Chapter 3

The Chinese Context for Technology Transfer: Strategies and Issues for Technology Imports

Photo credit: Eric Basques

Yu the **Mandarin's Garden in Shanghai is characteristic of the architectural style of the Ming and** Qing **Dynasties. The garden is divided into three parts, each separated by a white brick wall the** top of which forms an undulating gray dragon.

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In the post-Mao period, the Chinese leadership has consistently stressed the central role of science and technology for China's modernization. In 1982 Premier Zhao Ziyang said that it would be impossible to reach China's overall economic goals by year 2000 without major contributions from modern science and technology. The challenge for Chinese planners has thus been to develop a workable strategy and consistent plan for scientific and technological development. After some false starts in the late 1970s, a coherent set of objectives began to take shape in the early 1980s.

GOALS FOR TECHNOLOGICAL MODERNIZATION

China has four categories of goals for technology. The first is for Chinese industry to reach at least the present Western level of technology by year 2000. This will require a major effort at revitalizing established industries, including a special, well-funded program of "technological transformation' *~ishu gzu"zao),* which is being administered by the State Economic Commission (SEC).

The second objective is to ensure that modern technologies are diffused to China's rural areas. The interest here is not only to continue with the technological transformation of agriculture, but also to provide a modern technological foundation for burgeoning rural industry. China expects that the coming decades will see major movements of the labor force out of agriculture and into rural industry and services. A special project, the Spark program, administered by the State Science and Technology Commission, is designed to provide technological inputs into this major shift in the occupational structure.

A third objective is to give priority to the technologies needed to develop the country's infrastructure and natural resource industries. Thus, a wide variety of technologies pertaining to energy, telecommunications, transportation, and resource exploitation are targeted for acquisition and development. This part of the strategy, by necessity, involves the activities of many Chinese agencies.

Finally, the Chinese have identified a number of technologies that they believe will be the basis for new high-technology industries—electronics and computers (including advanced software applications such as CAD/CAM), biotechnology, materials, robotics, lasers, and space and ocean technologies. The Chinese expect these technologies will lead to major industrial advances and have targeted them for special attention in the hope of becoming competitive.

The achievement of these goals will require the modernization of the domestic research and development (R&D) system. But the Chinese also realize this cannot be achieved without the transfer of foreign technology to China. It is important to note, however, that the various goals entail different approaches for acquiring the appropriate technology. Whereas much of the technology desired is in the hands of foreign companies, some of it (e.g., transportation and telecommunication technologies) is in the hands of foreign governments or public corporations. In addition, the Western

university is the locus of much of the knowledge needed to launch high-technology or science-based industries. The sending of students and older scientists abroad to a Western university for advanced training, therefore, can be seen as an important channel for technology transferal

[1]This issue has been explored in Leo A. Orleans, "Chinese Students and Technology Transfer," *Journal of Northeast Asian Studies,* vol. 4, No. 4, winter 1985; and in Richard P. Suttmeier, "Academic Exchange: Values and Expectations in Science and Engineering," unpublished paper presented at the Conference on Sine-American Educational and Cultural Exchange, Honolulu, HI, The East-West Center, Feb. 18-22, 1985.

To gain access to these sources of technologies and use them effectively, the Chinese have initiated programs of domestic reform and have made extraordinary changes in their approaches to foreign relations. This chapter examines the Chinese experience with technology transfer more specifically, beginning with an overview of China's past history of technology transfer.

THE EXPERIENCE WITH TECHNOLOGY TRANSFER

Chinese experience with technology transfer in the 1980s is shaped not only by the current technology objectives discussed above and the overall economic modernization objectives examined in the previous chapter, but also by historical experience. Since the late 19th century, the Chinese have realized the importance of modern technology from the West but have been unable to reach an intellectually and culturally congenial relationship with it. As characterized by one foreign trade official, who was trying to dispel these attitudes, Chinese thinking often goes as follows:

> After the Opium War, imperialist powers carved up China. Our political and economic lifelines were controlled by foreigners, our markets were flooded with foreign goods, and our national industry was severely devastated. Such a period of national humiliation is still fresh in our memory. Therefore people always associate imports with the protection of our national industry, and tend to think that the less imported the better.[2]

Also of concern has been the danger of over-reliance on foreign help. The saliance of this historic concern was reinforced at the end of the 1950s, when, after the Chinese allowed themselves to become quite dependent on Soviet technology during the 1950s, the Sino-Soviet relationship soured, and Soviet technical assistance was withdrawn.

The scientific and technical infrastructure developed rapidly in the 1950s, but then the Chinese were forced to rely largely on their own efforts for the further industrial development of the country until the opening to the West in the late 1970s. (Some foreign technology, mostly for whole plants and equipment,[3] came from the capitalist countries after the Sino-Soviet split.) Some of the productivity problems noted in chapter 2 resulted from this extreme self-reliance, but another result was the development of indigenous technical capabilities.

From 1950 to 1960, China imported technology from the Soviet Union and Eastern Europe in support of 156 major industrial projects. These were concentrated in such basic industries as metallurgy, machine building, trucks, coal mining, electric power, and petroleum. Some 400 items of technology were introduced, with an approximate value of $2.66 billion. These transfers were indispensable for the timely establishment of new industries and contributed to the rapid economic growth experienced at the time.[4]

[2]Wei Yuming, "On Open Door Policy, Trade With Japan," *Xinhua*, Oct. *25, 1985.* In FBIS, Oct. *29, 1985,* p. A4.

[3]Huang Fangyi, "Analysis and Suggestions on China's Introduction of Foreign Technology and External Trade, '" *Asian Survey* (forthcoming).

[4]Ibid. Also, Robert F. Dernberger, "Economic Development and Modernization in Contemporary China: The Attempt To Limit Dependence on the Transfer of Modern Industrial Tech-

(continued on next page)

From the withdrawal of Soviet assistance in 1960 to the outbreak of the Cultural Revolution in 1966, the Chinese began relying more on Japan and Western Europe for technology. Some 84 major contracts worth $280 million were signed in this period. Industries targeted were metallurgy, chemicals and chemical fibers, and synthetic textiles.

From the early 1970s to 1978, China signed some 300 contracts for foreign technology, worth $9.9 billion. The emphasis in this period was on complete plants in such industries as steel, petrochemicals, and chemical fibers. Many of the contracts from this period were concluded in great haste in late 1978 and were subsequently canceled or postponed.[5]

It is interesting to note that China's technology transfer experience with the Soviet Union was intimate in that it involved a whole range of transfer experiences (including the importation of whole plants, the supply of Soviet blueprints, the presence of Soviet technical advisors in China, and the training of Chinese in the Soviet Union). China's subsequent approaches to technology acquisition in the 1960s and 1970s were more at arm's length, focusing on the importation of complete plants and sets of equipment without due attention given to the software, training, and advisory services that often contribute to successful assimilation.

A number of changes in China's approach to technology transfer have been made since 1978. The Chinese came to the conclusion that the arms-length, whole-plant mode of transfer was too costly and did not yield the know-how they expected. Since then, Chinese policy has discouraged the acquisition of complete plants and equipment and has stressed the acquisition of know-how: "acquiring the hen and not just the egg," as the Chinese put it. Thus, modes of technology transfer 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.[6]

In addition, China spends a greater percentage of its resources on importing technology than it did in the past. In the sixth Five-Year Plan period, for instance, $9.7 billion, or 15 percent of the investment funds provided for in the plan, went for foreign technology.[7] Two other changes are notable in this fourth period of technology imports: Whereas past emphasis was on technologies supporting the establishment of new enterprises, the emphasis since the early 1980s has been on technologies to upgrade or renovate existing enterprises. Finally, the locus of decisionmaking on technology transfer has changed. As part of the reformist decentralizations, the central ministries and a single foreign trade corporation are no longer the principal decisionmakers. Instead, many other players have become active, including enterprises, local governments, and a myriad of new trading corporations.

rmlogy From Abroad and to Control Its Corruption of the Maoist Socialist Revolution, *Technology and Communist Culture: The Socio-Cultural Impact of Technology Under Socialism,* Frederic Fleron (cd.) (New York: Praeger, 1977).

'l{uang Fangyi, op. cit.

'Ibid.

'Ibid.

INDIGENOUS CAPABILITIES: THE EXAMPLE OF THE DEFENSE INDUSTRY

The context for technology transfer cannot be understood without recalling the existence of significant technological capabilities indigenous to China. These include an extensive network of over 9,000 R&D institutes, including almost 120 in the Chinese Academy of Sciences, a large capital goods industry, and a military-industrial complex that has enabled China to develop nuclear weapons and launch satellites.

Over the years, Chinese industrial investment has been strongly biased toward heavy industry, resulting in the establishment of a large and comprehensive capital goods industry supported by a network of R&D institutes.[8] At the center of the capital goods sector is the vast machine building industry, the main domestic supplier of industrial technology and equipment and the chief alternative to foreign technology. Included in the machine building industry (see box A) are China's industrial assets for military production.

As part of the package of economic reforms, the Chinese have initiated a significant policy shift regarding the national defense industry. The latter had for many years been the beneficiary of priority investments of material and human resources. Commenting solely on the ordnance and aeronautics industries (just two of six main defense industry sectors), for instance, two Chinese observers noted:

> In the 1950s and 1960s . . . the State assigned the university graduates and the most outstanding scientific and technological workers to the departments in charge of the national defense industry, with the result that there was a concentration of talented people in the industry. At the same time, the Ministry of the Aeronautics Industry and the Ministry of the Ordnance Industry jointly owned a scientific and technological work force of more than 200,000. In addition, the best facilities and equipment went to the national defense industry.[9]

Until the late 1970s, however, this privileged sector had been largely insulated from the civilian economy and civilian R&D system. It thus had little impact on the latter in spite of technological achievements in the defense sector. China has produced military planes for 30 years but is only now starting to produce civilian air lines. It has designed and launched its own military satellites, but its telecommunications satellites are still experimental. It mastered nuclear weapons technology in the 1960s, but the first nuclear power station is still under construction.

In the post-Mao era, this situation has been changing. As the Chinese contemplated the modernization of national defense, they concluded that over the long run the nation's security could not be achieved without a vigorous and modernized civilian industrial economy. Defense modernization was therefore accorded the lowest priority position of the four modernizations. Cutbacks in defense procurement resulted in significant underutilization of defense factories. The latter therefore have been instructed to turn at least some of their productive assets to the service of the civilian economy.

The defense industry has become a vast empire of research and production units, but it is difficult to define their economic significance. Until recently, the Chinese rarely provided information on the defense industry, but as part of the "civilianization' program, more is coming to light. The extensiveness and degrees of vertical integration of the defense plants is depicted in a recent account of the "012 Enterprise Group, " an industrial complex of the

[8] A useful analysis of the capital goods industry, including its technological capabilities, is found in Zhang Renyu, *Technology Issues in the Capital Goods Sector: The Experience of the People Republic of China,* United Nations Conference on Trade and Development, UNCTAD/TT/57, 1984.

[9] Chen Siyi and Gu Mainan, "China's National Defense Industry Faces an Historic Turning Point-Sidelights on Zhao Ziyang's Meeting With National Defense Industry Specialists, *Liaowang* Overseas Edition, No. 6-7, Feb. 10, 1986. In FBIS, Mar. 5, 1986, p. K14.

Box A.—The Structure of the Machine Building Industry

The machine building industry has been reorganized to reflect its changing military and civilian responsibilities. The former Ministry of Machine Building has been combined recently with the Ministry of the Ordnance Industry (which also includes the China Northern Industries Corp. and produces instruments and meters, precision metal cutting and forging tools, diesel engines, bicycles, clocks, washing machines, sewing machines, oil equipment, magnetic heads, tapes, and discs) into the State Commission of the Machine Industry. In addition, there are special ministries of machine building (formerly numbered, but now renamed to reflect their new mixed military and civilian roles) listed below. Each of these has set up one or more of its own corporations to link it to the civilian economy and, particularly, to facilitate its entry into international trade. These ministries. their trade corporations (in parentheses), and their civilian product lines are listed below. The range of sample products gives some idea of the high degree of vertical integration that characterizes these ministries.

1. Ministry of the Nuclear Industry (China Nuclear Energy Industry Corp.). Products include meters and instruments, surveying and mining equipment, optical instruments, mechanical components, nuclear reactors, air filters, valves, and heat exchangers.
2. Ministry of the Aeronautics Industry (China Aero-Technology Import and Export Corp.). Products include transport aircraft, agricultural aircraft, lathes, motorcycles, transducers, switches, optical recorders, washing machines, air-conditioners, and technologies for the auto industry.
3. Ministry of the Electronics Industry (China Electronics Import and Export Corp.). Products include earth stations, navigation equipment, electronic materials, computers and peripherals, radios, TVs, other consumer electronics, and integrated circuit technologies.
4. Ministry of the Astronautics Industry (Great Wall Industry Corp., China Precision Machinery Corp., China Communications Satellite Corp.). Products include expendable launch vehicles, communications equipment, weather and earth resources satellites, telemetry, tracking and control equipment, microelectronic devices, and dishwashers.
5. China State Shipbuilding Corp. (China Shipbuilding Trading Corp.). Products include bulk carriers, container vessels, marine engines, seismographic and meteorological support services for offshore prospecting, yachts, and pleasure craft.

SOURCE: Adapted from Wendy Frieman, "National Security Risks of Dual-Use Transfers to China," app. 6, vol. 11 of this report. July 1986.

aviation industry located in Shanxi Province. '" The complex comprises of over 20 factories and emploYs more than 30,000 people, including 4,1000 engineers and technicians. Included also are 10,000 major pieces of equipment and one of the largest assembly workshops of its kind in Asia. 'l

Such complexes have been assumed by outsiders to be characterized by a high degree of vertical integration. The full extent of integrated industrial capabilities is evident from the diversity of industries to which the 012 complex now supplies goods and services under the current policy of aiding the civilian econ-

[10] Many of th, defense-related facilities established in the 1960s and early 1970s were located in mountainous regions in the interior, for national security reasons. This industrial location policy, sometimes referred to as the "third front construction' policy, leaves China with a spatial distribution of important industries that is not economically rational under the current policies of integrating the defense industry with the civilian economy, The Chinese are taking special action to deal with these third-front enterprises; a special office for them has been established under the State Council, and there is special mention of them in the Seventh Five-Year Plan.

[11] ''Quan Zong, "China's Large-Scale Aviation Industry Base Deep in the Mountain s-A Visit to the 012 Enterprise Group. " *Liaowang* Overseas Edition, No. 26, June 30, 1986. In FBIS, July 15, 1986, p. K21, ff.

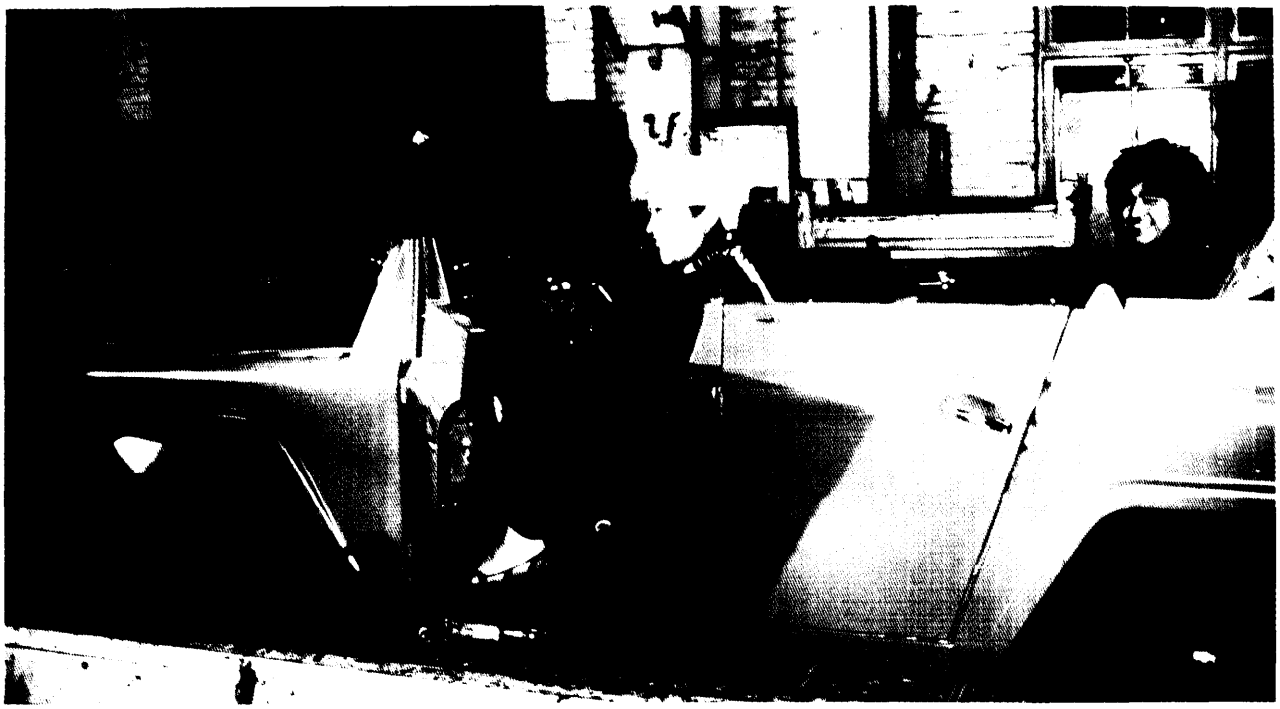

Photo credft " Eric Basques

Assembly of the BJ-212 jeep at the Beijing Automotive Works. This Soviet designed jeep has been produced for decades—annual output is set at 24,000 units. The assembly line has been shut down while these workers are on their lunch break, which in China is often 2 hours.

omy. Although one of the main products of the complex is the Yun-8 transport aircraft, member factories have produced such diverse products as light industrial goods (including copying machines), processing machinery, instruments and meters, home appliances, and farm machinery. The complex also cooperates with the textile, plastics, and food processing industries. A cooperative venture with the No. 2 Automobile Factory has been begun to produce minicars.

The degree of vertical integration in the defense industry and the privileged quality of this sector in the past may mean that there are "pockets of excellence' 'or special competence which will, under the new policies, begin to have more of an impact on the economy.'[12] For instance, some of China's more advanced technological competence in computers and electronics may be in the Ministry of Astronautics (MOA), not solely in the Ministry of Electronics Industry, where one might expect it. According to one report:

> Great progress has been made in the manufacture and application of computers used in rockets, satellites . . . All special-purpose computers for military use are made by China, Some computers have reached the advanced level of the early 1980s. At present this ministry (MOA) has developed a system that incorporates research, production, and application of integrated circuits, whole sets of computers, and peripheral equipment and software. It is now capable of annually producing 5,600 microcomputers, and small and medium-sized computers, as well as 5 million integrated circuits. It has established three bases for producing integrated circuits, and has put more than 2,000 computers into operation. '3

[12] Denis Simon, "The Challenge of Modernizing Industrial Technology in China: Implications for Sino-U.S. Relations, " Asian Survey, vol. 26, No. 6, April 1986, pp. 420-439.

"Beijing, *Xinhua*, June 13, 1986. In FBIS, June 30, 1986, p. K33. In January 1986, a U.S. delegation attending a science policy conference in China, which included a member of the OTA staff, visited a MOA facility in Lishan, Shaanxi province, where 3-micron circuits were being produced. The facility was in transition to civilian commercial sales.

MOA computer and electronic products are now being marketed throughout China and in 20 countries abroad. "

Clearly, such plants as the 012 Enterprise Group and the facilities of the MOA, as well as other parts of China's military industrial complex, have considerable technological potential that must be considered in assessing the prospects for technology transfer to China. The domestic suppliers of technology associated with the defense industry, and the machine building industry more generally, have the competence to meet many of China's technological needs, albeit not always as well as foreign technology. Nevertheless, the machine building industry consistently promotes itself and its capabilities as alternatives to foreign suppliers of technology, as the account of the 012 complex makes clear:

> In the past, the Wuhan Iron and Steel Complex imported spare parts for the cylinders of the hydraulic pressure systems of its rolling mills, The No. 572 factory under the 012 Enterprise Group undertook the task of the research and manufacture of the R2 main shaft balance cylinder. The balance cylinders it produced have been installed for trial use and proved to have a life of over 3 years, far longer than the 6-month life of the imported ones. "

Further evidence that the Chinese see the military industries and R&D institutes as important factors in the national technology transfer strategy is seen in the following editorial comment in *People Daz"ly:*

> At present, many enterprises have already attached importance to introducing advanced foreign technology. However, less attention has been attached to transferring our own defense industry technology to civilian enterprises. Transferring defense industry technology to civilian enterprises is a shortcut to enhancing technological progress, which should be accelerated.
>
> Introducing foreign technology is certainly a demand of the four modernizations. However, it has many limitations. We need to introduce many types of advanced technology, but since they are very expensive, we can only introduce what we most need. Moreover, the most advanced technology is usually unable to be introduced into our country. The transfer of defense industry technology to civilian enterprises has no such limitations. Therefore, we must energetically encourage this transfer. The more and the faster the transfer the better. "

Some of these ministries have made an aggressive entry into the civilian market. It is likely that this will continue and that the machine building ministries will have a more prominent role as exporters of goods, services, and technology during the remainder of the century. In the past, machinery and electrical products accounted for a small fraction of China's exports, representing only 4.7 percent in 1985. Current thinking, however, predicts a volume of machinery exports by 1990 worth US$l billion, or a 240 percent increase over 1985. [17]

The Chinese are also striving to become exporters of technology and high-technology services. In April 1986 they convened their first technology export fair in Shenzhen, at which the defense industries were well represented.[18] China's offers to provide satellite launch services to overseas parties and the marketing of the diverse services of the nuclear industry are two of the more prominent examples of possible future exports of services from the military industry. While technology exports from China are unlikely to be exclusively from the defense sector, many will be. Ironically, given the production and managerial problems that have inhibited the actual em-

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[15] {Ibid.

[16] Ibid., p. K22

[16] Commentator, "A Shortcut To Enhancing Technological Progress-On the Necessity of More Quickly Transferring More Defense Industry Technology to Civilian Enterprises, *Renmin Ribao*, Aug. 27, 1985. In FBIS, Sept. 5, 1985, p. K2.

[17] Interview With He Guangyuan, Vice Minister of the Machine Building Industry, " Beijing Domestic Television Service, June 6, 1986. In FBIS, June 16, 1986, p. K 16.

[18] Chen Zhiqiang and Yu Fengyuan, "Chinese Technology Moves Towards the World, ' *Renmin Ribao* Overseas Edition, Apr. 22, 1986. In JPRS-CST-86-025, pp. 17 ff. See also, a report on China's seeking patent protection services in Hong Kong for its technology exports in the *South China Morning Post (Business News* supplement). Apr. 1, 1986; and Huang Zhiping, "Chinese Technology Seeks Overseas Markets. *Intertrade*, January 1986, p. 29.

ployment of new technologies in civilian industries, it may be easier for the Chinese in the short run to sell technology developed in the defense industries than to sell products made in China employing that technology.

Products from the defense industry are likely to become an increasingly important part of China's exports. China is already a major arms exporter (see ch. 7), and recent reports indicate a desire to move to higher technology in its military exports. In some cases, this will be done with foreign help. For instance, China and Italy have entered into an agreement to upgrade the electronics and fire control system for the A-5M attack aircraft. 'g

China's new policy toward the relationships between the defense industries and the civilian economy not only has the potential for making the considerable technical resources of the defense sector available to the civilian economy, but also creates the possibility that the defense sector will become more innovative as it faces market demands, as it gains access to technology available in the civilian economy, and as it enters into cooperative technology transfer ventures with foreign firms.

Despite frequent statements from China that the technologies of the defense industries can often substitute for foreign technology, it is clear that the defense industries also see their current role as improving their technology through cooperative international civilian projects.'" Thus, it is likely that the new policy on the defense industry will not only contribute to domestic transfers of technology to the civilian sector, but also lead to the upgrading of the technology and the management of the formerly exclusively military sector of the Chinese economy.

"*See, Xinhua, Nov. 6,* 1986. In FBIS, Nov. 7, 1986, pp. K5-K6; and Daniel Sutherland, "China Plans To Expand Arms Sales, " *The Washington Post*, Nov. 12, 1986.

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'('For one account of the activities of the aviation industry, See *Intertrade*, December 1985.

THE DECISIONMAKING SYSTEM

Without a clear national consensus on the proper course for technology transfer, different perspectives and interests have led to a fractured decisionmaking system in China. Indeed, organizational complexity is often a dominant factor in China's relations with Western enterprises and is a major obstacle to China's modernization.

China's record of choosing, importing, and assimilating technology has been much influenced by the operation of its decisionmaking institutions, and particularly by the overlapping central and regional jurisdictions that characterize the decisionmaking system. For instance, coordination between the central ministries and between decisionmakers in Beijing and those at the province and enterprise levels has not always been good. Decisionmakers in Beijing who make purchasing decisions about foreign technology have not always had a good understanding of the technical problems in the field. There is a lack of coordination between the economic commissions at various levels of government and the science and technology commissions. 2.

The Chinese in recent years have sought to rationalize their decisionmaking for technology import policy, with mixed success. China's problems are in part a function of reconciling the many domestic bureaucratic interests in foreign technology into a coherent position,

A related problem is that of reorganizing a foreign trade bureaucracy that was set up originally to conduct trade with other socialist countries. In the original scheme, a centralized Ministry of Foreign Trade (MFT), which existed until 1982, was chiefly responsible for the conduct of trade and for the centralized allocation of scarce foreign exchange.[22] China's former

[21]Song Jiwen, "Digestion and Absorption of Imported Technology-A Shortcut to Technological Progress, " *Jingji Guanli*, Sept. 5, 1985. In FBIS, Nov. 4, 1985, p. K24.

[22]Samuel P.S. Ho and Ralph W. Huhnemann, *China Open Door Policy* (Vancouver: University of British Columbia Press, 1984), p. 34.

MFT oversaw eight national foreign trade corporations specializing in different commodities. As trade expanded rapidly in the 1970s (from $4.59 billion in 1970 to $20.64 billion in 1978), the old system was not able to handle this increase and became an obstacle to further growth in trade. Gradually, foreign trade corporations were set up under other ministries, not directly under the MFT.[23] Further complicating the situation was the granting of greater trade autonomy to local governments as part of the decentralization experiments. To bring some coherence to this system, the old MFT was combined with three other central trade agencies in 1982 to form the Ministry of Foreign Economic Relations and Trade (MOFERT).

Yet uncertainties remain about how the system works largely as a result of a series of centralizations and decentralizations of foreign trade decisionmaking authority .24 For both ec~ nomic reforms generally and for technology imports, the Chinese are still searching for the right balance between centralization and decentralization and between the achievement of centrally determined values for the whole economy and the encouragement of local initiative.

The foreign trade apparatus also shows a tension between the influence of the planning system and the play of the market. China clearly plans some of its technology procurements. For instance, the SEC had an import plan for the 1983-85 period that contained some 3,000 items of technology for its national effort to renovate small and medium-sized enterprises. Planning targets for other types of projects were also established.

In recent years, however, as enterprises have been allowed to retain foreign exchange, there has been a drift toward a more decentralized, market-driven approach to technology acquisitions. This trend and the attendant fear that the center will lose all control over technology imports have led to decentralizing technology transfer policy and foreign exchange controls, including the 1985 regulations described below.

The Chinese system for decisionmaking on technology imports is very complex and, at least for outsiders, uncertain. In the cases considered for this report, OTA saw considerable confusion about how decisions are made. There was also evidence of decisions being changed, sometimes because of changed circumstances, but also because of the underlying fluidity of the decisionmaking system itself.

Decisionmaking procedures vary according to the size of the project and the type of control over the project (central or local). Often, but not necessarily, these variations can be explained by the type of industry involved. The electronics industry, for instance, has experienced considerable decentralization in recent years, while the energy industry has retained greater centralization.[25] Decisionmaking also varies according to the mode of transfer being used; decisions concerning joint ventures, for instance, will involve different procedures and regulations from those involving licensing.

A further complication is the relationships that exist between the end user of the technology and the (often multiple) organizations that have jurisdiction over the end user. In addition, the making of a decision can be thought of as having stages—consultation, negotiation, ratification, implementation, evaluation—that often involve different participants. '6 Finally, the system is complicated precisely because in basic ways it is changing.

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[23] Ibid, p. 35.

[24] "Foreign trade reforms begun in 1980 opened the way for more Chinese companies-those under both central and local control– to participate in foreign trade. Companies wishing to enter *into* foreign trade must get the permission of It! OFERT, or a local government, and then must register with and get a license from the State Administration of Industry and Commerce. Once licensed, they may open foreign exchange accounts. Import licenses are required for 42 categories of goods. and export licenses are needed for 235 categories.

[25] Cf., Denis Fred Simon and Detlef Rehn, "Understanding the Electronics Industry, " *The China Business Review*, March/April 1986, pp. 10-15; Oksenberg and Lieberthal. *Bureaucratic Politics and Chinese Energy Development*, report prepared for the U.S. Department of Commerce, International Trade Administration, August 1986.

[26] See, Roy F. Grow, 'Transferring Foreign Technologies: Steps in the Chinese Decision Making Process, unpublished paper presented at the conference on *China New Technological Revolution*, Harvard University. May 9-11, 1986.

For instance, until recently, the role of the banking system was not central. However, with economic reform, which has increased the role of the banks in the running of the economy generally, banks-especially the Bank of China—have also become important in foreign trade and technology imports.

Perspective of the Enterprise

An enterprise may not always wish to incorporate new technology into its operations. In an economy of shortages, as has been the case for some time in China, producers can sell whatever they produce, giving them little incentive to assume the risks and costs of technological change.

If a decision is made to acquire new technology, several practical decisions must follow. How quickly can the technology be procured? How easily will it be absorbed or assimilated? What level of technology should be chosen? How will it be paid for? Should it be procured domestically or internationally? The economic and technical reasons for importing technology include domestic market competition and, increasingly (as a result of government pressures to export), international market competition. Foreign technology generally results in better products. In addition, it clearly carries a great deal of prestige. An increasing number of Chinese firms are establishing 'technology introduction offices" to aid in acquisition decisions.

Apart from the central question of what market exists for the enterprise's products, the Chinese environment has to be considered. Is the technology available in China? Has it been targeted as a high priority by the Chinese Government? Will it be addressed by the nation's R&D system? How much pressure does the enterprise feel to increase its exports? What kind of access does it have to foreign exchange? Can the enterprise get special benefits from the state by procuring the technology? The enterprise must also anticipate that these issues will be assessed by the layers of bureaucracy (local or national, and sometimes both) that must approve the enterprise's project.[27]

[27] "Simon and Rehn, op. cit.

Furthermore, the international environment must be considered. Is the technology available internationally, and are there agents (companies, governments) willing and able to transfer it? What mode of transfer is most appropriate for the technology, and is the adoption of that mode feasible? In this international context the importance of export controls comes in.

Hidden factors exacerbate delays from the enterprise perspective. Once a decision is made to import technology, which can be a lengthy process, the decision has to be approved by higher authorities to assure consistency with national policies, particularly those pertaining to types and levels of technology and to the expenditure of foreign exchange.[28] Thus, well before a contract would actually be signed, and indeed in some cases well before negotiations with foreign firms begin, the enterprise would have gone through considerable negotiations within its own system; anywhere from 6 to 18 months would already have passed. If the enterprise must then wait for a protracted export license decision, it could face delays of 2 years or more before the technology arrives. Given the complexities at the enterprise level, it is unlikely that there would be a simple, consistent set of benefits for choosing one technology over another.

The willingness of decisionmakers to take risks is also an important factor. China's economic system over the years has structured incentives in such a way that decisionmakers are often risk averse. Risk aversion has been further encouraged by the history of unpredictability in Chinese politics, which has made managers unwilling to take individual actions that could expose them as targets of a future radical political campaign. Foreign partners in joint ventures have reported risk aversion and a lack of initiative among middle managers as factors slowing the absorption of technology at the enterprise level. The present uncertainties are likely to aggravate this timidity.

Perhaps the most crucial factor in decisionmaking during the last few years is the availability of foreign exchange. Despite severe

[28] Ibid.

foreign exchange regulations, there are an increasing variety of viable strategies for obtaining foreign exchange. Some enterprises, for a variety of reasons, will be more privileged in their access to foreign exchange than others, and the technologies they demand will therefore tend to have a high priority. Central authorities are therefore challenged to ensure that the country's foreign technology needs are not determined by the pattern of availability of foreign exchange; what is best for China may not be what is best for the enterprise with foreign exchange.

The foreign exchange constraint also has a more indirect and often detrimental effect on technology transfer behavior. Because of its shortage, foreign exchange is rationed. When projects are approved, but not necessarily before a foreign vendor is chosen and contracts are signed, enterprises are given quotas for use in going ahead with the project. There are some indications that the technology transfer strategies of Chinese enterprises are determined more by considerations of how to use the quota than by how to save foreign exchange and make the introduction of the technology part of an economically progressive decision.

In one case, an American firm that took pains to package a sale with a selling price factored in both hard and Chinese currency (in order to help the Chinese save on foreign exchange) lost the sale to a Japanese firm that offered a somewhat lower total price but insisted on hard currency for all of the settlement. The foreign exchange cost to China was thus higher, although the sale price to the enterprise was lower. Since the enterprise had a quota that had to be used (or lost), it had no incentive to save on foreign exchange. In other cases, the Chinese foreign exchange allocation system seems to have led to the overvaluing of hardware transfers relative to software, despite policy to the contrary. In accounting for the use of foreign exchange to procure technology, it is easier to point to a piece of equipment than to something as amorphous as know-how. Foreign exchange limitations at the enterprise level also keep enterprises from buying all the support items necessary for making the projects work.

The Government Perspective

Chinese authorities in recent years have tried to bring central policy guidance and coherence to the business of importing technology, issuing a variety of new policy statements and regulations. From the perspective of the central government, the main principles for choosing foreign technology include the following. Technology to be imported should:

1. be above the level of that which is available in China;
2. be of practical use;
3. contribute to China's eventual self-sufficiency;
4. foster economic and social development; and
5. be useful for generating foreign exchange.

Judgments about how to apply criteria such as these become part of the technology import decisionmaking process, and periodically various agencies, particularly the State Science and Technology Commission (SSTC), are called upon to interpret these guidelines in specific cases.

As part of an effort to protect both China's interests (particularly regarding restrictive business practices by foreign firms) and the proprietary interests of foreign suppliers of technology, the Chinese State Council on May 24, 1985, promulgated new "Regulations of the People's Republic of China on Administration of Technology Acquisition Contracts. These regulations call for their administration by MOFERT, which subsequently drew up its "Measures for the Examination and Approval of Contracts for the Import of Technology, which took effect on October 1, 1985.

The regulations set criteria for the kinds of technology to be imported, limit the normal life of the technology transfer contract to 10 years, offer protection to foreign technology that falls outside the patent system, and charge MOFERT with establishing a system for reviewing and approving technology transfer contracts. As of this writing, it is still too early to judge the longer term effectiveness and the consequences of these new procedures.

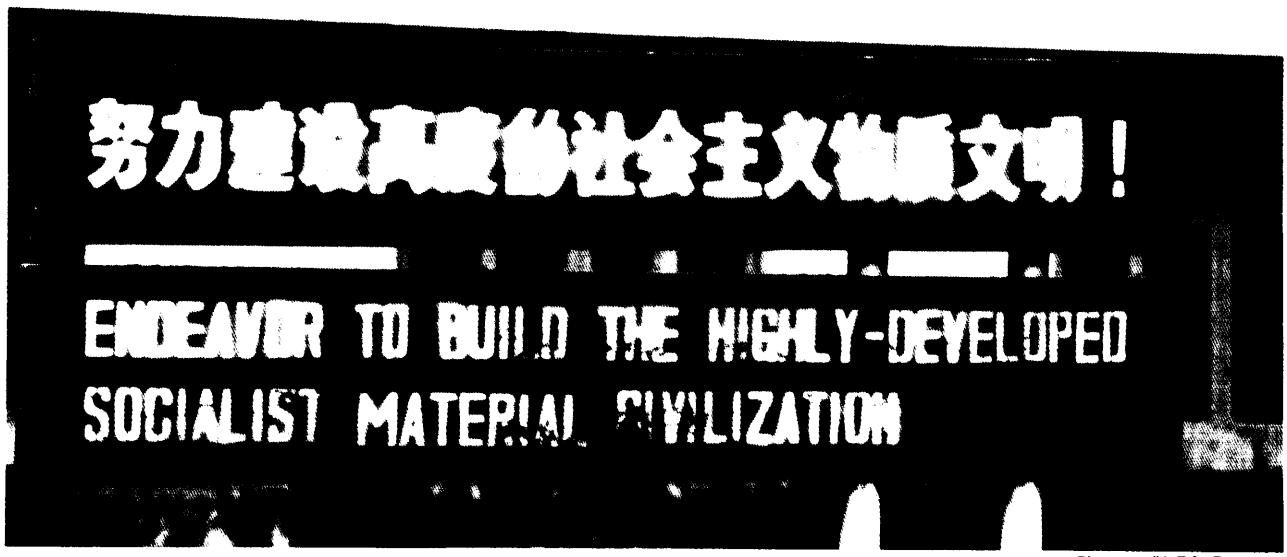


Photo credit' Erfc ***Basques***

This sign is posted on the grounds of the Beijing Jeep Corp.

Some of their ambiguities have been noted,[28] and complaints have been heard that demands by MOFERT for guarantees that the technology transfer will be successful place a heavy burden on the foreign supplier and lead to higher costs.'"

The regulations do seem to strengthen the hands of the central government over enterprises and localities. It also seems that the regulations were inspired by China's examination of the experiences of other developing countries that tried to centralize authority over technology transfers to protect national interests from the economic power of multinational enterprises.

The most important organizations for technology transfer decisionmaking in the central government are the State Planning Commission (SPC), SEC, MOFERT, and SSTC. In addition, the ministries having cognizance over the technology in question also play an important role. For very large projects or projects of special national importance, decisions would be elevated above the SPC level to an appropriate level, such as the Leading Group for the Invigoration of the Electronics Industry, or the Science and Technology Leading Group, or perhaps to the State Council itself.[31]

The role of the SPC in the Chinese economy is to prepare 1- and 5-year economic plans and to assure that financial, material, and human resources are made available for the execution of projects included in the plans. This includes annual authorizations to expend foreign exchange. Since the SPC can give only limited attention to specific project proposals for importing technology, it focuses on strategic commodities[32] and technology transfer projects with a value of US$5 million or more. There are exceptions to this $5 million figure, however. The central government has dele-

[28] Ellen R. Eliasoph and Jerome Alan Cohen, "China's New Technology Import Regulations, " *The China Business Review,* vol. 12, No. 6, November-December 1985, pp. 36-40.

[29] Foreigners also complain about the lack of transparency in decisions about what kinds of preferences the Chinese are prepared to grant or withhold in contract language, and call for more standardization on the contract language.

[31] For a good overview of Chinese central government decisionmaking, and the responsibilities of the key central agencies, see, Oksenberg and Lieberthal, op. cit.

[32] 1 bid., p. 37.

gated to the Shanghai municipal government, for instance, the power to approve projects up to the limit of US$10 million and the power to approve joint venture projects up to $30 million (selected other cities have approval powers over joint ventures up to $10 million).[33]

The SEC has traditionally implemented the plans. In recent years, the SEC has also assumed both the leading role in implementing the economic reform program and the responsibility for introducing modern management to Chinese enterprises. Its most direct role in technology transfer decisionmaking, however, is related to its responsibility to see to the technological transformation *Jishu gaizao)* of established Chinese enterprises.

The SEC has a special office, the Technical Transformation Bureau, and a special budget for technological transformation, including a foreign exchange account for importing technology that contributes to *jishu gazao.* During the Sixth Five-Year Plan, the SEC had responsibility for 3,000 transformation projects; another 3,000 are included in the Seventh Plan. During the last 2 years of the Sixth Plan, some US$5 billion per year was spent on enterprise renovation; the total number of technology import projects for the whole plan was 14,000.[34] The Chinese expect that this effort *will* be surpassed during the Seventh Plan.

Thus, technology import projects that fall under the category of technological transformation are approved by the SEC unless they exceed the $5 million-value limit. Ministries and enterprises wishing to undertake technological transformation projects using imported technology submit feasibility studies to the SEC or to economic commissions of local governments.

The mission of MOFERT is to plan and administer foreign trade. Through the activities of its Technology Import and Export Department, it provides policy advice on China's needs for a given technology, its ability to absorb the technology, and the likely overseas sources .35 MOFERT also approves the language of technology transfer contracts to ensure that it conforms with the country's regulations, and it takes the lead in proposing new regulations or revisions and clarifications of existing regulations. It also serves as the cooperating partner with the U.S. Trade and Development Program. In addition, it certifies Chinese end users of sensitive high-technology transfers in keeping with understandings reached with the Coordinating Committee for Multilateral Export Controls (COCOM) as part of the latter's liberalization of exDort controls.

The SSTC does not have a direct ongoing role in decisionmaking for the import of commercial technology, but is an important participant nonetheless. It is centrally involved in importing technology for the national research and technological development projects it controls and can also play a decisive role in providing technical assessments of important pieces of technology to be imported. Further, the SSTC plays a key role in setting national technology policy. This includes statements of priority about which technologies China should expect to have by the end of the century and whether these will be acquired by importing technology or by developing it indigenously. These statements of policy serve as points of reference for the SSTC'S own assessments of proposed projects and also guide the decisions of other participants in the system.

Many enterprises in China are local rather than under central control. The local government level has counterparts to the central government decisionmakers discussed above. These include planning, economic, and science and technology commissions; a bureau of foreign trade; and enterprise bureaus for different industries. In some cases, as with the central government, a corporate organization may exist between the enterprise and the industrial bureau. The level of decision will depend on

[33] In spite of the delegation of decisionmaking authority to local governments on the basis of the value of projects, the central authorities remain more involved in decisions than the rules of delegation would suggest. See, Simon and Rehn, op. cit.

[34] Sun Zonghao, Director, Technical Transformation Bureau, SEC, "China's Technological Imports and Vistas for Development, unpublished paper presented at the MIT Seminar on Technology Transfer, April 1986.

[35] Oksenberg and Lieberthal, op. cit., p. 90.

the value of the transaction. In all cases, however, the contract must be approved by the foreign trade bureau.[3G]

Financial and Trade Organizations

The Ministry of Finance has attempted to make technology import policy sensitive to the costs of technology transfer, with regard not only to the direct procurement costs, but also to the costs of absorption.[37] The Ministry of Finance has also attempted to establish the principle that technology imports should lead to expanded exports.

The Bank of China has become the key financial institution responsible for the distribution of foreign exchange and has an institutional interest in the financial soundness of technology import projects. The bank's role has been enhanced by the increasing reliance on the banking system, instead of the state budget, for investment. When projects are approved by the SPC or the SEC (or their local counterparts), a foreign exchange quota (e *du)* is established with the bank, which the enterprise can then draw on. The bank, however, reserves the right to conduct its own feasibility y studies before dispensing moneys from the e *du* if it is dissatisfied with the feasibility studies that have already been done. In some cases, the bank also sits in on discussions much earlier in the project approval process.[38]

Other important participants in the decision-making system are the foreign trade corporations (FTCS). Some of these, such as the China National Technical Import Corp., which specializes in technology imports, and the China National Machinery Import and Export Corp. are under the control of MOFERT. Others are under the control of the various industrial ministries. The trading companies are often the bodies that negotiate and actually sign a contract with a foreign company, and they are at times tasked by the end users, who help identify possible vendors of technology. In this sense, they act as middlemen. In recent years, however, there has been much more direct interaction between the end user and the foreign vendor, even in cases where the trading company still actually signs the contract.

Foreign Firms

Foreign firms differ in their motives and strategies for transferring technology. Some firms approach technology transfer as the sale of a commodity without presuming any equity participation in the Chinese economy. The appeal of the transaction may be tied to other corporate objectives, but basically it is a sales relationship.

For other firms, China is seen as an export platform and source of supply for components and finished goods. Such firms can be expected to transfer technology needed to accomplish those business objectives. In these cases the firms can be expected to be earners of foreign exchange for China, although, as the Beijing-Jeep case demonstrates, they may also require substantial amounts of foreign exchange during the startup period.

Other firms may be more interested in China as a source of raw materials. They too can be expected to be earners of foreign exchange, and may, if required by the Chinese, be willing to transfer technology. The foreign oil companies that have participated in Chinese offshore oil development fall into this category. In this case, a great deal of the technology is in the form of the experience of the personnel of the companies, something that cannot be transferred readily except imperfectly via training. A small portion of the technology of the oil companies, such as exploration technology, is highly valued and highly perishable proprietary information that companies normally refuse to transfer. The Chinese have been considerably disappointed over the implementation of the technology transfer provisions in the offshore oil development case because of Chinese misunderstanding about the nature

[36] According to Oksenberg and Lieberthal, in the late 1970s, the Ministry of Finance calculated that China should be prepared to spend four *yuan* of *renminbi* on absorption, for every one US dollar's worth of technology and equipment imported, Ibid., p. 62.

[37] Ibid., p. 97.

[38] CF., Simon and Rehn, op. cit.

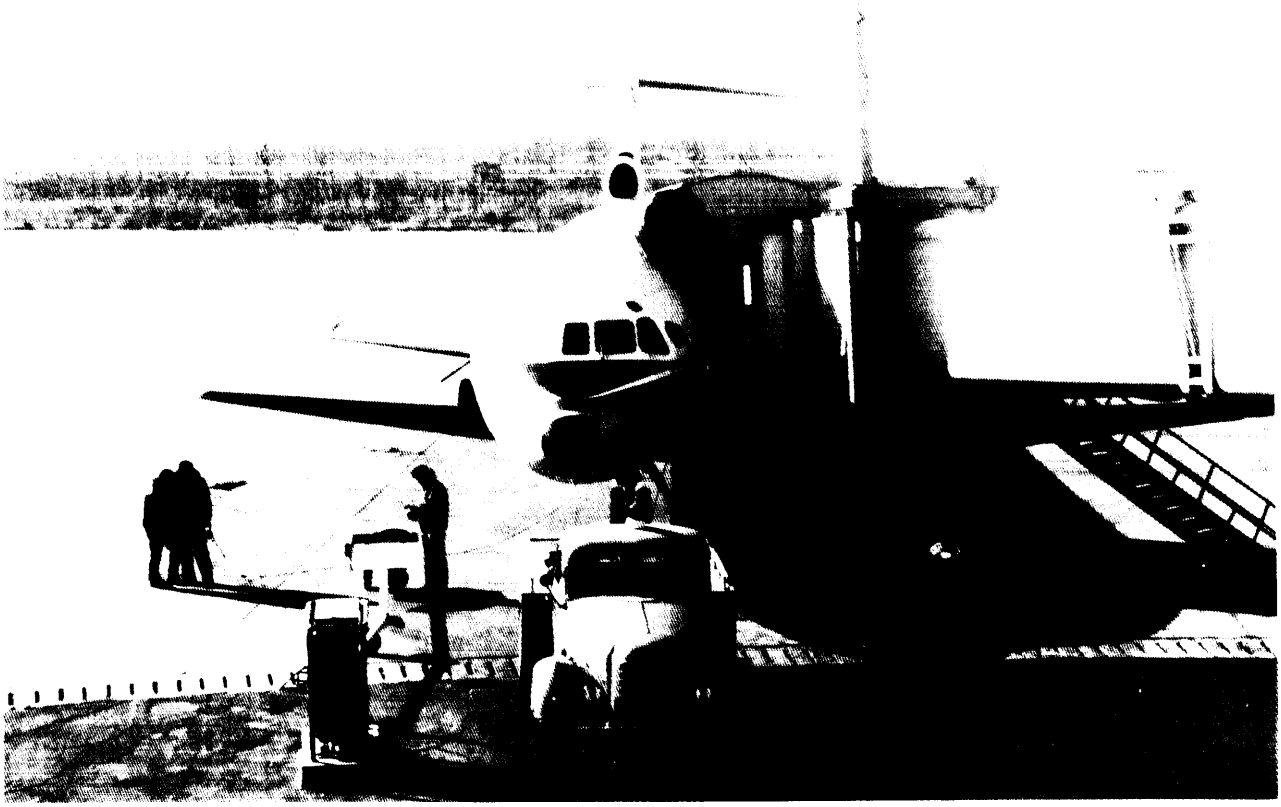


Photo credft Eric Basques

A jet airliner prepares for passenger boarding at the Beijing International Airport, The truck is a model produced until recently that was based on Russian technology of the 1950s.

of the technology and a failure of the oil companies to understand Chinese expectations.

Other industries have different dynamics. In some areas of high technology where the Chinese have a keen interest, the very identity of the foreign firm is tied to its technology. In these industries—electronics, materials, telecommunications, biotechnology-there is great expense involved in product development and a rapid rate of product obsolescence. Markets must be expanded to distribute costs. In such highly competitive cases, technology is not viewed as a commodity to be sold, and there is great reluctance to transfer technology unless it will lead to a long-term presence in China with opportunities to design products for the Chinese market and to repatriate profits. It also requires Chinese partners who have the organizational flexibility to respond to rapidly changing technologies and business opportunities.

There are some signs that China is coming to appreciate this diversity of motives and strategies among foreign firms. The new investment regulations, for instance, recognize the difference between export-oriented and technologically advanced firms that need access to the domestic market. However, there is still much in the nature of Chinese policies and in the Chinese economic and political systems that makes it difficult to accommodate the diversity of technology transfer issues.

The Foreign Exchange Constraint

Since the end of 1985, concern over the availability y of foreign exchange has become an even more important element in decisionmaking about technology imports. The officially preferred way of making a decision to import technology has been to fold it into the normal planning process. If a positive decision is made on a project, then in principle the necessary foreign exchange to implement it will be provided. However, it is precisely because foreign exchange costs are a factor in judging the desirability and feasibility of the project that decisionmaking through the planning system has in recent years been biased toward projects that promise to earn foreign exchange quickly. Thus, until recently, petroleum and coal projects promising to produce exportable commodities have enjoyed a privilege denied to electric power.

This bias of the planning system is one reason why enterprises, corporations, ministries, and local governments might find it in their interest to have decisions made outside of the planning system. There are also two other reasons. First, receiving formal plan approval can be time consuming if decisions on new projects are desired at a time out of phase with the planning cycle. In addition, present economic reforms are creating an environment in which enterprises often (though not always) wish to practice as much of their new autonomy as possible. To a considerable extent, they can do this if they have access to foreign exchange. The question of access to foreign exchange therefore becomes quite important for understanding decisionmaking.

As noted above, the SPC has the major role in allocating the right to expend foreign exchange to ministries, enterprises, and local governments. For the enterprise that wishes to import technology, therefore, one source of foreign exchange is that which is provided in the plan. For projects that have been included in the plan, provision is made, in principle, for the foreign exchange necessary to carry it out. This solution may not be optimal for more complex joint venture projects, where foreign exchange needs may be very fluid.

Enterprises can also earn foreign exchange themselves. The tight restrictions on foreign exchange imposed by the state in the last 2 years can be thought of as an incentive for enterprises to become more active foreign exchange earners, though they are allowed to keep only a fraction of their earnings and may need permission to spend even that. The enterprise can also approach the local government or the supervising ministries for out-of-plan foreign exchange, although the accounts held by these entities may not be large. Beijing, for instance, had only $100 million at its disposal.

In addition, the enterprise can attempt to buy foreign exchange from other units using local currency *(renminbi)* at a rate set by the Chinese Government. Or foreign exchange can be borrowed from the Bank of China if the bank approves of the project. In such cases, repayment is usually made in foreign currency. Other agencies, such as the China International Trust and Investment Corp. (CITIC), which have floated loans from foreign banks, are also prepared to lend foreign exchange.

It is clear that changes are occurring in the allocation of foreign exchange, just as in the economy as a whole. This does not necessarily mean that there is less overall central control over the total amount of foreign exchange expended. Within that total, new mechanisms for allocation are appearing, which may lead to more efficient use of the foreign exchange available. These new mechanisms complicate the task of trying to understand how the decisionmaking system actually operates, however.

The System in Practice

The decisionmaking system is supposed to operate as follows: Proposals for the import of technology originate in an enterprise under one of the central ministries or units of local government. The enterprise, however, is working under control figures that have already been supplied by the SPC (or local authorities) as a guide to enterprise planning. In developing the proposal, the enterprise typically must demonstrate the feasibility of the project

through a feasibility study. The project must then be submitted to the ministry or local enterprise bureau (or in some cases, a corporation under a ministry of which the enterprise is a part) for approval. The approving authority at this level may also conduct its own independent feasibility study. For local enterprises, the project must then be approved by the local planning committee. If the project (whether from a locally or centrally controlled enterprise) exceeds $5 million, [38] it must be submitted to the SPC for approval, and the SPC may also do its own studies as to the desirability and feasibility of the project.

For projects pertaining to the technological transformation of industry, the proposal would go to the SEC. For projects below the $5 million level that do not pertain directly to technological transformation, the approval decision would be made at the level of the ministry, a national corporation, or a local government.

After substantive approval by one of the bodies mentioned above, a contract defining an agreement with a foreign partner must be submitted for MOFERT (or local foreign trade bureau) review, which involves a comparison of the terms of the contract with criteria expressed in policy regulations.

It is difficult to say with confidence that the decisionmaking actually works the way it is designed to. Furthermore, the system is changing as reforms in the economy progress and as new approaches and new participants appear. 13anks have clearly emerged as more important parties, and relatively new organizations, such as CITIC, also influence the way the system operates. In addition, the decisionmaking system is embedded in an environment of bureaucratic struggles and shifting alliances, making the decision process, as well as the outcome of a decision, difficult to predict.

Despite much serious effort to establish policies and institutions for importing technology, the current Chinese system has become the object of criticism from outside and inside China. The criticism from outside, discussed in chapters 2 and 4, focuses on the impediments to doing business in China. The criticism of the current system from within China focuses more on whether the current system for technology transfer serves Chinese interests. Apart from those criticisms inspired by desires to protect domestic industries and R&D facilities from foreign competition, the more disinterested commentaries on the current situation focus on three main issues: the problems of duplication of imports, the negative consequences of decentralization, and the problem of assimilation.[40]

The problem of duplicative technology imports has been particularly evident in consumer-oriented light industry. Reportedly, over 100 color television assembly lines were imported since the late 1970s. If all were put into operation, they would more than saturate the market. To make matters worse, many of the components could not be made in China and had to be imported, resulting in a waste of foreign exchange. Similar problems were encountered with other consumer appliances, such as refrigerators and washing machines. Strong local interest in the production of floppy disks for computers has led to the proliferation of small plants to produce them, thus losing economies of scale.[41]

A related example is the field of optical telecommunication technologies. In this case, three different Chinese organizations have been negotiating with three different foreign companies, from the United States, Japan, and Europe. Instead of coordinating their efforts, they are all going separate ways, with the possible result of duplication and excess capacity. Since this area of technology has been identified as a national priority, two units of the central government have been charged with

[38] Except in those jurisdictions, such as Shanghai, which have been delegated authority to make decisions on higher valued projects.

[39] "This discussion is drawn from a three part article by Cao Jiarui entitled, "The Present Condition of, and Problems in China's Technological Imports," published in the overseas edition of the journal, *Liaowang*. Part 1 appeared in No. 18, May 5, 1986, and was translated in FBIS, May 16, 1986, p. K5 ff. Part 2 appeared in No. 19, May 12.1986, translated in FBIS, May 22, 1986, p. K1O ff. Part 3 appeared in No. 20, May 19, 1986, translated in FBIS, May 30, 1986, p. K13 ff.

[41] Cao Jiarui, Part 1, op. cit.

overseeing the importing of this technology. However, because these central authorities are linked to the organizations involved with the negotiations, they are unlikely to be disinterested arbiters and eoordinators.[42]

The current critiques of the decisionmaking system for technology imports reflect the underlying problems of Chinese institutional weaknesses and jurisdictional confusion seen elsewhere in this report. A recently reported case involving continuous casting technology used in steel plants illustrates this point. In this case, china imported the technology from West Germany in 1980 under a cooperative production arrangement. The technology was assimilated to the extent that the Chinese reproduced and employed the technology successfully in other steel mills. As is often the Chinese custom, the achievement was publicized as a case of how foreign technology can help China and how successful assimilation can be accomplished. On the basis of this success, the State Council issued a directive in 1981 to the effect that in the future, if steel plants need this type of continuous casting machinery, they should first try to acquire it in China.[43]

In 1985, by which time the decentralizing of decisionmaking on technology imports had been implemented, a Chinese steel plant was in need of a continuous casting machine of the type that had by then been successfully produced in China using the original German technology. Instead of looking for a Chinese supplier, however, the plant decided to import the machinery, in violation of at least the spirit of the State Council directive. The justification for going to the foreign supplier was that the foreign equipment had certain technical characteristics allegedly not available in China.

To proceed with the purchase, the plant had to secure the approval of the provincial authorities only. The first step was to conduct its own feasibility study. This was then followed by an approach to the provincial branch of the bank, which conducted its own assessment and report. Finally, the provincial economic committee gave the plant approval to proceed again, seemingly in violation of central policy .44

Information is not available on the technical differences on whether the plant, the branch bank, or the provincial economic committee were unaware of the State Council directive or simply chose to ignore and circumvent it. Nor is it known whether the plant and provincial authorities genuinely believed that the foreign technology was most appropriate, whether they were attracted to the foreign technology simply because they assumed it was best because it was foreign, whether there was some form of corruption involved, or whether the authorities were simply incompetent to evaluate the proposed transfer in light of China's own capabilities. Any or all of these explanations are possible, given a variety of reports from China in recent years. What is clearer, however, is that from the central government perspective, this is the kind of experience that leads to duplicative imports that unnecessarily drain foreign exchange reserves.

Would the decision have been more in keeping with the national interest if there had been greater centralization? The answer to this question is not certain. The answer would almost certainly be positive if the center had a limited number of such cases to decide and could devote the necessary resources to information gathering and analysis. However, the number and variety of technology import cases clearly are far greater than the central authorities can handle. Central planner incompetence and ignorance of local particularities is precisely the weakness of centrally planned economies, and the main justification for decentralization. While the central authorities can and do rectify grievous mistakes, as they have now done in the TV, refrigerator, and washing machine cases, routine and efficient central direction of technology imports is seemingly beyond the capacity of the system.

China has had difficulty finding an institutional formula that would allows effective central policymaking, the observance of these pol-

[42] Ibid.
[43] Ibid.
[44] Ibid.

icies in their implementation, and the flexibility of decentralized decisionmaking. The problem is the one alluded to in the previous chapter, that of the legacy of past decentralizations that empowered local (especially provincial) governments.

The Chinese sometimes refer to the structure of economic authority in China as a checkerboard, meaning that vertical authority emanating from the central government through ministries and commissions is crosscut by the horizontal interests of local or regional authorities. This system is sometimes also referred to as *tiao tiao kuai kua*", literally "branches and lumps," in which the central ministries and commissions are the "branches" and the "lumps" are formed when these are crosscut by regional authorities. As one commentator put it. "The crucial point of our existing system is the division of departments (read ministries) and regions, which develops into a series of complicated contradictions between different departments (ministries), between department and region, and between different regions.'"[45]

This system of institutions has the effect of constraining the decisionmaking effectiveness of all parties and explains why even in periods of greater centralization, central authority is not necessarily determinative even on high-priority matters.

Not surprisingly, Chinese perceptions of institutional deficiencies differ. From the perspective of the production enterprise, decentralization has not gone far enough, since the enterprise's own autonomy is constrained. If the enterprise is under the jurisdiction of a local government, it is constrained by the interests and prerogatives of the latter, as well as by national policy. If the enterprise is under the jurisdiction of a central ministry, it is constrained by the interests and practices of the ministry and by overall national policy. However, it is also subject to the discretion of the local authorities, who typically would have a say in the management of the enterprise's personnel matters and in the supply of such goods as water and electricity. From the view of central planners and high-level economic and technology policy makers, on the other hand, the impression is one of fragmentation, with authority dispersed among ministries and regions.[4G]

The current economic reforms and efforts at political institutionalization would seem to promise some improvement in decisionmaking. However, the record to date is mixed. For instance, management of Chinese industry has in many cases been removed from government ministries and vested in new corporate entities, which in principle are to run as profit-making organizations. However, these have not always been able to escape the heavy hands of party cadres, who want to maintain old ways of doing things even as the forms of organization change. Efforts are being made throughout the government and the economy to promote younger, more technically qualified, and more entrepreneurial individuals into managerial positions. On the other hand, the economic system still does not generate the economic information on which managers can base sound technology transfer decisions, nor the incentives for managers to assume the risks of innovation.

The now-standard insistence on feasibility studies for technology import decisions is intended to inject additional technical judgments into decisions and to force the attention of more interested parties on assimilation problems. The mechanisms for horizontal technical communication, noted in the next section, also aid in Chinese decisionmaking. Although this was not true in the late 1970s, decisions about importing technology are often informed by some of the best technical judgments in China. This is largely a result of the growth of consulting and advisory services.

However, the best technical judgments do not necessarily result in the the most appropriate technology decisions, and it seems that the full integration of technical, economic, and political criteria remains something of an ideal. There are some reports, for instance, that fea-

[45]1 bid.

[46]Cao Jiarui, Part 3, op. cit.

sibility studies are not always taken seriously and are used for manipulative purposes. The prevalence of this practice, not unheard of in other countries, is not known.

A summary assessment of China's decision-making system for technology imports is difficult. The system is composed of elements of centralization and decentralization, of market principles and planner influences. An optimistic interpretation is that it can be thought of as a transition to a more market-driven, decentralized system. This interpretation is clearly consistent with the intent of current policy, and much Chinese reform experienced since 1979 provides evidence for it.

The pessimistic interpretation is that the system is stymied, stuck between the imperatives of centralization and decentralization, of market and plan. In this view, the inertia of the established institutional setting is so great, and its power so entrenched, that reform policies cannot be fully implemented. Instead, reform impulses from the center will be distorted at various points in the system, producing undesirable and unanticipated consequences of the types noted above.

ISSUES OF ASSIMILATION AND DIFFUSION

Acquiring technology is only half of China's problem. Once transferred, the technology must be assimilated and diffused effectively if China's modernization goals are to be achieved.

The question of assimilation is linked to the underlying issue of technological dependency on the foreign suppliers of technology. Since the end of the 1950s, China has been particularly sensitive to this issue of dependency and has striven to avoid it. Ironically, however, the policies and institutions established in the past to foster self-reliance are now obstacles to the full assimilation of technology under the new assumptions of the open-door policy. The risk of dependency thus increases as the problems of assimilation remain unsolved.[47]

In discussing the assimilation of technology, it is useful to distinguish between production (using the imported technology), manufacturing (replicating the import), and design (the capability to redesign the technology) .48 Overall, China's ability to assimilate production technology has been greater than its ability to absorb manufacturing or design technologies. However, it is also useful to recall the various periods of Chinese technology imports, since assimilation experience has varied somewhat from period to period.

The Chinese seemingly did better at assimilating all three types of technology during the 1950s than in the subsequent two periods. Soviet provision of blueprints, technical advisors, and training programs undoubtedly contributed to this success. On the other hand, the technology transfer experiences of the 1960s and 1970s were not notably successful in terms of thorough assimilation. 'g

China's past history of importing technology suggests that many factors influence effective assirnilation.'" Choosing the right technology at the outset is clearly important. Many of the cases of unsuccessful assimilation were due to procurement decisions made by technically unqualified people, which resulted in the import of technology having the wrong properties for the intended task. Also, the Chinese underestimated the value of expertise relative to hardware, and neglected the support items necessary to make assimilation successful.

A second concern has been that managers have not been willing to make the effort to fully absorb the technology. That is, they have been

[47] Zhang Shihong, "A Noteworthy Issue: Digestion, Absorption and Renewal in Technology Importation as Viewed From Shanghai," *Renmin Ribao*, May 3, 1985. In JPRS-CST-85-027. Aug. 22, 1985. p. 62.

[48] K.C. Yeh, "China's Assimilation of Foreign Technology, 1950-1985, 'paper presented at the conference on *China New Technological Revolution,* Harvard University, May 9-11, 1986.

[49] Ibid.

50 This discussion is drawn from Ibid.

more interested in expanding output by exploiting the production technology without attending to the acquisition of the underlying manufacturing and design know-how. Imported technology has been seen as a shortcut to technical progress. Yet, effective assimilation requires focused attention to the problems of absorption. In addition, it requires communication and cooperation among a variety of organizations, such as enterprises, research units, government agencies, and universities. China's segmented society has often frustrated the meeting of this requirement.

Another problem has been the lack of adequate managerial know-how to employ the technology fully. This was less of a problem in the 1950s since the Chinese imported Soviet management along with the technology and had the services of Soviet advisors. In subsequent periods, however, Chinese managerial backwardness became a hindrance.

China's past experience also points to the importance of having domestic R&D resources committed to the tasks of assimilation. As the Chinese currently see it (which is in keeping with international analyses as well), much of the Japanese success in assimilation was due to the attention given to adaptive engineering and R&D in support of absorption, with expenditures on the latter running five to seven times those of the purchase of the technology."

Although China's R&D resources are not insubstantial, they have often been poorly deployed and misused; China's best talent, for instance, is typically employed in centralized research units not physically proximate to the enterprise importing the technology. Furthermore, Chinese R&D personnel have been compartmentalized, keeping researchers and engineers from the academies, the universities, and the production ministries from working together on assimilation tasks.

China has many of the same problems of assimilation that other developing countries receiving transferred technology experience. Yet, China also has both distinctive advantages and disadvantages in dealing with technology from the international economy. During the last 2 years, the Chinese have come to realize the importance of paying special attention to the problems of assimilation. Current discussions of assimilation, however, indicate that the problems that troubled the assimilation process in the past have by no means been overcome. An examination of current assimilation problems points to the following problems.

51 Ibid.

Technical Manpower

A first constraint facing many developing countries is a shortage of qualified technical and managerial manpower and a lack of scientific tradition. In absolute terms, China has a large pool (approximately 2.4 million) of scientists and engineers.[52] Even though the quality of training received by those in the pool varies a great deal, and the distribution of talent by region and economic sector is unbalanced, China does have a cadre of technical specialists to facilitate technology transfers.

China is also rapidly expanding its technical manpower ranks through its own new educational policies and by taking full advantage of educational and training opportunities offered abroad by institutions of higher education, companies, and foreign governments. Thus, while manpower inadequacies do appear in the context of technology transfers, foreign firms seem to agree that the Chinese are moving up the learning curve effectively.

Manpower limitations affecting the assimilation of foreign technology are exacerbated by two characteristics of the Chinese technical community. The first is the misuse and maldistribution noted above. Too much of China's technical manpower is concentrated in centralized research institutes, which have historically not been well connected to production enterprises. Meanwhile, at the level of the enterprise, there is often a severe shortage of engineers.

[52] See, Leo A. Orleans, *The Training and Utilization of Scientific and Engineering Manpower in the People's Republic of China,* U.S. House of Representatives, Committee on Science and Technology, October 1983: and Orleans, "Graduates of Chinese Universities: Adjusting the Total, *The China Quarterly* (forthcoming).

Limitations on the mobility of technical personnel also hinder both the assimilation and diffusion of technology. The tendency of enterprises and research institutes to regard technical personnel as the propert y of the unit has been a major obstacle to labor mobility. A variety of new approaches to stimulate the movement of technical personnel have been introduced since the early 1980s. Although these have had some positive results, the problem remains serious.[53]

Second, problems with the educational system affect the seriousness of the manpower constraint. Two deficiencies in particular stand out. First, the typical Chinese graduate is usually stronger in theory than in hands-on experience relevant to the tasks of technology absorption. Second, the educational system, especially in engineering, has focused too much attention on training narrow specialists who are often ill-equipped to deal with problems requiring interdisciplinary approaches. In addition, the failure of the educational system to produce economists who are familiar with the economics of the industries in which the transfers are occurring is a hindrance to effective decisionmaking.[54]

Management

China's lack of personnel with modern management capabilities may be of greater immediate importance for assimilation than the shortage of scientists and engineers. Although often capable and experienced in working under conditions of static technology and the dictates of a planned economy, China's managers now face a very different environment.

Effective technology assimilation requires a systemic understanding of how the technology will fit into the social system to which it is being transferred and a willingness to take risks and to adopt a timeframe that sees the value of the technology over the longer run. It also requires an understanding of the forward and backward linkages needed for the effective deployment of the technology. As noted above, these are not traits that were instilled in Chinese managers by the old system, which put immediate production targets foremost in the manager's mind and made risk avoidance a rational individual strategy.

The Chinese government is well aware of the limitations of the present enterprise managers. Modernization in management has been encouraged by policy changes such as decentralization of authority, institution of managerial accountability, provision of incentives and flexibility in organizational design. The most effective improvements have resulted from direct contact with modern managerial techniques—through joint ventures and other forms of technology transfer and in training centers, such as the Dalian Institute sponsored by the U.S. Department of Commerce. The number of managers that can benefit directly from such contact is minute compared to the total need in China, but the effect appears to be multiplied by the dissemination of information from the centers and by learning from the example of the now more effective managers. Since managerial inadequacy is one of the most severe constraints, special attention is warrented if technology transfer and China's modernization are to be supported.[55]

Research and Development

In contrast to many developing countries, China has a comprehensive industrial structure and an extensive R&D network. Yet Chinese R&D has had many problems and, like the economy as a whole, is now the target for extensive reforms.[56]

Most sectors of the industrial economy have research, design, and educational institutes.

[53] See, Leo A. Orleans, "Reforms and Innovations in the Utilization of China's Scientific and Engineering Manpower, ' paper presented at the conference on *China New Technological Revolution,* Harvard University, May 9-11, 1986.

[54] Geoffrey Oldham and Alyson Warhurst, "Technology Transfer to the Chinese Offshore Oil Industry, " unpublished report, University of Sussex, Science Policy Research Unit, no date, p. 43.

[55] William A. Fischer, "The Transfer of Western Managerial Knowledge to China, " app. 5 in vol. I I of this report, May 1986.

[56] See, Richard P. Suttmeier, "New Directions in Chinese Science and Technology, " in: The Asia Society, *China Briefing: 1985* (Boulder, CO: Westview Press) 1986.

Many of these had experience with technology transfers from the Soviet Union in the 1950s, and all of them have had experience with technological self-reliance since 1960. This R&D system was terribly disrupted during the Cultural Revolution, and its capabilities were reduced. Nevertheless, it is important to recall the evolution of this system since 1949, its many achievements, and the renewed support it enjoys in the post-Mao period. It is a significant resource that could aid China in assimilating foreign technology and avoiding technological dependency. China's technical community needs to be brought up to world levels, but it does not have to be created anew.

Ironically, the existence of an established industrial structure and R&D system at times works against technology transfer. Because do mestic industry and the R&D establishment have interests in domestic supply, China is faced with make-or-buy questions that would not trouble other developing countries. In addition, China's domestic industry has had trouble converting the results of its research into serially produced new products. These problems, and the more general relative technological backwardness of the domestic industry, provide opportunities for the foreign suppliers of technology. It is likely, however, that effective international technology transfers will also stimulate the domestic industry to improve its capacity for indigenous innovation.

Like the manpower problem, the R&D system has historically been compartmentalized, and R&D has been concentrated in centralized institutes rather than at the level of the enterprise that needs the technology. The current reforms in China's science and technology management system are intended to change this situation, but it is likely that the strengthening of R&D at the enterprise level will take time.

A second problem is that R&D supportive of technological assimilation has not received priority attention and adequate funding. The linking of R&D plans to technology import plans is a recent development. The new policy emphasis being given to assimilation is intended to bring attention to the need to forge this link, but a lasting solution to the problem is not likely to be found in central policy directives. More likely, the solution will depend on the course of the reforms of the economic and the science and technology systems, with their emphases on enterprise autonomy and the strengthening of enterprise R&D.

The Supply System

China's ability to absorb and assimilate technology is influenced by problems in the domestic economy. Many characteristics of the economy that inhibit domestic innovation in China also affect the assimilation of foreign technology. The inability of the economy to supply high-quality inputs reliably-up to the technical standards required by the foreign technology-to enterprises engaged in the importation and assimilation of technology is one of the more serious of these problems.

One example is the well-publicized case of the Wuhan steel mill, which imported advanced German technology but found that the machinery in which it was embedded could only be used for a fraction of the designed time. The electronic control technology of the imported mill presumed the supply of a reliable source

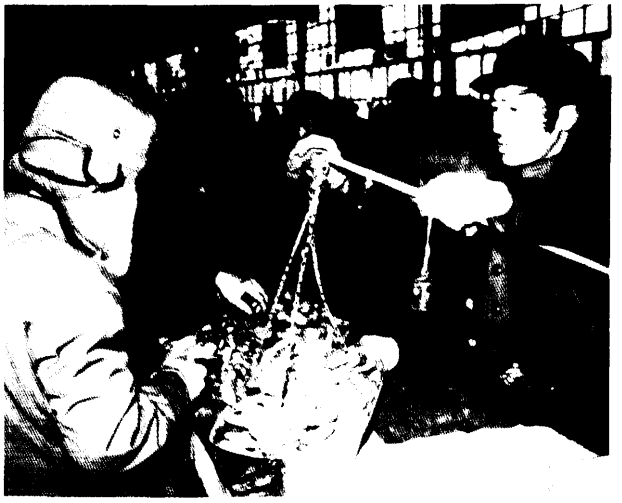


Photo credll Eric Basques

This ginger root salesman is completing a sale in the Changchun agricultural "free market. " Produce In excess of government quotas can be sold for what the market will bear.

of electric power, which the city of Wuhan did not have. In other cases—the Shanghai Foxboro and Beijing-Jeep joint ventures, for instance-the supply problem is also seen in the supply of raw materials, semi-processed materials, and finished intermediate goods.

The uncertain availability of these inputs slows the full assimilation of the technology, prolongs reliance on foreign suppliers, and thus increases the demands for foreign exchange. Scarce supplies have been a particular irritant to joint ventures. In some cases, the best hope is to go to enterprises from the military industries that are now instructed to serve the civilian economy. These enterprises are often able to meet the quality standards required, but they may not have the incentive to link up with the joint ventures. Undercurrent economic conditions and policies, they often find it more profitable and less demanding to produce for the Chinese domestic market.

The response of Chinese enterprises to the uncertainties of the supply system has been to pursue vertical integration, creating a technological system different from those in capitalist countries, in which components for technologies are often sourced from many different supplier companies. This systemic difference influences Chinese choices of technology and assimilation. The Chinese often expect more technology transfer than the Western firm can supply, since some of the component technologies are the property of other firms. The full assimilation of the technology supplied to China may therefore be blocked because the supporting, component technologies are neither available to nor being supplied to China.

Internal Diffusion

The question of how effectively foreign technology is diffused within China remains uncertain. This issue is particularly pertinent for the transfer of dual-use technologies to civilian entities. U.S. national security implications arise if these technologies diffuse to the military. Foreign firms have also been concerned that without effective patent protection, technology licensed to one enterprise may be illicitly transferred to another. China's new patent law and other recent policies designed to encourage technology transfer, should help alleviate some of these concerns. A separate question, however, is the capability of the Chinese system for internal technological diffusion.

Chinese organizations are excessively bureaucratic and compartmentalized. Contrary to the principle of communalism embedded in official ideology, Chinese enterprises and research institutes often act as if they have proprietary claims on technology and, more importantly, on the technical manpower they employ. The clarification of property rights pertaining to knowledge is an important element in current reforms of the science and technology system. Yet the Chinese continue to lament what they refer to as departmentalism, and the lack of effective horizontal, interorganizational communication. Instead, communications follow the strong vertical orientations along which Chinese organizations were designed.

For example, world-class bicycle-manufacturing machinery is produced by the Shanghai Bicycle Co. (SBC), one of China's leading bicycle makers, for its own production. The company has no interest in, nor incentives for, the production and marketing of its manufacturing equipment. The Shanghai Light Industry Bureau had to establish a specialized factory for the production of bicycle-making machinery. While the new plant is able to use the designs and manuals of the SBC'S equipment, the personnel from SBC who possess the know-how have not been deeply involved in the diffusion."

The Chinese have attempted to overcome the problems of technological departmentalism by creating mechanisms for crosscutting technological communications. The first of these are the professional societies organized around academic disciplines and industrial technologies. The professional societies draw individuals from different vertical systems (different

[57]The World Bank, *China: Long-Term Issues and Options: The Main Report* (Washington, DC: 1985), p. 172.

ministries, academies, and universities) into a common forum. A second mechanism is a network of scientific and technical information services which was developed with the cooperation of the U.S. National Technical Information Service. In addition to these two mechanisms, a large number of technical consulting organizations have been formed in recent years, and other organizations, including production enterprises, universities, and research institutes, have been active in establishing consultancies, as well. Recent policy has also sanctioned consulting by individuals.

Most importantly, however, the economic reform program is designed to alter the strong vertical, bureaucratic orientations of the economy by creating the conditions for horizontal market exchanges. This is true in the area of technology as well. With the initiation of technology markets for the buying and selling of technology, the regime has, in effect, recognized the de facto proprietary claims to knowledge that had been made by enterprises and research institutes as they resisted the sharing of technology without appropriate compensation. Thus the leadership now encourages the view that technology be considered a commodity to be bought and sold in a market rather than a free public good to be allocated by the state.

The Chinese are also trying to allow greater mobility of technical personnel. To create these conditions, the Chinese have had to modify established practices of administratively assigning technical personnel to jobs and have attempted to establish, on a trial basis, a limited labor market for scientists and engineers.

It is difficult to assess how effective this reform has been, but there are a number of indications that its impact has been dulled by the unwillingness of work units to allow their personnel to leave. Since most social services, including housing, are only available through the work unit, individuals may be reluctant to seek opportunities to move.[5g]

[5g]Cf., Orleans. "Reforms and Innovations ., . ."

The climate for the diffusion of technology has improved markedly in recent years even though the inherited structure of the Chinese economic and research systems still inhibits it. Current Chinese thinking calls for the attraction of foreign technology to the more developed coastal cities and the subsequent diffusion to the interior and throughout the economy. This strategy is becoming increasingly likely to be successful. The problems associated with the power of individual work units to make proprietary claims on technology and technical personnel, however, are formidable.

The Prospects for Assimilation

The financial, manpower, decisionmaking, and economic problems noted above make it likely that assimilation will not go as smoothly as the Chinese and their foreign commercial partners might like. It is important to remember, however, that China also has capacities that make it likely that some of these limitations could be overcome in the relatively near future. These include an expanding pool of trained personnel; an established, extensive R&D system; and new policies to encourage foreign investment and technology transfer, as well as those for economic, administrative, and educational reform. China's leaders, furthermore, have incentives to maintain an environment favorable to technology transfer and absorption.

As these policies have been refined, the importance of the assimilation issue has come into focus. China clearly seeks technology transfer agreements that will facilitate assimilation and include as much of the manufacturing and design know-how, as well as the production technology. Western firms however, have diverse motivations in their dealings with China and in their uses of technology transfer in corporate strategies. The behavior of the supplier of the technology, considered in the following chapters, can also influence China's assimilation ability, thus adding another variable to any analysis of likely assimilation experiences.

CONCLUSION

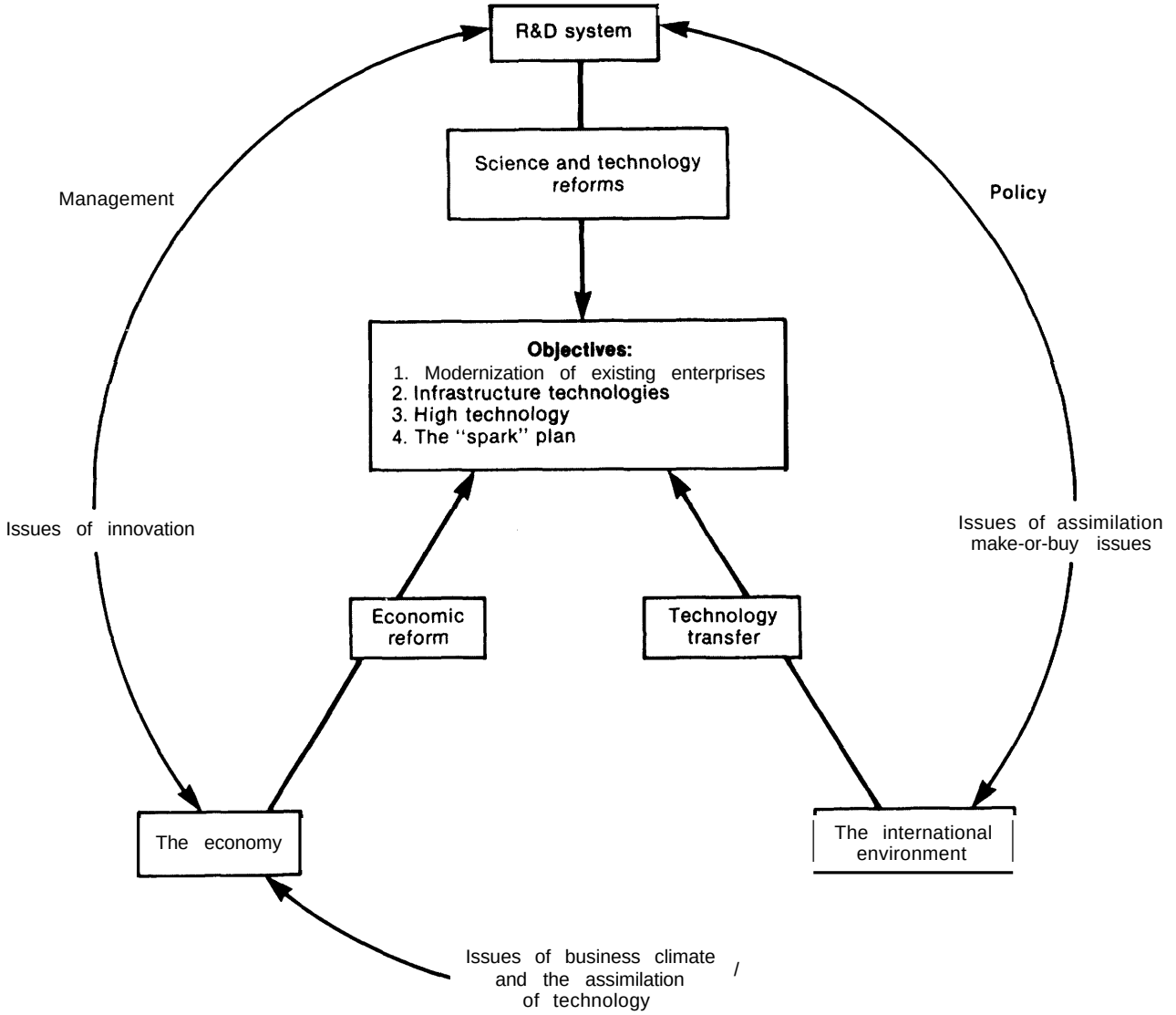
China has ambitious expectations about the role technology will play in its modernization and has set a course both to acquire technology abroad and to increase its domestic capabilities for producing technology. There is much to be said for the course chosen; there are also significant problems of decisionmaking, of assimilation, and with basic economic institutions; problems that must be solved if the full economic value of technology transfer is to be realized. Reforms under way should contribute to the solution of these problems, but the solutions will take time. Cases of China choosing inappropriate technologies and having difficulty with their assimilation are likely to be seen in the future, but they are likely to become fewer.

China's larger quest for modern technical capabilities involves much more than interactions with the foreign suppliers of technology. It is also shaped by the operational objectives of technology policy, by the nature of the domestic economic and R&D systems, by the quality of management, and by the policy environment. The complexity of this context for technology transfer can be seen in figure 3.

As depicted in figure 3, the underlying challenge the Chinese face in creating technical capability is to realize change on a number of fronts simultaneously. An enhanced capability for technological innovation entails changes in both the R&D system and the economy. Economic reform and changes in the policy environment are necessary for improving the climate for foreign investment. Effective absorption of foreign technology requires not only a policy environment conducive to the operation of foreign businesses, but also further economic reform and changes in the domestic R&D system.

While the Chinese realize the significance of the systemic nature of the technology transfer phenomenon, and while their modernization policies are intended to bring the elements of the system into greater harmony, the very complexity of the system makes it likely that there will continue to be problems with technology transfer. The wider significance of these problems is explored in chapter 6.

Figure 3.— The Acquisition of National Technical Capabilities: A Revised View of the Elements Involved



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