith in the raw merits of hardware. Foreign business partners and industry analysts view this, at best, as naive, at worst, blind. Central government acquisition plans reveal continuing belief that hardware purchases will somehow make China "modern." The telecommunications bureaucracy has an ambitious wish-list of broadband and fiber optic systems. But to acquire the technology is one thing; to develop the skills and know-how to understand and recreate these systems is quite another.

Recognition of this problem has led to an increasing emphasis on software. In the late 1980s, a Chinese manager visiting the 3M Corporation in Minneapolis made a dramatic realization. "If only we had one percent of what is here," one member of his delegation remarked of the 3M equipment, "we could change our entire province." But the manager was astounded less by the modern machinery than by 3M's methods. He recognized that technology acquisition involved more than technical sophistication.[37]

Current policies, then, reflect the mixed history of technology acquisition in China. The continuing stress on hardware that foreign coproducers, licensees, and sellers find so discouraging follows trends from the height of Sino-Soviet cooperation. But the new government emphasis on software—which differs from the private sector in its stress on targeting and narrowly construed state goals—echoes a similar concern for indigenization and priority on software in military technologies in the 1960s.

A Continuing Role for the Center

The dramatic shift in the locus of decision-making has in no way vitiated the importance of the Center in technology acquisition. Rather, the nature of the Center's role and the configuration of its players has changed.

As a result of recent Chinese reforms, the central ministries and foreign trade corporations have ceded ground to a myriad of players, including enterprises, local governments, and new trading corporations. This is one of the most significant departures from China's past technology transfer experience.

37. Roy F. Grow, "Acquiring Foreign Technology: What Makes the Transfer Process Work?" in Simon and Goldman, 319–21.

But the Center's role in planning "strategic" technology acquisitions remains crucial in several respects. Only the Center can call upon a broad array of technical experts from the spectrum of disciplines, for only it has mobilized such individuals for more than forty years. Most important, as Chinese technicians have argued in recent years, only the Center can ignore the market considerations that often impede forward-looking R&D investment.[38] It is one thing for a wealthy American or Japanese corporation to invest in R&D with few near-term commercial applications in anticipation of long-term results. It is quite another for a Chinese company to make investments with little prospect of short-to-medium term commercial gain. This will change with economic growth and encouragement, largely unknown in the past, of enterprise R&D.[39] Likewise, foreign partners will increasingly assume the role, formerly played by the central government, of cushioning the impact of change.

Still, the Center continues to play an important partnership role for China's technology industries. It calls upon the services of a multitude of specialists and submits a variety of new technology analyses and planning processes. This mirrors the role of government investment in many other countries. Even the United States has proposed several versions of a national technology strategy since the Eisenhower administration created a Presidential Science Advisory Committee (PSAC) in response to evidence (from Sputnik) "that American science was not all it was expected to be."[40] Most important, this is part of an intensifying debate in China and elsewhere about the proper role of public, as opposed to risk and equity, finance in fostering innovation.[41] This debate is real. But the growing importance of outside agents in Chinese technology acquisition and planning does not mean that the Center's former powerful role has evaporated.

38. For detail on both these issues, see Feigenbaum, "Who's Behind China's High Technology 'Revolution'?" 106–9, and idem, "Soldiers, Weapons, and Chinese Development Strategy," 298–99.

39. This resulted from a reflexive adoption of the Soviet-style system, in which research was separated from production. The Chinese tinkered with this many times under Mao's rule, but the weakness (and general lack) of enterprise-level R&D has been a pervasive problem. In many state-directed sectors, it remains so. This is one reason why the development of private enterprise in high-tech areas has been so significant in the late 1990s.

40. Wolfgang K. H. Panofsky, "SLAC and Big Science: Stanford University," in Peter Galison and Bruce Hevly, eds., *Big Science: The Growth of Large-Scale Research* (Stanford, Calif., 1992), 132.

41. For some discussion of this issue, see Feigenbaum, "Who's Behind China's High-Technology 'Revolution'?" 124n51.

China's Challenge: To Break with the Past

That role, at least in its present form, will likely hinder China's efforts to join the ranks of international technology superpowers. For it challenges much of what Chinese policymakers have learned over the past decade about the difficulty of "managing" innovation from above.

China remains weak in at least two of four areas that have proved critical to industrial success in Silicon Valley and elsewhere: private equity and government deregulation. In two others—entrepreneurship and strong university-led basic research—it has only just begun to make a breakthrough.[42]

Risk investment, for example, has virtually no history in China. And private equity scarcely has a toehold in China's expanding financial services sector. As the economist Nicholas Lardy has noted, China's central bank long set uniform lending rates for each loan category.[43] While the bank periodically permitted slight adjustments above or below posted rates, lenders "were not encouraged to adjust from the posted rate on the basis of risk." This imposed blinders on banks that precluded systematic risk assessments associated with different borrowers.

As Lardy has shown, this mired Chinese banks in a mountain of bad debt. It also frightened off potential lenders to promising technology ventures. Even if the government were to encourage banks to take greater risks in loan decisions, small-scale start-ups remain too great a gamble for most banks in their current debt-ridden condition. For these ventures, foreign equity is the most viable source of capital. This accounts for the popularity among new Chinese technology firms of initial public offerings on U.S. markets or on Hong Kong's new Growth Enterprise Market (GEM). But when Minister Wu reaffirmed the state's ban on foreign participation in Internet service providers in the fall of 1999, he undercut the fastest growth area of foreign equity capital in China.

The failure to introduce risk to lending decisions is compounded by continued regulation from above and a top-down approach to technology R&D investment. Military and commercial ministries and their research organs have instituted a variety of targeted investment programs designed to replicate past success with strategic weapons and other technologies developed through a mobilizational approach. This

42. On these factors in a Hong Kong context, see Blaise Zerega, "Hong Kong Fooey: Can the Former British Colony Become the Silicon Valley of Asia Even as it Assimilates into Greater China?" *Red Herring* (November 1999), 134.

43. Nicholas R. Lardy, *China's Unfinished Economic Revolution* (Washington, D.C., 1998), 207–8.

approach mixed a top-down resource commitment with a flexible set of managerial institutions, and the new programs borrow from that organizational style.[44] But mobilizational targeting can have only a limited effect on China's industrial base at a time when resource commitments are less secure and competing demands more vigorous than in the past.

University-based innovation faces a variety of external pressures. In the 1950s and 1960s, academic scientists were critical to Chinese success in weapons and other strategic technology efforts. But the transition from mobilization to the market has decreased official funding of university science and forced academics to go into business. At first glance, this is one of the most promising trends in China's innovation system. It introduces competition, blends a healthy degree of market incentives into China's R&D process, and compels university laboratories to think beyond socialist-style target-setting. But top-quality basic research has suffered. And market pressure has left many university laboratory "spinoffs" producing cheaper versions of technologies that are widely available in the West. This is hardly the Silicon Valley method that Chinese technology planners dream of introducing into China.

It is, therefore, the growth of small-scale entrepreneurship that will ultimately determine China's future prospects as a leader in high technology. But this requires a clean break with China's historical approach to technology transfer and indigenization. In 1999–2000, as in 1959–60, China's technology experts continue trying to seize the hen, not simply the egg.

But in a world of networked firms and networked people, Chinese entrepreneurs have forged links abroad that have redefined the meaning of "transfer" in a Chinese context. Small-scale start-ups have sprouted in great numbers. Most are poorly positioned either to absorb technology from abroad or to innovate themselves. Thus, expatriate venture capitalist Bo Feng funded just two of 1000 prospective Chinese companies while managing U.S.-based equity funds—both of them Chinese-language web portals. But some new private firms have extraordinary potential. They are networked to a borderless world that has given them strategic alliances to engineers—many of them, expatriate Chinese in Palo Alto, Sunnyvale, and Redwood Shores. They are tied to venture capital from American and Hong Kong investors and can participate in technical innovation as a collaborative project from the ground up. This is a new development occurring almost entirely outside the state sector, beyond the scope of old-style technology planners and "target-setters." It lies at the very heart of China's new private economy.

44. Feigenbaum, "Who's Behind China's High-Technology 'Revolution'?" 118–21.

Although this is the best hope for a new industrial style in China, Beijing's industrial bureaucrats may yet seek to regulate this new economic system. It represents, after all, a near-complete break with China's past approach to technology indigenization and innovation. So long as China looks to history as a model for future policy, it is unlikely to achieve its leaders' dreams of sweeping technological modernization. This ties technology issues more tightly than ever to the future of U.S.-China relations. At the same time, it demonstrates the historic significance of China's entry into the WTO.

The debate among American strategists about the emergence of Chinese power increasingly pits those who place their faith in the transforming powers of commercial liberalism against skeptics of Chinese ambitions in East Asia, who anchor many of their arguments in technology issues. Indeed, the way that China organizes its quest for technology is central to the assumptions that all sides make in this debate.

Among those who view globalization as transformative, technology transfer has represented the most important element of foreign penetration into China for more than two decades. Liberalization of technology sectors was among the critical concessions facilitating China's entry into the WTO, and technology startups and cross-national strategic alliances lie at the heart of the new private economy described above. Domestically, this sector represents the most important alternative to five decades of state-led industrial policy. Externally, it has become one of the pivots of foreign penetration into China's highest growth and profit sectors.

For skeptics of Chinese ambitions in East Asia, meanwhile, a China without the capability to project power will be unable to challenge American hegemony even if it wished to do so. China remains decades away from possessing the capability to challenge U.S. forces on the open ocean. Its strategic forces are backward and vulnerable. PLA projection capabilities remain negligible to nonexistent. But a China plagued by across-the-board weakness can challenge U.S. power through the acquisition of "asymmetric" capabilities—targeted strengths that can be used to counter specific U.S. and allied weaknesses. This concern lies at the core of most critical analyses of the open approach to technology trade with China that has removed some export controls and placed commerce at the center of U.S. policy.

The evolution of Chinese technology policy intersects with this debate in complex ways. A China that breaks decisively with the past described in this article will be a nation more deeply embedded in the global economy than at any time in its modern history. But China would also shed many of the structural impediments that have hindered indigenous technical innovation. This would anchor the country in the global economy. Yet it would gradually reduce Chinese dependence

on foreign technology transfers. It would also provide a far stronger foundation for defense modernization than currently exists.

By contrast, a China that clings to the core tenets of Mao-era technonationalism will remain burdened by an inefficient high-tech sector capable only of limited indigenous breakthroughs. This is precisely what has made the country so dependent on foreign technology transfers. But this would, in some ways, represent a China that continues to look askance at its trade partners, including the U.S., and at the process of globalization itself—viewing it largely in instrumental terms as a strategy for acquiring from abroad what the country cannot provide for itself.

It is this set of contradictions that makes China's entry into the WTO so significant. For the first time in the history of the Communist state, the Chinese government has committed itself to principles that are inconsistent with many past technology and economic policy practices. This is a sweeping change. But it must still overcome obstructionism from the entrenched industrial bureaucracies and policy constituencies that have determined key aspects of China's technology transfer policy since the 1950s.