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China's Technology Modernization Program: A Progress Report [redacted]

A Research Paper

Secret
EA 88-10004
January 1988
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China's Technology Modernization Program: A Progress Report [redacted]

Summary

Information available as of 1 January 1988 was used in this report.

From Deng Xiaoping down, Chinese officials have identified scientific and technological progress as a key to modernizing industry, agriculture, and national defense. But the impact of technology on specific national development priorities has varied considerably:

- The military has filled several key gaps in areas such as ground force weapons, communications, remote sensing, and tactical and strategic missile systems by acquiring Western equipment and production technology and through indigenous development. Although China's defensive position vis-a-vis the Soviet Union or the United States will remain largely unchanged, China's improved capability to project power enhances China's role as a regional military power.

- The impact of the science and technology (S&T) reform program on the civilian economy is harder to gauge—it is one of many factors contributing to the economic progress of this decade—but it can be seen clearly in certain sectors. Beijing's success in improving technology in such areas as textiles, petroleum, consumer goods, and light industry has been a major factor in increased foreign exchange earnings from textiles, oil, and arms. It has also begun to alter China's imports and exports, as China has developed domestic substitutes for foreign consumer goods and has even begun to export production lines for black-and-white TVs and pharmaceuticals.

- The importation of production lines and military production of civilian goods has also increased the quality and variety of consumer goods available, contributing to the improved standard of living of the average Chinese.

- The impact on agriculture has been less but advances in plant and animal breeding, new cultivation techniques, and increased applications of pesticides and fertilizers hold the potential for greater gains in the future.

- China has had little success in civilian applications of high-priority, advanced-technology sectors such as semiconductors, computers, and telecommunications. This failure will in our view hold back advancement in other high-priority areas, such as the development of automated production capabilities and communications networks for business and government.

- China has increased the number and skills of its S&T personnel, and is establishing a scientific community that is more capable and responsive to national needs, although these improvements are occuring more slowly than Beijing would like.

The S&T modernization program that has produced these results has seven interrelated goals that have evolved since 1978:
- Improve personnel management.
- Reform research management.
- Change S&T funding procedures.
- Commercialize technology.
- Increase acquisition of foreign S&T.
- Break down the barriers between civilian and military research and production.
- Promote regional development.

We believe China has made significant strides toward rebuilding its scientific community, which was devastated by the Cultural Revolution, reforming funding and personnel procedures, and acquiring foreign technology. Progress is less evident in breaking down the barriers between organizations and in promoting regional development. Working conditions tend to be poor and key skills—such as computer specialists—are still in short supply.

We believe additional progress will depend on China's leaders coming to grips with a number of interrelated problems, including:
- Differences over priorities and the allocations of resources.
- The balance between military and civilian needs.
- The relative priority of basic and applied research.
- Reliance on imported, versus the development of domestic, technology.
- The proper role of economic incentives and market mechanisms to boost S&T development and use.

In addition, the S&T modernization program also suffers from infrastructural shortcomings and problems of its own making. The Chinese have often imported advanced equipment ill suited to their needs. Compared with the production of older electronic goods, moreover, the use of new electronics technologies often requires different types of knowledge, more stringently controlled environments, and more competent managers and assembly line personnel. Beijing's decision at points to rely on indigenous technology has in some cases wasted resources, delayed completion of projects, and added to the costs—including social costs, as when China decided to develop on its own a hepatitis vaccine when one was already available abroad. The S&T community also has been guilty of setting unrealistic goals and making promises it could not keep.

Despite these problems, we believe the sheer size of China's investment in S&T and Chinese achievements to date indicate progress in research and commercial applications will continue. Only in the last few years have the key elements of the reform program begun to have an impact. Only now are students returning from overseas in sufficient numbers to improve the educational system and research capabilities. Other long-term technology programs that have been slow to bear fruit—such as joint projects between research institutes and factories—should begin to raise the technological capabilities of traditional industries. On the basis of programs already under way, we foresee potential successes in military areas including lasers, optics, and space launch vehicles, while commercial development in areas such as biotechnology is promising.

China's S&T modernization program creates both opportunities and problems for the United States. On the one hand, China's policymakers as well as individual scientists retain favorable attitudes toward the United States, which in some cases translates into a preference for cooperation with US suppliers. We expect the returned students to strengthen this bias, although they will not necessarily prevail over those who favor non-US or indigenous technology. On the other hand, China's desire to protect domestic industries, diversify sources of imports, and obtain concessionary financing will compound the difficulties of selling US equipment to China. Moreover, Western technical assistance has increased the competitiveness of Chinese firms in such products as textiles and small manufactured goods.

Several aspects of China's S&T modernization program may pose more serious threats to US interests. China's aggressive arms marketing—as demonstrated by the Silkworm sales to Iran—can complicate the Sino-US relationship and undermine US foreign policy goals in other regions. The acquisition of advanced telecommunications equipment improves Chinese command and control, increases force projection capabilities, and complicates US efforts to monitor civilian and military networks. China is developing and should deploy by 1997 mobile missile systems that will add to the uncertainty over the size and location of China's strategic forces, and that could become a factor in US-Soviet arms negotiations; Moscow has said negotiations on deep cuts—beyond 50 percent—in strategic nuclear forces would have to consider third-country systems. And while China's defensive posture vis-a-vis the Soviet Union or the United States will not change significantly, China's growing S&T capabilities and accompanying military improvements will increase Beijing's ability to project power against the nations on its periphery.

[redacted]

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Contents

China's Technology Modernization Program: A Progress Report [redacted]

China's Science and Technology Program
Although China's leadership has identified progress in science and technology (S&T) as a key to developing industry, agriculture, and national defense, the scientific community has had poor facilities, too few skilled personnel, insufficient incentives for quality performance, and heavy political interference—problems that were aggravated by the Cultural Revolution. In addition, the achievements of Chinese scientists traditionally have been largely confined to military needs. Chinese officials increasingly criticized both military and civilian research for overemphasizing theoretical work, duplication of effort and wasting resources, and an inability to apply research results to improving industrial productivity. [redacted]

In 1978, Beijing announced a broad program calling for basic and applied research in these priority areas: agriculture, energy resources, material sciences, computers, lasers, space, high-energy physics, and genetic engineering.[1] As with China's other reforms, the S&T modernization program focused on broad goals rather than specific measures. And it contained little evidence that Beijing had weighed the costs—financial, political, and social—or given great thought to the mechanics of implementation. Much of this latter responsibility was subsequently delegated to various state council oversight organizations and to individual enterprises and institutes. The 1978 National Science Conference, which established the priority areas, declared that, if China was to close the gap with the West as quickly as possible, China would have to rebuild its S&T establishment and refocus scientific work to better meet national needs. Beijing called on its scientific community to:

- Improve personnel skills and management. Beijing recognized that new mechanisms were needed to upgrade and expand training, provide incentives, improve working conditions, and more effectively use S&T workers.
- Reform research management. Beijing called for replacing party appointees with qualified scientists, and increasing the authority and responsibilty of research directors for planning research.
- Change funding procedures. Research institutes were encouraged to seek outside support for research in order to better link research to production.
- Commercialize technology. Beijing defined technology as a commodity to be bought and sold, subject to market influences, to encourage research and innovation.
- Acquire greater amounts of foreign science and technology. Beijing recognized that technology imports were key to meeting immediate needs and to upgrading indigenous capabilities.
- Break down the barriers between civilian and military research and production. By merging the previously isolated research systems, Beijing sought to improve the use of advanced technology in both sectors, and to increase the military's contribution to the civilian economy by using excess military production capacity to produce civilian goods.
- Promote regional development. Beijing sought to speed development of rural and remote areas through the dissemination of additional technological support. [redacted]

Toward Meeting the Goal . . .
Progress toward realizing these goals has been uneven, but in our judgment China has made significant strides in the last 10 years. We cannot quantify the progress, nor is it all due to the S&T program—other reforms and China's broader political ties to the West are important factors—but examples of China's improved S&T capabilities abound. Since 1978, China

[1] Appendix B is a chronology of the key decisions and developments in China's evolving S&T modernization program [redacted]

Examining China's S&T Claims

Our analysis of China's S&T modernization program incorporates information from the Chinese press, statements by Chinese officials, information from reliable reporting, and our knowledge of Chinese political behavior and technological and industrial development. In our judgment, public statements are useful sources of information, but—like other reporting—they must be carefully scrutinized. Chinese public statements serve many purposes, from recording a scientific contribution for worldwide knowledge and seeking enhanced international prestige, to persuading domestic critics of the value of S&T reforms or encouraging further indigenous technology development. Thus, some Chinese statements on S&T achievements are remarkably candid about progress and remaining problems, and most reflect Chinese intentions for technological development in particular fields. [redacted]

Some statements, however, are slanted—overstating capabilities or ignoring foreign assistance—to achieve certain goals. [redacted]

•[redacted]

•[redacted]

•[redacted]

has deployed a nuclear-powered submarine, offered satellite launch services to other countries, and produced civilian aircraft. China has developed more advanced products in areas such as computers, consumer electronics, medicine, and telecommunications, and knowledgeable foreign observers report research progress in biotechnology, composite materials, and other fields. Chinese researchers have submitted over 45,000 patent applications since China instituted a patent law in 1985 (see inset "Examining China's S&T Claims" and figure 1). [redacted]

We believe China's S&T reforms are also rebuilding the scientific community into one that is more capable and more responsive to national needs (see inset "A Profile of China's S&T Community"). By rebuilding the domestic educational system and using overseas training, China is improving both the number and skills of scientists. Students and scholars returning from study abroad are working in every field China

Figure 1
China's Technology Gap[a]

● Gap Steady
◄ Gap Increasing
► Gap Narrowing

		Years		
		15 to 10	10 to 15	Fewer than 5
Microelectronics			◄	
Computers	Microcomputers		◄	
	Minicomputers		◄	
	Mainframes	◄		
	Supercomputers	◄		
Telecommunications	Switching			●
	Fiber optics			●
	Satellites		●	
Automated manufacturing		►		
Special structural materials			►	
Biotechnology				►
Transportation	Rail	●		
	Shipping			►
	Road	●		
	Air		●	
Energy	Coal		►	
	Petroleum		►	
	Thermal, hydroelectric		►	
	Nuclear	►		

[redacted]

[redacted]

has designated as a priority—many of which are important for military purposes—and many have been promoted to positions where they will have a significant impact on China's future capabilities through both teaching and research. The Chinese press reports, for example, that, at the Chinese University of Science and Technology, returned students have introduced over 100 new courses and 74 returnees now head departments. Similarly, to revitalize research management China has removed many unqualified party cadre from scientific work, and replaced over 70 Chinese Academy of Sciences (CAS) institute directors with younger, more qualified persons. China also established a new basic science research foundation that seeks to improve research quality by choosing projects on a competitive basis after peer review.

[redacted]

The introduction of funding changes, incentives, and commercial mechanisms are stimulating technology development and transfer, according to Chinese and foreign observers (see figure 5). To prompt research institutes to work more closely with enterprises, Beijing is requiring that institutes involved in technology development become self-supporting and is gradually reducing their state funding; many institutes will be required to merge with businesses by 1990. To provide further incentives, collectives and individuals have been permitted to set up scientific or technical service organizations for profit. Even the prestigious Chinese Academy of Sciences, long a bastion of basic science advocates, has set up some 80 technical companies, with more than 1,000 personnel of high and middle rank engaged in technology development and transfer activities. Beijing is also setting up information services to make buyers aware of available technology, offering patent protection for inventions, and drafting other legislation to govern sales. [redacted]

These activities have been complemented by China's acquisition of foreign technology. Since 1978, China has acquired more than $13 billion worth of foreign equipment and technical assistance through purchases, joint ventures, and some illegal acquisitions. It

A Profile of China's Scientific Community

The size of China's S&T contingent has doubled in eight years, according to Chinese statistics. Between 1985 and 1986 alone, S&T personnel increased from 7.82 million to 8.67 million, including scientific researchers, mathematicians, and agricultural, hygiene, and engineering technicians. In 1985, China had 2,529 secondary technical schools (compared with 1,714 in 1978), 1,016 institutes of higher education (up from 598), and 740 institutes offering postgraduate training (compared with 509). [redacted]

Organizations involved in S&T planning and oversight also have proliferated in recent years. To improve coordination between China's five previously isolated research systems, Beijing established supraministerial leading groups that bring together policymakers, researchers, and technology users (see figure 2). Policies encouraging joint projects, such as requiring research institutes to look to industry for funding, are reducing the barriers between research organizations, and between research and development (R&D) organizations and production enterprises. [redacted]

The 8.67 million figure for scientific personnel includes persons with minimal or no training, but whose jobs nevertheless have a research or technology component. The number of skilled scientists and researchers is far fewer. Within China's 4,690 civilian R&D organizations above the county level, for example, there are only 231,000 scientists and engineers,[a] *according to Chinese statistics. Moreover, Beijing defines scientists and engineers as persons who have the equivalent of a college undergraduate degree or higher as well as those with a senior middle school education. China particularly lacks technical personnel in sectors designated as priorities under the Seventh Five-Year Plan—energy, transportation, and communications. Agricultural technicians are in short supply as well; on the average, of every 10,000 agricultural workers, only nine are scientists or technicians (see figures 3 and 4).* [redacted]

[a] *This number excludes research groups subordinate to educational institutes, factories, and the defense establishment. China does not publish information on research in its defense industrial system. We estimate that there are more than 200 research facilities under national defense establishments, including some of the most advanced facilities in China.* [redacted]

has greatly expanded its S&T cooperation with other nations, invited almost 20,000 foreign experts to visit China, and sent over 40,000 students and scholars abroad for training. Almost two-thirds have come to the United States. [redacted]

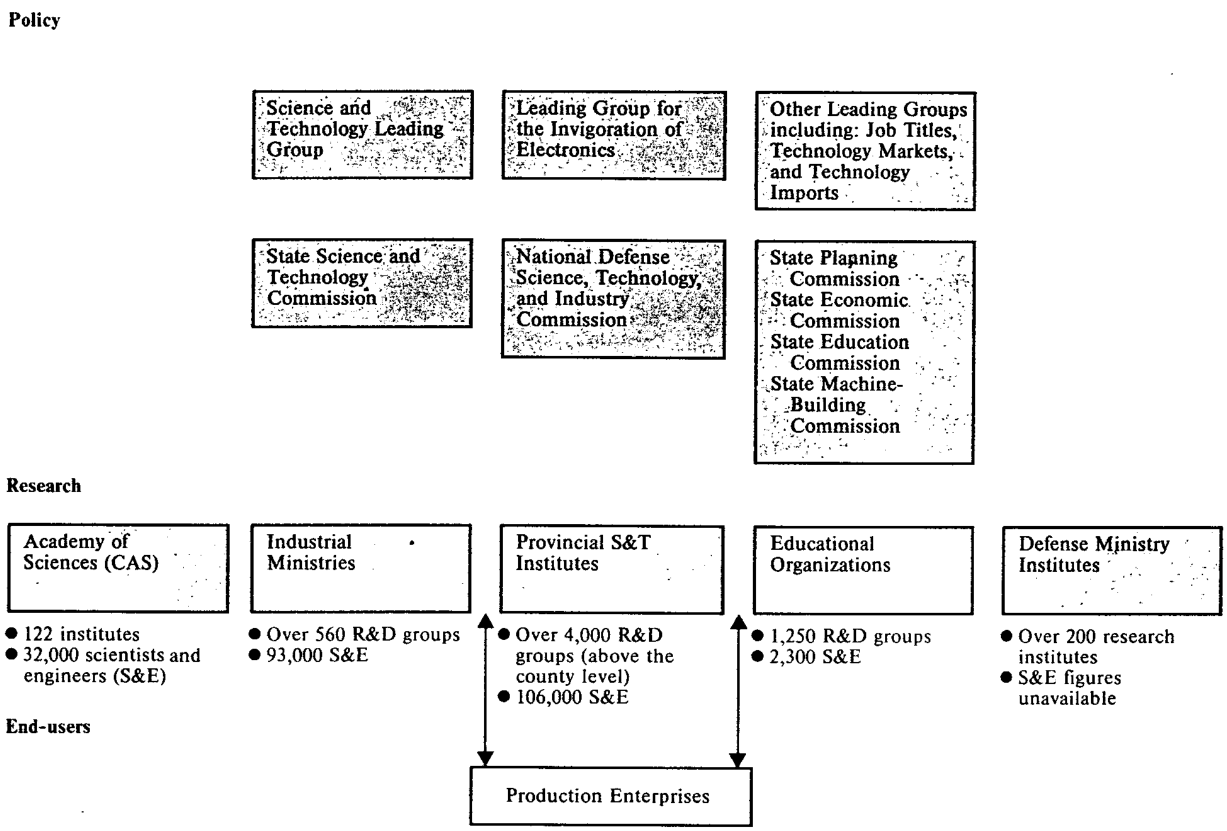
More numerous contacts between military and civilian organizations, and between universities and research institites, are, in our judgment, helping break down barriers between segments of China's S&T community, thereby eliminating some of the duplication of effort, wasted resources, and isolation that have long characterized the science sector. Military enterprises have slowly begun transferring technologies to the civil sector. We also see increased indications that greater cooperation between the military and civil sectors is contributing to technical education. For example, the Beijing Industrial University in 1980 was a secretive military college without a sign marking its existence. By 1986, according to Chinese press reports, it was operating a night college, a correspondence school with 63 stations in 17 provinces, and three branch academies in Beijing for training technical personnel needed by industry. And miltary production of civilian goods—slated to reach 80 percent of total military production by 1990—has increased considerably. For example, 40 percent of nuclear industry production was for civilian use in 1986, according to press reports [redacted]

. . . But a Long Way To Go. Significant personnel management problems remain, however. Although the growing number of trained personnel is diminishing S&T personnel shortages, visitors and China's own scientific community point out:

- Specific skills—such as those of computer specialists—continue to be in short supply.

- Low wages discourage scientists. Although opportunities to increase incomes through consulting and other outside activities have increased, some scientists are not given permission to engage in such

Figure 2
Elements of China's S&T Establishment



[a] This figure shows the major government S&T organizations under the State Council. The party also influences S&T activities through the party Central Committee, the Central Military Commission, and party cadres in each institution.

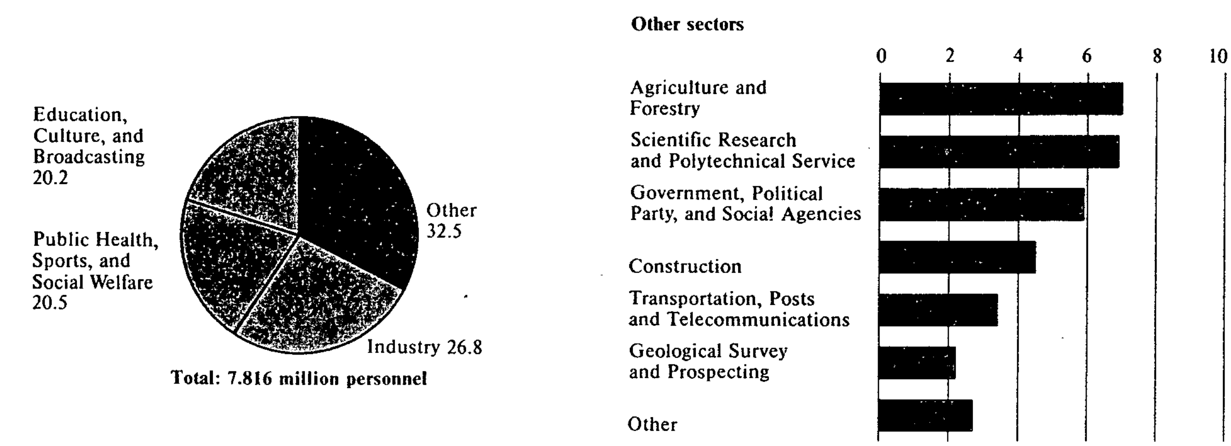
[redacted] [redacted]

activities, and in some cases local administrators take a cut of their earnings—despite regulations to the contrary.

- Poor working facilities and lack of equipment hinder research, despite some equipment imports and efforts to develop indigenous equipment. Evidence suggests that returned scholars are functioning as a pressure group for forcing better working conditions.

Figure 3
Distribution of Science and Technology Personnel by Sector, 1985

Percent



Source: Statistical Yearbook of China, 1985.

[redacted]

[redacted]

- There is an uneven geographic and sectoral distribution of S&T and plans by the reformers to increase transfers have encountered resistance from individuals reluctant to relocate and organizations unwilling to lose skilled workers [redacted]

Chinese newspaper accounts and reliable reporting also indicate that much of the technology transfer in China involves low-level, relatively inefficient technology that offers only minimal improvements in productivity. Both buyer and seller apparently look for technology that can be applied quickly and with little effort. They tend to avoid more complicated equipment and techniques that can generate more growth in the long run [redacted]

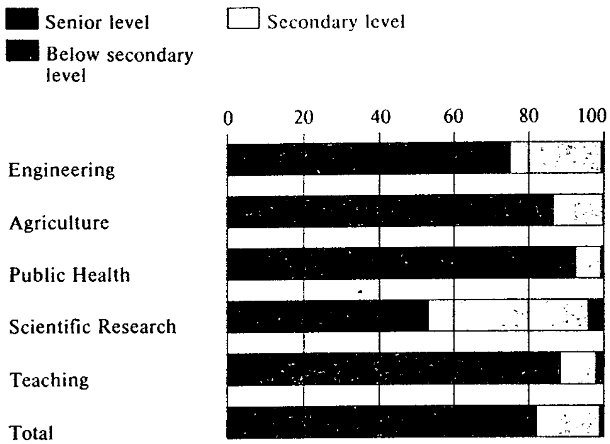
[redacted]

[redacted]

The S&T community has only recently turned its attention to regional development programs. Projects such as the Spark Plan and the Bumper Harvest Plan

Figure 4
Skill Levels of Science and Technology Personnel, 1985[a]

Percent



[a] Job titles based on a combination of education and experience.

Source: Statistical Yearbook of China, 1985.

[redacted]

have been developed to provide funding and know-how to rural areas to improve agricultural production, develop equipment for rural commodity production, and improve the skills of rural workers. Problems in funding and choosing projects, however, are hampering implementation. [redacted]

National Defense: A Major Beneficiary

In our judgment, the impact of the S&T modernization program is most clearly seen in the national defense sector (see figure 7). Our analyses of Chinese military capabilities indicate substantial improvements in such areas as ground force weapons, communications, remote sensing, and tactical and strategic missile systems during the last nine years as China has acquired Western technology and filled key gaps through indigenous developments. The table lists significant improvements to specific weapon systems.

[redacted]

[redacted]

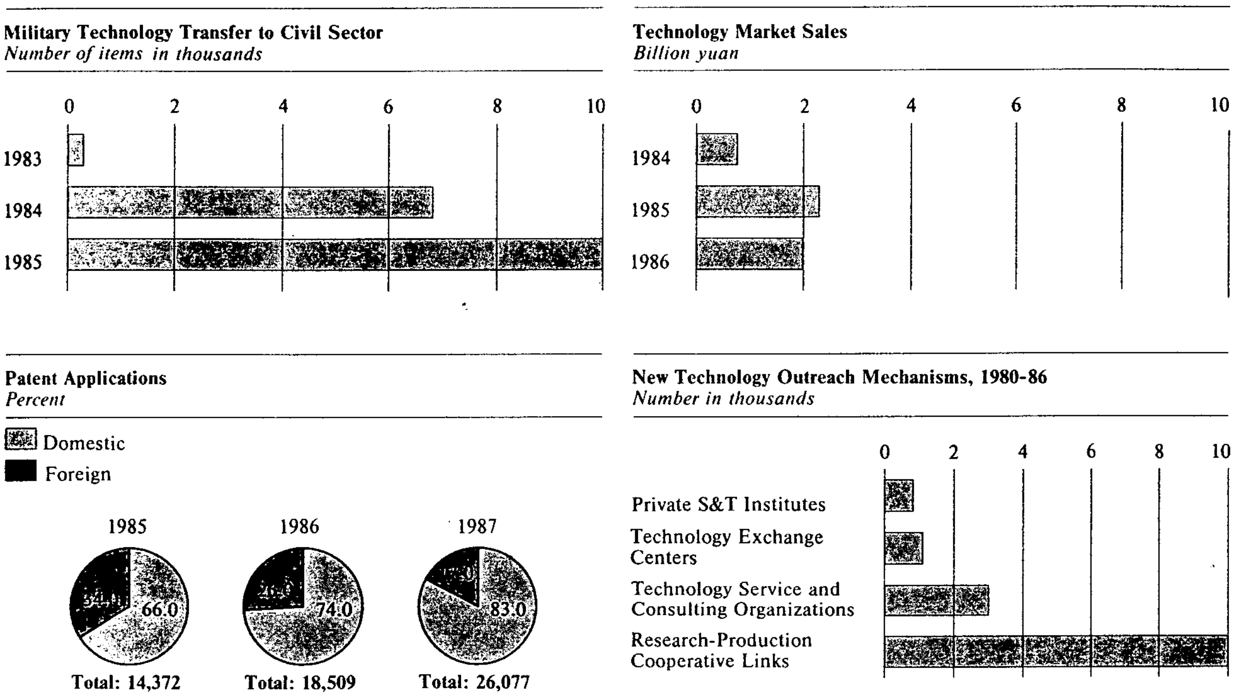
The military is also benefiting from its expanded S&T ties to the civilian sector, principally in greater access to civilian S&T expertise. Although we believe the most important military projects and facilities have always had access to the best S&T resources, reporting now suggests that less prestigious military projects also are benefiting. The Chinese press reports, for example, that the Lanzhou Military Region has hired 50 experts and specialized technicians as S&T advisers—including the chairman of the Chinese Optics Association—in fields such as computers, telecommunications, chemistry, optics, and cartography.

[redacted]

Impact on the Economy

The impact of the S&T modernization program on the economy is more difficult to gauge, largely because it is one of many factors—the broader economic reforms, a relatively stable political leadership, good weather, a comparatively peaceful international environment—that account for the demonstrable improvement in the quality of life for most Chinese. Moreover, progress varies considerably by sector. Beijing claims that $13 billion spent to import technology during the Sixth Five-Year Plan (1981-85) increased output by more than $19.4 billion, and increased taxes and profits by $9 billion. We believe such claims for a

Figure 5
Technology Development and Transfer Activities, Selected Indicators



[redacted]

[redacted] [redacted]

high rate of return on investment are exaggerated, but we do not doubt Chinese statements that investment in technology—both domestic and foreign—has increased production significantly. [redacted]

Perhaps as important for the average Chinese is the increased quality and variety of consumer goods available (see figure 6). Some of this is attributable to imported production lines and to increased military production of civilian goods. Chinese officials say that more than 30 percent of China's electronics products, and 10 percent of Chinese machinery products, now meet international standards of the late 1970s or the early 1980s—a statement that reflects both how far they have come and how far China has yet to go. [redacted]

China's Antarctic station, established in early 1985, provides research opportunities and a basis for Chinese participation in international discussions on the future of Antarctica. [redacted]

China clearly has had far less success with civilian application of higher technologies. [redacted]

[redacted]

China's slow progress in these high-priority areas has held back advancement in other high-priority areas. For example, development of an automated production capability depends on the use of electronics and computers, and a limited telecommunications system hampers data networking plans for research, business,

[redacted]

Upgrading Chinese Weapon Systems and Exports: Sources of Technology (continued)

[redacted]

and government. The inability to achieve self-sufficiency in key components forced factories dependent on imported chips to halt production when China ran into foreign exchange problems in 1986. [redacted]

On the brighter side, Beijing has been more successful in adapting and absorbing technology in less advanced industries, such as textiles and light industry, as indicated by China's national invention awards. Of 976 awards since 1979 for discoveries that "have proved useful in practice," nearly two-thirds were related to textiles and light industry.[2] Oil, food processing, shipbuilding, and chemical sectors have also had noticeable success in adopting technological advances. Largely as a result of foreign technology acquisitions, for example, China currently is the world's fifth-largest builder of commercial ships. [redacted]

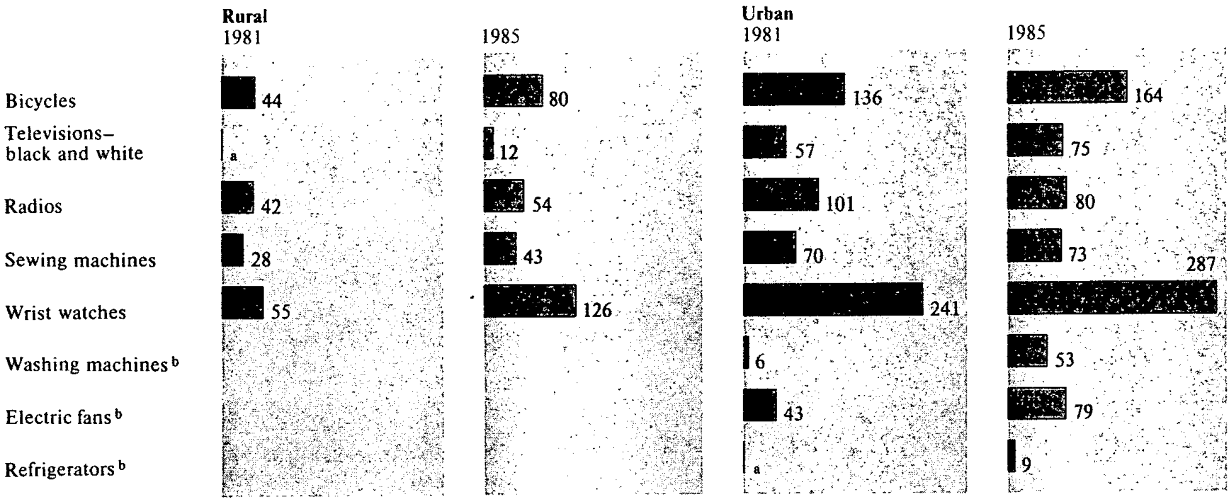
China's growing capabilities in these areas have begun to alter its imports and exports. Imports of consumer electronic goods and production equipment, for example, dwindled as domestic firms became better able to meet consumer needs, and as Beijing instituted import controls in 1985 to protect Chinese producers from competition. China recently announced, for example, that imports of 17 products, including electronic calculators, tape recorders, and refrigerators, decreased by almost 42 percent during the first half of 1987, compared with the previous year. According to the Chinese press, the growing domestic technology market is also contributing to reduced foreign exchange expenditures as factories discover domestically available technologies and cancel import plans. The Ministry of Machine Building, for example, canceled 88 import projects in 1986, in part because similar technology was available in China. [redacted]

China has also begun to export production lines for consumer goods—such as black and white TVs—and pharmaceuticals. In addition, technological improvements have contributed significantly to earnings of much-needed foreign exchange in several key areas:

- Foreign textile plant purchases, supplemented by transfers of indigenous technology, were key factors in increasing exports; in 1986 this industry became China's leading foreign exchange earner.

[2] Almost one-fourth of the awards were related to defense industries. [redacted]

Figure 6
Durable Consumer Goods per 100 Households



[a] Represents less than one per 100 households.
[b] Rural figures not available.

Source: Statistical Yearbook of China, 1985.

[redacted] [redacted]

- Discovery of new oilfields and the introduction of enhanced recovery techniques by both foreign and Chinese experts helped China increase its oil production. Over 80 percent of the additional oil was exported, reinforcing oil's role as China's second-leading foreign exchange earner.

- Arms sales, although small in comparison with textiles and oil exports, are a major source of funds for China's military. We estimate that, since 1980, Beijing has sold [redacted] arms abroad and is aggressively pursuing new sales by offering weapons upgraded with Western technology [redacted]

The S&T program's contribution to agriculture is clearly less important than government economic policies and several years of good weather. But advances in plant and animal breeding, the introduction of new agricultural technology, and increased production of fertilizers and pesticides as a result of technology imports in the chemical industry have contributed, in the judgment of foreign experts, and may have significant long-term impact. According to Chinese statistics, for example, the introduction of 327 separate crop strains over the last five years has increased annual grain output by 10 million tons. The rural sector has also benefited from improved livestock breeds and breeding techniques; fine-wool sheep are now competing on international markets, and peasants are increasing production and profits by raising leaner livestock more quickly [redacted]

Figure 7
Relative Sectoral Impacts of S&T Modernization Programs, 1978-87

[redacted]

Future Directions

Unsolved Problems. Although China's leaders generally agree on the need to upgrade S&T to meet national needs, we believe they differ on what China's needs are and how best to meet them. Given China's limited resources, competition between civilian and military leaders, heavy and light industry, and national and regional enterprises is intense. For example, Beijing called for closer coordination of military and civilian S&T resources as early as 1978, but resistance from the national defense sector prevented implementation of such reforms for several years. Criticism from the military sector diminished after Beijing

[redacted]

assured military leaders that defense programs would continue to be given a high, if not the highest, priority in decisions regarding resource allocation and access to technology acquired for the civilian sector. [redacted]

Disagreements over whether to develop technology indigenously or purchase it abroad have also slowed key projects. In the mid-1980s, for example, bickering between the projected users of a direct broadcast satellite system over whether to develop independently, jointly develop, or buy the satellite was a major factor in the decision to suspend negotiations with foreign suppliers. Indigenous development, in some cases, exacts high costs from military and civilian users. We believe, for example, that overconfidence in the ability of Chinese designers has been a major impediment to modernizing a number of weapon systems. Similarly, the Ministry of Public Health reportedly decided China would develop its own hepatitis B vaccine rather than license or buy the vaccine from a US supplier. [redacted]

The S&T community continues to debate the proper balance between applied and basic research. China's leaders have pressed for greater emphasis on applied topics—a decision made when economic problems in 1981-82 forced China to reassess its priorities—but according to a variety of reports, some scientists continue to resist working on applied topics. By emphasizing market-oriented, quick-turnaround inventions, in our opinion, China risks shortchanging the development of more complex technology that may be more difficult to introduce, but offers more growth opportunities in the long run. [redacted]

Moreover, despite Beijing's efforts to reduce the role of the party in scientific affairs, the S&T modernization program remains subject to political considerations. In January 1987, for example, the President and Vice President of the Chinese University of S&T were fired for their handling of student riots. The riots, which then spread to other universities, ultimately served as a pretext for the ouster of party Secretary Hu Yaobang and the kickoff of a national campaign against "bourgeois liberalism." Zhao Ziyang and other leaders specifically and publicly reaffirmed the importance of science and technology, but we suspect that the political debate may make some scientists hesitant to take advantage of market-oriented reforms; critics have charged that letting scientists "get wealthy" ahead of others is unsuitable in a socialist society. The recent program of sending students to rural areas during their vacations—on the one hand, part of China's transfer of technology to the countryside; on the other, reminiscent of the banishment of intellectuals to rural areas during the Cultural Revolution—may reinforce their hesitation. [redacted]

Trying To Improve Technology Use

China has been hampered by the low level of its indigenous technology. Compared with production of older electronic goods, for example, the acquisition of new electronics technologies often requires different types of knowledge, more stringently controlled environments, and more competent managers and assembly line personnel. Imported semiconductor or computer lines have been more difficult to put into operation than, for example, whole plant imports in the textile industry. Restrictions on sales of Western technology to China also obviously affected industries such as electronics more heavily than other industries. Factories expended—and in some cases wasted—considerable time and effort trying to import the most advanced technologies, which were often subject to delays caused by COCOM review. [redacted]

China has recognized these problems and begun to tackle them by:

- *Improving technology choices. The technology market and new technology information systems are providing more information to enterprises about what technologies are available. Both Chinese sources and foreign observers note that managers have become more interested in doing feasibility studies.*

- *Providing technical support for using technology. Government regulations now require foreign equipment purchases to be accompanied by transfers of know-how and technical support. Also, research institutes are providing help to Chinese factories by installing, integrating, and maintaining both foreign and domestic equipment.* [redacted]

- *Creating a supportive environment for using technology. Beijing is adjusting tax and investment policies to encourage efficient use of equipment. China also is introducing more training to improve conditions within the factory for organizing and using technology and is adopting Western quality-control techniques, including a nationwide quality inspection network.* [redacted]

The advocates of the S&T modernization program must also come to grips with legitimate criticism. The reformers have been guilty of wasting resources by importing technology that could not be used (see inset "Trying To Improve Technology Use"). Also, Chinese officials promoting S&T programs have often made promises they could not keep, raised expectations, and exacerbated existing problems. For example, official statements about one program—the Spark Plan for rural technological development—have promised to improve the quality of life in China's rural areas, but the benefits of technology accrue unevenly across sectors and geographic locations with the richer areas getting richer, according to the Chinese press. Programs such as the Spark Plan may even perpetuate disparities, and contribute to existing tensions between rich, coastal provinces that have the infrastructure and the poorer, interior ones. [redacted]

[redacted]

Cause for Cautious Optimism. These problems notwithstanding, we believe the impact of the S&T reform program is only beginning to be felt, and is likely to increase. Only in the last two or three years has the bulk of the scientific community really begun redirecting resources toward helping industry. Many recent research successes—for example, in fiber optics, composites, and space—were achieved in the old way, through marshaling resources under military

With solar power bringing heat and electricity for lights, television, and consumer appliances to remote areas—often for the first time—prospective brides in Inner Mongolia have begun demanding solar cells as part of their dowries.[redacted]

oversight to meet military needs, with foreign technology being used when available. Only now are joint research projects between factories and research institutes and between military and civilian institutes beginning to bear fruit. Other means of diffusing scientific information, such as networks set up by returning students to facilitate the exchange of research results, are also in the early stages of development. The full impact of the returned students is yet to be felt and, in addition to improving research capabilities, we expect them to contribute to educational improvements and the training of a new generation of S&T personnel.[redacted]

On the basis of programs now under way, we believe progress is probable in a number of areas. Military research in lasers, optics, and space are likely to produce commercial spinoffs, as the military's contribution to civilian industry increases. Development of biotechnology products is a potential growth area, given the improved skills of China's foreign-trained biotechnology researchers, their research progress, and China's determined efforts to acquire production technology. China's space industry illustrates that China, given suitable market conditions, can compete even if its technology is less advanced. China's space industry is 10 to 15 years behind that of the United States, Europe, and Japan in technology, but it has the capacity to launch more satellites than Beijing will need for its own programs. Moreover, China's launch program is functioning at a time when the US and French programs have suffered serious setbacks; we believe China's sales of space launch services alone could generate foreign currency earnings of $100 million in 1988 and $500 million per year by the mid-1990s.[redacted]

The relatively small impact so far of technological modernization on the composition of China's trade is likely to increase, in our opinion. The Chinese press reports a number of instances in which individual factories and ministries have canceled imports after finding a technology available locally. The State Machine Building Commission just published a list of 50 domestically produced products—engines, generators, tractors—recommended as import substitutions. Foreign equipment and technical assistance will remain critical, however, for the development of certain high-technology sectors such as large computers.[3]

[redacted]

Implications for the United States

Chinese policymakers as well as individual scientists retain favorable attitudes toward the United States, which in at least some cases translates into a preference for cooperation with or equipment purchases from US suppliers. Evidence suggests that scholars returning from study in the United States, for instance, have tended to favor US suppliers. Nevertheless, they do not necessarily prevail over those who

[3] We believe illegal acquisitions and diversions—always a small portion of total technology acquisitions—will be even smaller in the future as a result of increasing liberalization of Western export controls. We have no doubt, however, that China will continue to use illegal methods to try to get technologies for priority military programs that remain restricted by the West.[redacted]

prefer indigenous or non-US technology. And China's desire to protect domestic industries and to diversify sources of technology imports, coupled with the tendency of West European and Japanese suppliers to offer concessionary financing, compound the difficulties US suppliers will have in selling equipment to China. [redacted]

Western technical assistance has created economic competition for the United States in several sectors, and competition is likely to grow. For example, the late Commerce Secretary Baldridge in April 1987 said the biggest issue in US-China trade is textiles. [redacted] to compete commercially with the United States include biotechnology products and small nuclear plants. [redacted]

In addition, China's military modernization, in at least a couple of cases, may run counter to specific US interests. China's Silkworm sales to Iran have demonstrated how its aggressive arms marketing can complicate the Sino-US relationship and affect the achievement of US foreign policy goals in other regions. Similarly, China has offered for export other missiles that may prove destabilizing in regional conflicts, including the M-9 mobile solid-propellant missile armed with a conventional warhead, the HQ-2 surface-to-air missile, the HN-5 and HN-5A shoulder-fired surface-to-air missiles, and the C-801 missile—China's version of the Exocet. Sales of missile systems still under development, such as the M-9, allow China to obtain foreign funding to help underwrite development, and provide an opportunity for battlefield testing before deployment to Chinese forces. [redacted]

In addition, the transfer of high-capacity, high-speed, secure telecommunications equipment allows China to develop improved command, control, and communications networks. These systems can enhance China's military force projection capabilities and complicate US efforts to monitor military and civilian communications. [redacted]

Although China's defensive posture vis-a-vis the Soviet Union or the United States will remain largely unchanged, Chinese acquisition of weapons technology will improve China's ability to project power against weaker nations on its periphery. Taiwan will feel especially threatened as Beijing's currently limited capacity to blockade the island improves over the next 10 years as the Chinese Navy builds new warships and upgrades its technology, in part through the [redacted] import of Western naval technologies. Neither Malaysia nor Indonesia is confident of the ultimate loyalties of their large ethnic Chinese populations and are certain to grow nervous over China's higher regional profile. At the same time, Malaysia and other Southeast Asian countries are concerned about China's naval activity in the Spratly Islands. As these nations become increasingly sensitive to Beijing's enhanced military capabilities, they will probably seek closer ties to the United States, pressing the United States to sell them more advanced US military equipment and to limit technology transfers to China. [redacted]

[redacted]

[redacted]

[redacted]

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