Technology Transfer from the Soviet Union to the People's Republic of China

1949–1966

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ABSTRACT Technology transfer to China on a large scale from the Western world began during the middle of the 19th century and went through several different stages. One of the important stages was from the 1950s to the early 1960s, when the Union of Soviet Socialist Republics (USSR) was involved in a comprehensive program of technology transfer to China. This program included three parts: one was to transfer industrial technology by aiding the construction of industrial projects; another was to develop Chinese capacity in science and technology through various forms of cooperation; and the third was educational and involved helping China adjust and construct technology colleges, as well as recruiting a large number of Chinese students to study in the USSR. As part of these assistance and cooperative projects, the USSR sent thousands of experts or consultants to China. This paper tracks the process of transfer through all three elements, examining their main content, characteristics, and influence of this enormous program of technology transfer.

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OVER THE PAST TWO CENTURIES, the development of modern technology in China has often involved the acquisition of foreign technology. Perhaps the most ambitious attempt to borrow outside technology was the program of transfer developed with the former Soviet Union during the 1950s and the early 1960s. This effort laid the foundation of modern technology and industry in China and as well as promoting the development of Chinese scientific research. The program exercised a large influence upon the new Chinese society.

This episode of technology transfer constitutes an indispensable chapter in the Chinese history of science and technology, as well as an important case study of international technology transfer. Chinese, Western, and Soviet scholars all have contributed to understanding this transfer program.[1] However, scholars have not yet prepared a synthesis of the different national literatures, nor have issue-specific doctoral dissertations been undertaken. This paper summarizes, from a Chinese perspective, the primary aspects of technology transfer from the Soviet Union, the main stages of diffusion, and the various forms it took. Attention is given to both interaction and interdependence, with consideration given to technological, economic, political, international diplomacy, and national security perspectives.

INTRODUCTION: SOVIET–CHINESE RELATIONS, 1950–1966

It is important to understand the specific international and local environments that surrounded the transfer of technology from the Soviet Union to China in the period 1950 to 1966. After World War II, a bipolar international order emerged, dominated by the confrontation and competition between blocs headed by the United States and the Soviet Union. During the Chinese civil war, ultimately won by the Communist Party of China (CPC), the U.S. government supported the Kuomintang with military, economic, and political assistance. From the winter of 1948 and again during the Korean conflict, the U.S. government refused to recognize the communist government in Beijing and imposed export regulations.[2] At the same time, the Soviet Union kept expanding its own socialist bloc in Eastern Europe and with other developing nations. The CPC had adopted ideals and goals quite similar to those of the Soviet Union, including the

[1]For example: М. И. Слалковского (1977b), Задчерскав (2003), Филатов, Л. В. (1975). However, we could not avail ourselves of Western research work, such as Goldman (1967).

[2]Edited chiefly by Wenzhao (2003, pp. 3, 132, 154).

political concept of communism. This connection provided an important ideologic basis for cooperation between the People's Republic China and the Soviet Union. However, ideologic similarities could not always overcome political considerations related to the achievement of national benefits. After the World War II, for example, Stalin sought to acquire an ice-free port on the Pacific Ocean and looked covetously at China. The Soviet Union also obtained special benefits in northeast China, and cooperated with the Kuomintang government of the Republic of China. At the same time, the Soviets wanted to restrict the Kuomintang government and confront the United States through an alliance with the Chinese Communist Party.[3] When the CPC gained its military triumph in the late 1940s, Soviet officials hoped that Communist China would join the Soviet bloc. Simultaneously, leaders of CPC were eager for help from the Soviet Union. From the end of January to the beginning of February 1949, they discussed the reconstruction of China and Soviet assistance with Анастас Иванович Микоян (Mikoyan), a representative of the Soviet Union, during that summer, when a delegation headed by Shaoqi Liu secretly visited Moscow, Zedong Mao, the chairman of the Chinese Communist Party, declared his policy of "leaning to the side of Soviet Union" in a newspaper article (Mao, 1967a, pp. 1362–64). In December 1949, Zedong Mao himself visited Moscow to negotiate a treaty with Soviet Union advancing Chinese national security and economic reconstruction (Luan, 2003b). On 14 February 1950, in Moscow, Chinese prime minister Enlai Zhou and Soviet leaders signed The Treaty of Amity, Alliance and Mutual Aid between Soviet Union and China and The Convention on Soviet Union's Granting a Loan to the People's Republic of China of 30 years' duration.[4] Henceforth, a series of economic trade agreements were endorsed between China and the USSR. The Soviet government mobilized manpower and material resources to help China launch a 5-year plan of national economic development (1953–1957) and organize a planned economic system with industrial projects. The USSR also pledged to provide equipment and technology, and sent consultants and experts to China. The Soviet Union swiftly became China's largest external trading partner. The Chinese foreign policy

[3]Although aiding the CPC, the Soviet Union did not want to risk open confrontation with the United States. While negotiating with the Republic of China, for example, Soviet officials claimed they would encourage the CPC to give way to the Kuomintang.

[4]Soon, the two parties endorsed a secret Additional Convention—the Loan Convention—and later signed the Trade Convention, which made the Merchandise Exchange Convention an open one between the two governments, which was endorsed between Soviet Union and the North East government of CPC at the administrative level of the two parties on 30 July 1949. The main contents in the convention of 1950 were the same as those in 1949.

of "leaning to the side of Soviet Union" increased its exclusion and hostility from the United States and the developed countries of Western Europe. Western countries joined the United States in isolating China, launched an economic blockade, and made it impossible for China to buy material, machinery, and technology directly from the West. China was forced to restrict its foreign trade relationships to the Soviet Union and the socialist countries in East Europe.[5]

With the United States as a common opponent, the Soviet Union and China shared similar concerns about national security. The American policy on China, the tension in the Taiwan straits, and the eventual conflict in Korea all appeared to Chinese leaders as threats to the security of Communist China. Chinese involvement in the Korean War came at a heavy economic price. Most of the loans provided by the Soviet Union were used to purchase Soviet weapons.[6] At the same time, Chinese entry into the Korean conflict eased Stalin's suspicions and apprehensions about China, leading him to expand cooperation with China in other directions (Li, 2002). After being elected secretary-general of the Central Committee of the Communist Party of the Soviet Union in September 1953, Nikita Khrushchev began to adjust foreign policy to win Chinese support. He tried to eliminate elements of disagreement between the Soviet Union and China, and identified China as the Soviet Union's most important partner. On 29 September 1954, Khruschev himself headed the first high-ranking delegation to visit China and announced seven agreements and protocols aiding China.[7] To strengthen Soviet influence after Stalin, Khrushchev enlarged the scale of economic, technology, science, military affairs, and culture assistance.[8] More than Stalin had, he respected Chinese opinions and Sino–Soviet cooperation reached its peak between 1953 and 1956.

Nonetheless, the leaders of the Soviet Union and China never fully trusted each other. Although China was determined to master modern technology, especially national defense technology, the Soviet leaders were

[5]On 2 September 1958, when interviewing two Brazilian journalists, Zedong Mao said that the commercial embargo of the Western world "didn't cause any damage to us, instead, it made us reap much benefit," and that it helped us eliminate "blind faith in foreigners." See Zhonggong Zhongyang Wenxian Yanjiushi, 1992, pp. 387–389.

[6]It was estimated that China spent as much as U.S. $10 billion on the War to Resist U.S. Aggression and Aid Korea (see Yao, 1980).

[7]During the Stalin era, Chinese leaders were expected to travel to Moscow to develop and sign treaties, conventions, and contracts.

[8]In the early 1950s, the Soviet Union was still recovering from the war and its own economy was not strong. The leadership of Soviet Union held differing opinions about aiding China on a large scale. Some Soviet officials worried that this aid would have negative effects on the Soviet economy or cause other problems. Khrushchev intervened with a lot of persuasion and refutation.

always of two minds. On one hand, Soviet leaders remained unsure of Zedong Mao's desire to remain independent of Soviet technology, nuclear protection, and general strategy, and expressed reluctance to provide China with advanced weapons. On the other hand, Krushchev needed Zedong Mao to support the Soviet Union's leadership inside the socialist bloc during his campaign to remove Stalinism in 1956. He agreed in 1957 to give China advanced military technology. Thereafter, Khrushchev and Zedong Mao slowly moved toward different interpretations of socialism and communism, and their divergence escalated. Ideologic, national benefits, and foreign policy differences emerged, and Sino–Soviet relations worsened. Soviet leaders responded by not releasing pivotal technology and technological details. By 1959, the Soviet Union began to restrict high-tech transfers to China because of this widening gap involving Sino–Soviet diplomatic and military cooperation, and because of Soviet negotiations with the United States on nuclear nonproliferation. During the early 1960s, the tensions between the two Communist Parties erupted into a public controversy so serious that it damaged the alliance between the two countries and disrupted all technology transfer efforts (Haiyincixi, 2001, p. 676). In December 1964, Khrushchev was removed from power, but the Sino–Soviet relationship did not improve. Instead, the two governments (and parties) gradually hardened their antagonism. In March 1969, with a frontier clash between their armed forces, the Sino–Soviet relationship hit rock bottom.[9]

INDUSTRIAL TECHNOLOGY TRANSFER AND THE SOVIET UNION

The history of the technology transfer program from the USSR to China must be understood against this political and historical background. Yet politics was not the only obstacle to its success. Before 1950, China did not emphasize the development of industry as the main arena for technology transfer from foreign countries. Not surprisingly, then, technology transfer from the Soviet Union to China began with Soviet aid to industrial projects.

[9]During the clash, the Chinese army captured a T-62 tank made in the Soviet Union, which was used as a model for improving the T-59 tank that the Soviet Union had introduced earlier.

1950 to 1957. When the CPC was about to come to power, CPC officials pressed hard for economic and technical assistance from the Soviet Union. In early February 1949, one of the main problems Stalin's representative Анастас Иванович Микоян discussed with CPC leaders was how the USSR might support reconstruction of the Chinese economy. Zedong Mao appealed to the Soviet Union for a U.S. $300 million loan. Soviet officials agreed in principle to send experts to work in China, and expressed willingness to help modernize Chinese defenses (Haiyincixi, 2001, pp. 262–270). On 27 June 1949, Stalin promised a delegation from the CPC that he would supply fighter planes and help China to establish aircraft construction and repair facilities.

By the end of 1952, the Soviet Union and China reached several agreements that promised aid for 50 important projects. On 21 March 1953, the two countries signed a convention on Soviet Union assistance in expanding and building power plants (Baolisuofu & Keluosikefu, 1982, p. 54). On 15 May 1953, Fuchun Li, a vice prime minister of the Chinese government, and Микоян, vice-chairman of the USSR's Council of Ministers, endorsed a treaty promising Soviet help in the establishment and reconstruction of 41 additional industrial enterprises. In return, China agreed to provide the Soviet Union with strategic raw materials including tungsten, copper, antimony, and rubber (Bo, 1991, pp. 300–301).

A turning point for Soviet aid to China occurred in 1954, when Chinese officials demanded that the Soviet Union speed up its assistance for heavy industry. In August 1954, a memo from the Soviet government promised to provide equipment and aid for 15 national defense enterprises and to develop another 14 industrial enterprises. By October, Khrushchev and Enlai Zhou headed government delegations that initiated a series of negotiations in Beijing that led to both sides endorsing documents that included "The Convention on Soviet Union Helping the People's Republic of China Build 15 New Industrial Enterprises and Expand the Supply of Equipment to 141 Primary Industrial Enterprises on the Basis of Technical Assistance" and "The Agreement on Soviet Union Government's Granting a Long Term Loan of 520 Million Rubles to the People's Republic of China." The total number of the projects targeted for Soviet assistance reached 156.[10] Most of the new projects were in the fields of energy, raw

[10]In fact, only 150 locations actually received assistance from the Soviet Union, 146 of which were developed during the period of the "First Five Year Plan." Because these projects were promulgated earlier, they continued to be called "156 Projects." The 150 projects actually constructed

materials, and manufacturing. China was to receive additional advanced equipment that was not even installed in most factories in the Soviet Union (Gangchalianke, 2002). Then on 28 March 1955, the Soviet Union and China signed another agreement calling for Soviet assistance to another 16 industrial projects, including projects in national defense, shipbuilding, materials, and manufacturing.

The primary concern of the newly established People's Republic of China was to build an infrastructure of basic and defense industries. This approach laid the foundation for China's industrialization (Bo, 1991, p. 297). As far as the specific criteria for choosing projects, Yibo Bo, a leader of Chinese economy, recollected:

> Frankly, at the beginning when "The First Five" plan was worked out, as to industry building, we were not so clear about what should be done first, what should be done next and how we could make every department cooperate with each other. Therefore, the projects aided by Soviet Union, some of which were put forward by us and some by the Soviet Union, were not determined before repeated negotiations. (Bo, 1991, p. 297)

For instance, the State Planning Commission of the Soviet Union and Soviet experts offered opinions on the industrial projects that might be constructed and which problems should be emphasized during the "First Five Year Plan."

In 1956, the Soviet Union and China endorsed additional agreements on assistance and cooperation. The "Industrial Aid Convention" signed on 7 April stipulated the development of 55 new industrial enterprises in China. The equipment and technology provided by the Soviet Union was worth 25 hundred million rubles (Baolisuofu & Keluosikefu, 1982, p. 77). On 7 September, 12 industrial aid projects were approved.

From 1953 to 1957, the various aid agreements between the two countries listed 244 industrial projects and 11 nonindustrial projects, 13 of which were counted more than once. Ten were cancelled, and 63 were accomplished by the end of 1957. The plans for another 169 projects were

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(*continued*) can be divided into five areas: energy, metallurgical and chemical industries, machine building, military industries, and light industry and pharmacy. Specifically, there were 25 projects in the coal industry; 25 in power; 2 in petroleum ; 13 in nonferrous metals; 7 in iron and steel; 7 in the chemical industry; 24 in machine building; 16 in the weapons industry; 12 in aviation; 10 in electronics; 4 in shipbuilding; 2 in space; and 3 in light industry and pharmacy. The 150 projects absorbed about half of the total industrial investment during the period of the "First Five Year Plan." Such items as entire sets of equipment imported from Soviet Union were about equal to 30% of the total industrial investment (see Maikefakuaer & Zhengqing, 1990, p. 184).

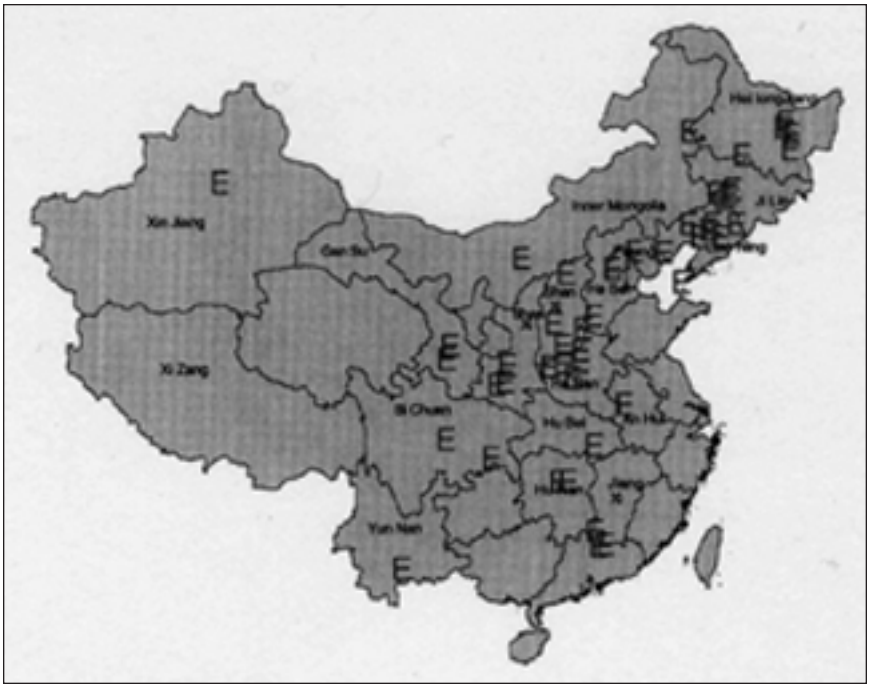

Figure 1 *Map of China.*

adjusted by China (Zhang, W., 2003). Before 1953, about 70% of the industry in China was centralized on the coast.[11] The projects that the Soviet Union and East European countries aided changed the overall industrial arrangement in China, adopting three placement considerations: (1) proximity to resources, (2) ability to change economically underdeveloped areas, and (3) military considerations.[12] Of the 106 civil industrial enterprises in the "156 Projects," 50 enterprises were located in the Northeast and 32 in the middle of the country; 35 of the 44 national defense enterprises were situated in the middle and Western areas. The distribution of non-defense enterprises among cities is shown in Figure 1.

1958 to 1962. The industrial achievements between 1953 and 1957 increased the confidence of China's leaders. Inspired by improved circum-

[11]During the "First Five Year Plan," countries such as East Germany, Czechoslovakia, Poland, Hungary, Romania, and Bulgaria promised to help China build 116 factories and to provide some equipment for another 88 factories (Peng, 1989, pp. 52–53).

[12]Yibo Bo said, "In view of national defense, in view of safety, this was one of the main factors to determine the sites of the factories" (1991, p. 299).

stances within and outside China by the fall of 1957, Zedong Mao proposed that Chinese economic indices should exceed those of England and United States within 50 years; in 1958 he added that this should be accomplished within the next two years. The aim was subjective and impractical. But following Zedong Mao's instruction, agriculture began to advance, followed by other sectors. This was "The Great Leap Forward," a revolutionary idea characterized by intense confusion over the goals of increasing economic indices and promoting collectivization of agriculture, communal dining, and random superintendence. Arrogance created the illusion that agricultural self-sufficiency was achieved. In fact, this resulted in a series of poor decisions, such as the shifting of agriculture labor to mass industrialization projects and huge economic imbalances. The dream of exceeding the economic output of England and the United States in the short term greatly damaged the Chinese economy. Rather than a Great Leap Forward, the Chinese economy suffered a great setback.

During the "Great Leap Forward" (1958–1960), Zedong Mao was much more optimistic than before about China's technological capabilities. On 10 March 1958, at a meeting in Chengdu, he said that because the Chinese had known so little in the past, they were forced "to obey blindly" Soviet experience, but the result was dogmatism.

First, as to heavy industry—its design, construction, and installation—all could not be done by the Chinese. Not having experience or experts in China, we had to imitate foreign countries, and even with imitation, we could not always duplicate the technology. Furthermore, we had to rely on Soviet experience and experts to overcome the bourgeois ideology of earlier Chinese experts. Additionally, although most Soviet designs adopted for use in China were sound, some were flawed, but were copied without thinking.

Second, China had no idea about the overall economic situation, and knew even less about the economic differences between the Soviet Union and China. Thus, China blindly accepted the Soviet's perception. "Now, things have changed. Generally, we can complete the design and construction of large enterprises. In five years, we can make equipment. We now know the different situations of the Soviet Union and China" (Mao, 1967b, pp. 27–29).

On 28 June, at the group leaders' symposium of the enlarged session of the Military Commission of the Central Committee of CPC, Zedong Mao said, "It was quite necessary to shoot for the support from Soviet Union, but primarily, we will rely upon ourselves" (Mao, 1967c, pp. 78–80). During the second session of the Eighth Congress of the Representatives of the Chinese Communist Party in May, Zedong Mao again warned, "Without

the Soviet Union, (industry and military affairs) can't survive. This argument is unacceptable" (Zhonggong Zhongyang Wenxian Yanjiushi, 1992, p. 203).

However, other leaders, including premier Enlai Zhou and vice premiers Fuchun Li and Rongzhen Nie, were more practical. On the whole, they recognized the value of Soviet technical assistance. Even as the political differences between the Soviet Union and China became obvious, these leaders sought more industrial, technical, and scientific assistance from Soviet Union, and pressed on with the introduction of Soviet technology for national defense and manufacturing. On 6 August 1957, Enlai Zhou delivered a letter to Soviet leader, НиколаЙ Алєксандрович Ђулганин (Bulganin), which specifically requested assistance in strengthening the national defense forces of the P. R. China and in working out a second 5-year plan. The letter also suggested that a Chinese delegation negotiate with the Soviet government in Moscow (Zhang, W., 2003). In May 1958, Enlai Zhou delivered a letter to Khrushchev, requesting that the Soviet Union design 48 industrial projects during the second "Five Year Plan" and supply machinery and equipment. That July, the Chinese government requested Soviet help with several guided missile factories (Gangchalianke, 2002). Then on 8 August, in Moscow, the delegations of Soviet and Chinese governments endorsed "The Convention on Union of Soviet Socialist Republics Helping the People's Republic of China Build and Expand 47 Industrial Enterprises on the Basis of Technical Assistance." This convention stipulated that the Soviet Union would transfer gratis the products needed for the 47 enterprises. On 7 February 1959, Khrushchev and Enlai Zhou officially endorsed "The Convention on Union of Soviet Socialist Republics Helping the Peoples' Republic of China Build and Expand 78 Industrial Enterprises on the Basis of Technical Assistance" in Moscow. The Soviet Union tried its best to meet the needs of three key heavy industries, including metallurgy, thermal and hydro power plants, and machine building. The Chinese government planned to pay for technical assistance, equipment, and materials from the Soviet Union with goods.[13] The Soviet Union agreed to send experts to China, and to accept Chinese experts and workers who would study technological processes and practice production techniques in Soviet factories.

Compared with the projects aided by Soviet Union in the period of the "First Five Plan," the scope of projects from 1958 to 1962 was at least

[13]The details are found in "The convention on Union of Soviet Socialist Republics helping the Peoples' Republic of China build and expand 47 industrial enterprises on the basis of technical assistance" (and three annexes).

twice as large (Guojia Jiwei Dangzu, 2003). All together, the Soviet Union supported 304 projects with complete equipment during the 1950s (Peng, 1989, p. 53.). Dieter Heinzich estimated that one third of the industrial enterprises and other establishments receiving such support between 1950 and 1959 fell into military branch (Haiyincixi, 2001, p. 671).[14]

technical assistance

Soviet assistance to Chinese industrial projects took several forms, including the transfer of entire designs; shipment of manufacturing technology and equipment; deployment of experts to instruct Chinese during construction, installation, and debugging of equipment; and training and instruction of Chinese technical and administrative cadres and workers during trial production. Thus, the Soviet Union provided China with designs and manufacturing or processing technology for such industries as alloy steel and petroleum products, heavy machinery, machine tools, measuring and cutting tools, power plants, electric generators, mining machines, oil extracting and oil refining devices, trucks, caterpillar tractors, locomotives, instruments, bearings, switches, rectifiers, films, heavy artilleries, tanks, tank engines, fighter jets, airplane engines, and rockets. Eastern European countries provided product designs and manufacturing technology for instruments and wireless components. China had not manufactured most of these products; if it had, Chinese products were substandard. But now China sought to acquire the design of accessories and equipment that Chinese factories could manufacture.

Complete equipment transfers. Exporting complete sets of equipment was one of the most important means of providing assistance to China. The machines the Soviet Union and Eastern European countries provided equipped collieries; power plants; steel smelting and processing factories; nonferrous and rare metal factories and mines; chemical plants; machine tool factories; heavy machine plants; car, truck, tractor, and tank manufacturing plants; locomotive works; airplane factories; electric generator factories; mining and petroleum machinery manufacturing plants; electrical equipment and radio plants; special paper-producing factories; sugar refineries; pharmacy production; and many others. Altogether 304 projects received complete sets of equipment; 149 of these projects were finished, and 66 others continued. Another 64 projects gained a single workshop or piece of equipment, and 29 of these basically were finished (Peng, 1989, p. 53) (Figures 2 and 3).

14. The Chinese indicated that 87 of 304 projects fell into military branch (Zi, 2004, p. 156).

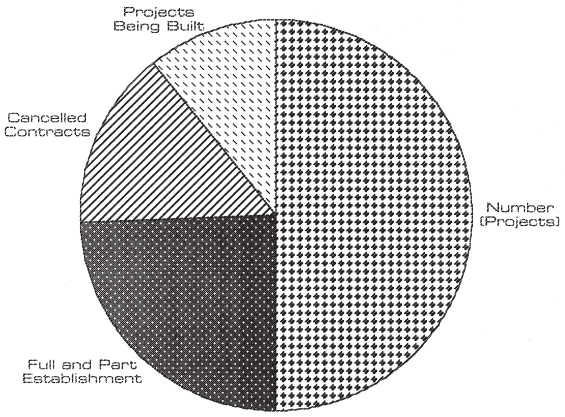

Figure 2 *Full sets of equipment received from the Soviet Union: number (projects), 304; full and part establishment, 149; cancelled contracts, 89; and projects being built, 66.*

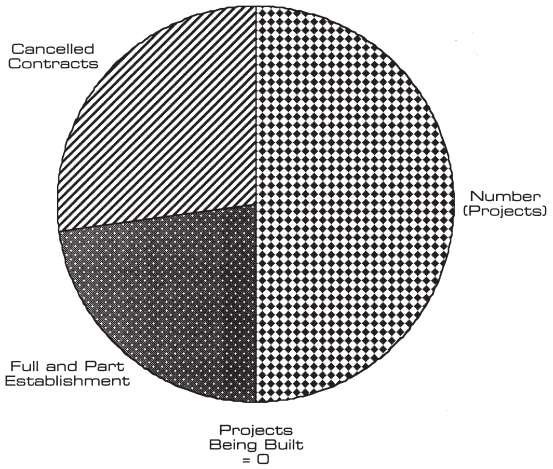

Figure 3 *Single workshop or equipment projects: China and the Soviet Union: number (projects), 64; full and part establishment, 29; cancelled contracts, 35; and projects being built, 0.*

The Soviet Union invested 76.9 hundred million old rubles (money used in the Soviet Union in the early 1950s when Zedong Mao first negotiated with Stalin in Moscow) and Eastern European countries invested 30.8 hundred million old rubles in technology and equipment in China (Peng, 1989, pp. 54–55). According to data in the Soviet Foreign Policy

Archives, Soviet exports to assisted enterprises totaled 9,409 hundred million rubles, of which equipment accounted for 8,394 hundred million rubles. This massive transfer amounted to 7.7% of the Soviet Union's annual national income from 1950 to the mid 1960s.[15]

The scale of economic reconstruction in China resulted in enormous orders to Soviet enterprises. In the early 1950s, Soviet Union took on the design, manufacture, and supply of entire sets of equipment for China. By the beginning of the "Great Leap Forward," every economic zone in the USSR had received orders for goods from China. More than 100 design institutes took on Chinese tasks, and thousands of industrial enterprises produced the equipment.

When discussions about projects for 1958 and 1959 began, the Soviets were falling short in their efforts to meet the Chinese demand for equipment. Driven by Zedong Mao's "Great Leap Forward," China demanded too much too quickly. The two nations negotiated the delay of certain equipment, but at the end of 1950s, a large volume of machinery, equipment, and other material arrived from the Soviet Union. The size of these orders occupied quite a large proportion of Soviet industrial capacity. For example, between 1960 and 1966, the steel rolling equipment planned for delivery to China was one third of the Soviet's annual production.

Clearly the Soviet Union made a great contribution to China under significant production pressures, but the Soviet Union also gained an opportunity to earn export revenues.[16] In the interest of maintaining good Sino–Soviet relations, China publicly stated that Soviet aid was selfless. In fact, China purchased much of the Soviet technology, equipment, and experts.[17] Khrushchev frankly admitted that Soviet technological, economic, and military aid to China was not selfless and benefited both nations. He also concluded that reinforcing China in this way could consolidate the socialist bloc and ensure the security of the Soviet Union's eastern border (Guifan, 1999).

Designs and Technical Data. The Soviet Union and Eastern European countries also transferred designs for factories and mines and related machinery to China. Engineering design institute and enterprises in those countries had experience with geological prospecting, choosing mill sites,

[15]This brought great pressure to the Soviet manufacturing and related technology departments. However, the Soviet Union took raw materials, agricultural products, and foreign exchange from China (Gangchalianke, 2002).

[16]The same situation existed with the U.S. Marshall Plan in Europe (Hogan, 1987).

[17]Moreover, in 1945, the Soviet Union sent troops into northeast China to defeat Japanese troops there. After occupying this territory, the Soviets removed more than half of the industrial equipment there.

assigning enterprises, planning phased construction, and preparing engineering designs, product designs and other technical data. Such data went to a number of factories not receiving complete equipment packages, and sometimes included technical data not included in the contracts.[18] By 1966, the Science and Technology Cooperation Commissions of the Soviet Union and China had held 15 meetings, and the Soviets had provided China with 6,536 data reports. Furthermore, such data were not treated as patents when exchanged. Instead, China covered only the cost of copying the data. As one Chinese document reported, "This [*sic*] data played an important role in the improvement of the technical level of Chinese industry and agriculture, and in the production of new products" (Peng, 1989, pp. 56–57).[19] For example, of the 51,000 sets of metal-cutting machine tools made in China between the 1952 and 1957, 43,500 came from technical data obtained from the Soviet Union (Baolisuofu & Keluosikefu, 1982, p. 153). And because China accepted Soviet product designs, technology, and other technical data, this meant that China also adopted Soviet technology and industrial standards. For example, many of the technical standards for Chinese mechanical industries were worked out in accordance with Soviet standards during the 1950s and 60s (Zhang, Zhang, & Huang, 2000).

China also received a large number of books and magazines on science and technology from Soviet Union (Baolisuofu & Keluosikefu, 1982, p. 154), and translated Russian books into Chinese. For example, in 1952, China published 8.6 million copies of 756 texts that were translated from Russian to Chinese.

impact of Soviet technological assistance

Developing Plant and Product Design Capacity. The importance that China attached to learning from the Soviet Union was apparent in the gradual improvement in the introduction and assimilation of equipment and technology. For example, the Chinese Central Finance and Economics Commission was interested in the knowing the difference between design-

[18]For example, according to the items in the contracts, it was enough for the Soviet Union to provide design information for the ЗИС-150 truck. However, when China wanted to imitate ЗИС-157 cross-country truck, the Soviet Union supplied the drawings of the cross-country truck.

[19]On 14 July 1963, a letter from the Central Committee of the Communist Party of Soviet Union responded to complaints from the CPC, noting that the Soviet Union had helped China to establish 198 industrial enterprises and other projects, provided more than 1,400 copies of design data, and trained thousands of Chinese experts and workers. This letter emphasized that they were still supporting 88 Chinese industrial enterprises and projects with technology (Wang, 2000, p. 75).

ed capacity and actual output. The commission demanded that the design and construction branch of Chinese government summarize their work experience in studying and absorbing the data supplied by the Soviet Union, compared to information from the previous Chinese enterprises.

Of the equipment needed by the "156 Projects," Chinese plants supplied 52.3% by weight (45.9% measured by cost).[20] Most of the equipment made in China relied on product drawings from the Soviet Union (Zhang, Zhang, & Huang, 2000). By analyzing the design of Soviet products and related data, as well as by copying machinery directly, Chinese engineers developed theories about Soviet design thought and methods. They then proceeded to develop new products based on this information. In the same way, Chinese engineers copied the manufacturing technology of products introduced from other countries. In fact, imitation is an effective way for an underdeveloped country to produce industrial products. Product design often requires a substantial scientific base, basic research and development capacity, as well as design ability. Imitation can limit the risks of failure and produce direct economic gains. Moreover, through imitation China gradually understood the introduced technology and gained design capability, allowing for internal development. For example, the First Automobile Factory in Changchun received Soviet equipment and technology and produced quality Jie Fang trucks. But this factory, having assimilated Soviet technology, imitated American and other production systems and developed its own design, the Dong Feng truck.

Through practice and the acquisition of technical data from the Soviet Union, Chinese enterprises and design institutions developed the capacity to design important products. In 1956, Enlai Zhou said, "As a result of learning from Soviet Union, our engineering circles have mastered a lot about how to design and construct modern factories, mines, bridges, and water conservation. And we have improved a lot on the design of large machines, locomotives, and ships" (Zhonggong Zhongyang Wenxian Yanjiushi, 1994, p. 19). By 1957, Chinese design institutions already could design and construct large projects with more complicated technology (Guojia Tongjiju, 1959, p. 8). For example, in 1957, engineers at the Harbin Electrical Machinery Plants designed hydroelectric equipment capable of generating 10,000 kilowatts, and those at the Dalian Rolling Stock Plant designed a large freight locomotive (1-5-1 type).

[20]Additionally, in 1955, 30% to 50% of the equipment needed in "156 Projects" designed and assisted by Soviet Union was made in China (Zhonggong Zhongyang Wenxian Yanjiushi, 1993b, p. 453). In February 1958, Yibo Bo announced that the proportion of the equipment needed in "156 Projects" that was made in China would increase from about 42% in 1957 to nearly 60% in 1958 (Zhonggong Zhongyang Wenxian Yanjiushi, 1995, p.119).

After 1957, the Chinese began to reduce demand for Soviet equipment when negotiating with the Soviet Union for assistance because of these improvements in design, manufacturing, and training. By this time, certain design and manufacturing tasks could be assigned to Chinese units. In 1958, for example, of the 47 projects that Soviet Union assisted with, the Soviet Union provided technology for 44; Chinese engineers designed another 37 projects that were supplied with key equipment from the USSR. China now possessed some capacity to design factories and mines and to manufacture production equipment. However, Chinese design institutions still could not manage the design of large or, especially, complicated projects using the most advanced technology. In fields where the Chinese lacked technical experience, Soviet technical assistance was still necessary.

Soviet Technology and Production. To ensure the scheduling of the projects aided by the Soviet Union, the Chinese government mobilized substantial resources to support the construction of projects that the Soviet Union designed. By the end of 1957, 68 of the 146 projects the Soviet Union supported were in full or partial production;[21] 27 of the 64 projects assisted by Eastern European countries were complete or in partial production (Peng, 1989, p. 55.). These facilities produced aircraft, automobiles, new types of machine tools, electrical generating equipment, and mining and smelting equipment. Clearly, Soviet assistance substantially upgraded the production technology in Chinese enterprises, filled gaps in many technologies, and expanded industrial production. Figure 4 demonstrates the extent of Soviet assistance to Chinese production (Guojia Jihua Weiyuanhui Duiwai Jingji Maoyi Si, Duiwai Jingji Maoyi Bu Jishu Jinchukou Si, & Jixie Dianzi Gongye Bu Jishu Yinjin Xinxi Jiaoliu Zhongxin, 1992, p. 13).

Of the different methods of industrial technology transfer China used in this period, the introduction of complete sets of design and equipment resulted in the greatest economic benefit. The borrowed Soviet product and engineering designs were well-developed and sound, and Soviet experts had experience in engineering; the quality and supply of equipment and materials was also assured. By way of contrast, projects that relied solely on

[21] The register, signed by Курдюков, the director of the Far East Department of the Ministry of Foreign Affairs in Soviet Union on 29 May 1957, indicates that Soviet Union would help China build 211 enterprises and 27 single workshops, and supply equipment worth 960 million rubles. Between 1951 and 1956, 26 enterprises were established and put into production; 31 enterprises were partly finished; and 17 single workshops and factories were constructed and put into production. There were 5,092 Soviet engineers, section chiefs, and workers working in China (Gangchalianke, 2002).

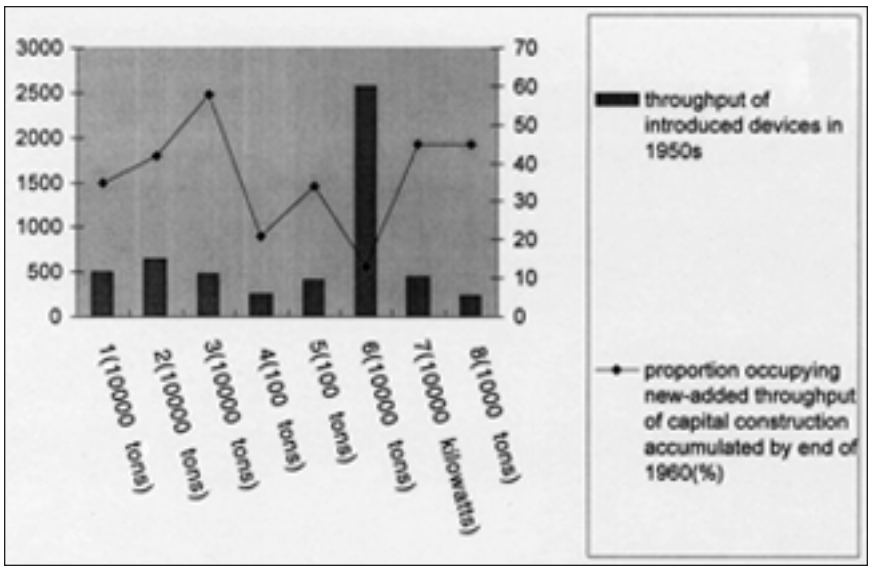

Figure 4 *Projects: 1: pig iron; 2: steel; 3: steel products; 4: copper; 5: tungsten; 6: raw coal; 7: capacity of generating sets; and 8: synthetic ammonia.*

Soviet drawings or imported products generally did not perform as well. The Nanjing Automobile Factory, for example, combined a Soviet truck design and homemade manufacturing techniques and equipment. The resulting truck had many technical problems and was inferior to those from Changchun. Other factories that tried to design products themselves encountered many more problems and hardly ever succeeded. Some products were imitated by copying directly from imports, but without supporting technical resources the resulting designs often had many flaws. Chinese engineers usually lacked experience and their design institutions and factories had to make do with whatever was available. It was not surprising that the Central Government concentrated on the introduction of technology via the transfer of complete installations of equipment with supporting experts.

TECHNOLOGY TRANSFER VIA TECHNOLOGICAL COOPERATION

The CPC established its government in 1949. Rapid economic development was a great and immediate challenge, with the core task being construction and upgrading of the industrial sector. By 1952, the Chinese economy had recovered. Conditions seemed suitable for the government's

efforts to develop other undertakings to support the transfer of technology. At this point, China developed cooperative relations with the Soviet Academy of Sciences and other research and design institutions in the USSR. Technical cooperation was practiced mainly as short-term technical exchange contracts. The primary form of cooperation involved Chinese invitations to Soviet experts to initiate and direct technological research. At the same time, Chinese experts went to the Soviet Union to study, conduct investigations, and attend scientific meetings. In addition, the two nations periodically exchanged scientific and technological information, books, and periodicals. Later, China expanded the scope of the introduction of Soviet technology and equipment to include technical designs, such as product research and development. The goal was to increase the technological capacity of Chinese scientific research institutes, design institutions, and enterprises.

the science and technology cooperation commission

From Understanding Each Other to Endorsing Conventions. In November 1949, the central government founded the Chinese Academy of Sciences (CAS), bringing together most Chinese researchers working on the mainland. Most of these researchers had been trained in Western countries (including the United States and Japan) or had worked for the Kuomintang government. With their Western knowledge and backgrounds, most knew little about Soviet science and technology; few knew Russian.

In the early 1950s the Western-trained scientists and engineers in the CAS were required to shift their focus from Western to Soviet-based technology. The government not only criticized their Western leaning, especially from the United States, but also made them accept Soviet ideas of learning and then work toward national economic and defense goals (Wu, 1991, pp. 18–37). In October 1952, the CAS approved "The Decision of CAS on Strengthening the Learning and Introducing Soviet Advanced Science" at an enlarged presidents' meeting.[22]

China embarked on its first 5-year economic plan in 1953. Realizing the importance of science and technology in carrying out that plan, in February 1953, Zedong Mao called on all Chinese to learn Soviet advanced science and technology to develop China (Zhonggong Zhongyang Wenxian Yanjiushi, 1993a, pp. 45–46). To this end, a delegation of the CAS visited Moscow in March. The main purposes of the delegation were to

[22]The Chinese Academy was established in November 1949 on the basis of Academia Sinica and Academy of Beiping, which were supported by the Republic of China.

(1) learn how the Soviet Union organized and led scientific research; (2) identify the status and trends of Soviet science; and (3) evaluate the prospects for Sino–Soviet scientific cooperation (Zhang, J., 2003). After returning to China, the delegation publicized both Soviet science and technology and management experience. By that time, more than 93% of the CAS staff spoke Russian and 73.5% could read the language (Wu, 1991).

In September 1954, Khruschev headed a Soviet government delegation to China, and met with Chinese leaders, including Enlai Zhou. The discussions promoted science and technology cooperation on a large scale (СладковскиЙ, 1977a, p. 218). On the evening of 11 October, the two governments signed a 5-year convention—"The Convention on Science and Technology Cooperation Between the Union of Soviet Socialist Republics and the People's Republic of China." Through the end of 1950s, more than 800 scientific research institutions in the Soviet Union and China cooperated across nearly every field of science and technology.

The Science and Technology Cooperation Commission Soviet Union and China. "The Convention on Science and Technology Cooperation Between Soviet Union and China" stipulated establishment of a Science and Technology Cooperation Commission between Soviet Union and China (STCC) to manage and coordinate cooperative affairs between the two countries. Newly created Chinese and Soviet groups took charge of management and coordination.

Beginning in 1955, the STCC usually held two annual sessions, alternating between Beijing and Moscow, to summarize the previous year's efforts, plan and make specific arrangements for the following year, and discuss problems and their solutions. The commission worked through 1966 and held 15 sessions (Table 1). Before every session, each ministry in the Chinese government brought forward a number of projects that needed Soviet assistance, and after they were authorized by the State Council, the projects were submitted to the session for discussion. With the deterioration of Sino–Soviet relations in 1960, the STTC declined to one meeting a year and even no meetings at all. No session was held in 1960, for example, because of the withdrawal of Soviet experts. Even so, the technical data the Soviet Union provided to China was far greater than that supplied to the Soviet Union by China.

One important task of the Sino–Soviet STCC was to exchange all kinds of technical data, especially documents from the Soviet Union.[23] At the first session in December 1954, the Soviet Union agreed to provide at no

[23]From the beginning of 1950 to July 1954, the Soviet Union handed 698 items of technical data to China (Baolisuofu & Keluosikefu, 1982, pp. 56–57).

Table 1

SESSIONS HELD BY THE SCIENCE AND TECHNOLOGY COOPERATION COMMISSION BETWEEN SOVIET UNION AND CHINA AND THE TASKS TAKEN BY THE TWO PARTIES

		CHINESE RESPONSIBILITIES		SOVIET RESPONSIBILITIES	
No.	*Location and date*	*Technical data provided (no. of items)*	*Soviet experts accepted (persons)*	*Technical data provided (no. of items)*	*Chinese experts accepted (persons)*
1	Moscow, December 1954	17	4	169	
2	Beijing, June 1955	29	3	159	6
3	Moscow, December 1955	41	22	570	13
4	Beijing, June 1956	66	5	540	28
5	Moscow, December 1956	48	8	480	26
6	Beijing, July 1957	114	13	1,176	24
7	Moscow, July 1958	284	54	1,782	32
8	Beijing, January 1959	88	22	478	36
9	Moscow, July 1959	109	15	429	16
10	Beijing, October 1959	100	12	259	10
11	Beijing, September 1961	246	11	376	4
12	Moscow, June 1962	45	2	72	3
13	Beijing, June 1963	36	9	51	8
14	Moscow, June 1965	12	1	12	2
15	Beijing, November 1966	3	2	3	2
		1,238	**183**	**6,536**	**210**

charge design data for the construction of smelting factories, machine tool factories, and power plants; drawings and technical data for manufacturing machines and equipment; and other technological documents. The convention signed at the first session also stipulated that the Soviet Union would provide China with 169 specific items of technical data. By 15 May 1955, Soviet experts already had completed 81 of these projects.

At the second session, held in June 1955, the number of cooperative efforts increased greatly (Zhongguo Kexueyuan Bangongting Lianluochu, 1955). The Soviet Union agreed to do its best to meet Chinese demands, and promised to bring 47 Chinese experts into the Soviet Union to conduct investigations. They also promised to provide technical data for 151 large projects, seeds for crops, and medications.[24] The data fell into four

[24]The number in this statistic was eight fewer than that in "The Table About the Sessions Held by Science and Technology Cooperation Commission Between Soviet Union and China and the

categories: (1) design data for facilities such as coal mines, power stations, nonferrous metal plants, locomotive factories, car assembly factories, and petroleum plants; (2) various kinds of drawings and technology for machinery; (3) oil paint, dye, lacquer, and the technical data for other products; and (4) 2,868 items from various in-house technical publications, teaching plans, syllabi, and technical standards.

Before the second session, upon the authorization of the Council of Ministers of the Soviet Union, STCC decided to bring all problems that needed technical aid into the framework of scientific and technical cooperation, including efforts to transfer entire sets of equipment. Even problems already solved were listed under the scientific and technical cooperation structure as additional items. Thus the second session stipulated that the "156 Projects" should be solved through scientific and technical cooperation, which included problems related to the drawings for standard equipment, and the technical data needed by the attached enterprises and 200 design experts.

During that session, the discussions alerted the Soviet Union to Chinese intentions for this cooperative endeavor. In addition to the "156 Projects," China wanted to build 694 large factories, a desire that explained why China needed so much immediate assistance from the Soviet Union. Soviet representatives agreed to do their best to meet Chinese demands as soon as possible. Because of the shortage of technical data in China, the Soviets hoped that Chinese institutions would coordinate realistic requests and that Chinese factories would ask only for information that they really needed. China thought that each institution should determine the priorities of requests and that the highest attention should go to drawings for the "156 Projects," then to design data and production technology needed by the additional 694 factories, and finally to new projects.

During the STCC sessions, many problems were dealt with cooperatively, promoting an atmosphere of Sino–Soviet cooperation. For example, at the sixth session, held in Beijing in 1957, it was agreed to promote direct contact between every similar organization, scientific research institute, and design institution in the two countries. The two sides also agreed that the Soviet Union would provide China with design or technical data for hydroelectric power stations, building material enterprises, machines, and other industrial products, and would accept Chinese experts (Baolisuofu & Keluosikefu, 1982, p. 79). Thus, before 1958 industrial assistance projects promoted technical and scientific cooperation. The Sino–Soviet STCC played an important part in harmonizing technology transfer by effectively supporting the construction of industrial projects.

(*continued*) Tasks Taken by the Two Parties"; perhaps some projects were added when projects were being put into practice.

China's long-term program and Soviet assistance

Working out a long-term program of science and technology development was one of the most important measures that the Chinese government undertook during the 1950s. It set the direction, purpose, and basic policy for the development of science and technology in China, and deeply influenced later activities. This step also promoted the participation of the Soviet Union in Chinese scientific activities.

According to the goals identified in the Communist Party's general policy for the transition period, the State Planning Commission decided to work out a 15-year national economic plan (1953–1967). On 29 May 1954, the routine meeting of CAS set out to mobilize resources and develop such a 15-year plan.

In January 1955, В. А. Ковда, the president's consultant to the CAS, drew up "The Measures About Planning and Organizing the National Scientific Research in the P. R. China" (a protocol). This document suggested that China organize and plan national scientific research and develop a long-term program of scientific development designed to resolve the most important problems identified in the national economic 5- and 15-year plans (Zhongguo Kexueyuan Lianluoju, 1955, pp. 7–13). On 22 April, the Politbureau of the Central Committee of the Communist Party of China discussed the CAS report. Liu Shaoqi, a vice chairman of the Central Government, thought that В. А. Ковда's advice was important and deserved attention. He instructed related departments to put forward their ideas about bringing the CAS suggestions into practice (Fan, 1999, p. 51). With the help of the second president's consultant, Б. Р. Лазаренко (B. R. Lazarenko), and through the hard work of nearly 360 scientists, the CAS prepared the first draft of the "Fifteen-year Long-term Program of the CAS" in February 1956 (Zhu, 1989, p. 658). Thereafter, the Science Planning Commission of State Council organized 600 to 700 Chinese experts and with the help of Soviet experts developed the "Long-Term Program for Developing National Sciences and Technology Between 1956 and 1967."

On 14 January 1956, Enlai Zhou suggested three areas where Soviet assistance would help to realize the 12-year long-term program:

> First, according to the categories that we need most urgently, [we] most rapidly send expert groups, excellent scientific researchers, and excellent graduates to Soviet Union and other countries for one or two years to practice or to be graduate students there. When returning, they should lay the foundation immediately for the development of such sciences and technologies both in the CAS and within each department of government, and train a large number of new cadres. At the same time, according to

> our needs, people should be sent out to practice and study every year. Second, in other areas we should invite and employ groups of experts from the Soviet Union and other related countries. Ask them to help us establish scientific research institutions in the CAS and other related departments within the shortest possible period, and to train cadres, or to cooperate thoroughly with our scientific circles in every aspect. Third, organize large numbers of scientific researchers and technicians to learn from the Soviet experts who are in China now. Just use them as teachers, not as ordinary personnel. During the process when the enterprises in the 156 projects supported by Soviet Union are being constructed and when they are producing, [we] organize systematically a large number of technicians to study and master the new technical principles and to spread them quickly. . . . (Zhou, 1994)

In February 1956, according to the suggestion of the president's consultant, Б. Р. Лазаренко, the State Council invited Soviet experts to help China realize its 12-year program for science and technology by introducing international science and technological trends. On 29 March, the Soviet government sent a group to China consisting of 16 scientists. Two others who had been working in China at that time, Сугачёв (Sugachev) and Обалин (Obalin), were invited by the CAS president's consultant B. R. Lazarenko to join the high-ranking delegation. The majority were academicians or corresponding members of the Soviet Academy of Sciences. One third of these experts worked in wireless electronics, automation, or semiconductor and computing technology, a topic identified as one of "Four Urgent Measures" in the long-term program. Furthermore, another six Soviet experts already in China took part in drawing up the program.[25]

These experts introduced Soviet experience and contemporary approaches and topics in science and technology to China. They also suggested how China could develop modern science and technology programs. They continued to help create programs for such new technologies as electronics, precision machinery, computing technology, marine acoustics, semiconductors, automatic controls, and jet engines. Their main tasks included (1) providing suggestions on research direction and the main research tasks for two or three years; (2) establishing research institutions, cadre training; (3) preparing instruments and equipment; (4) recommending that Chinese scientific institutions develop connections with

[25]According to Yibo Bo's memoir, China invited nearly a hundred Soviet experts to take part in the practical work of preparing the program (Bo, 1991, pp. 510–511). Gongde Li, however, later reported Soviet experts were never gathered together. Rather, the Soviet experts may have been invited when each ministry and commission separately developed their programs. He added that such a misunderstanding had the effect of "overstating the Soviet experts' effect" (Li, 1994).

related Soviet scientific institutions; and (5) proposing possible cooperative research projects, investigations, and possible assistance from the Soviet Union.

During the period when the program was worked out, most Chinese scientists thought China should develop science and technology on their own. They believed Chinese scientists needed to learn and master the advanced achievements of the world, and on this basis, begin to conduct research, innovate, and improve the technology. The Soviet consultant Lazarenko argued again and again that the Soviet Union could impart its technological knowledge, from theories to technical methods, to China. He said, "Before going to China, I received instructions from the leaders of Soviet Academy of Sciences and other institutions that China can obtain any assistance from the Soviet Union, including arranging many more visits for study in the Soviet Union than now approved and the acquisition of scientific information, if only China brings forward their requirements" (Bo, p. 512).

The Soviet experts who helped China develop its long-term program remained in China for more than a month, returning in May 1956. Lazarenko also returned to the USSR, but came back to China with the Soviet Union's ideas. The Science Planning Commission weighed the Soviet and Chinese opinions, and to help it resolve the difficulties, China sent delegations to Soviet Union. For example, in September 1956, the CAS sent a group to study Soviet computing technology; and in December, Jici Yan led 38 Chinese experts who investigated such important technical subjects as titanium alloys, semiconductors, electronics, mechanical engineering, and dynamics.

While this was going on, high-level discussions about the program continued, along the lines that vice premier Fuchun Li described in February 1956 in an official communication to the Soviet government. Li asked the Soviet Academy of Sciences and State Planning Commission to comment on the China's "Long-Term Program for Developing National Sciences and Technology Between 1956 and 1967," and stated that the two nations would negotiate the terms. About six months later, the Science Planning Commission of Chinese State Council prepared a protocol for the long-term plan, as well as its annex. In 1957, China sent this protocol to the USSR and again asked for comments. In July, the Soviet Council of Ministers instructed the Soviet State Science and Technology Commission, the Soviet Academy of Sciences, and the research institutions of every ministry to examine the Chinese protocol. The Soviet government offered many written suggestions, and agreed to help China design seven research institutes in such fields as computing technology, semiconductors, and electric power, and agreed to provide key equipment.

On 1 November 1957, Moruo Guo, the president of CAS, led a 120-person Chinese delegation on science and technology to Moscow to ask Soviet scientists for additional opinions about the "Long-Term Program for Developing National Sciences and Technology between 1956 and 1967" and its performance. The group prepared to endorse the convention, which was to be pursued during China's second 5-year plan (Zhongguo Kexueyuan Bangongting, 1957). While in the Soviet Union, the Chinese delegation also visited relevant Soviet research institutions, negotiated subjects of cooperative studies. They also decided how many students and scientific and technical personnel should be sent to the Soviet Union and what they would study there. Negotiations considered which experts the Soviet Union would send to China and what kinds of scientific and technical problems would be included in the program (Liu, 1999). During November and December, the delegation discussed with the Soviet State Science and Technology Commission, the Soviet Academy of Sciences, the Foreign Economic Liaison Commission, the Ministry of Higher Education, and several main scientific research institutions how to develop science and technology, and how to expand scientific and technological cooperation between the two countries. More than 600 Soviet experts took part in the discussions (Baolisuofu & Keluosikefu, 1982, p. 119). In general, Soviet reaction to the Chinese program was this: "it is basically right, but there are some shortcomings, and it will be an arduous effort to realize" (Guo, 1959). Of the planned projects, "in approximately 11 percent, Soviet experts had no complaints at all, in nearly 78 percent Soviet experts thought they were basically right but needed modifications, and in about 11 percent Soviet experts thought they were basically wrong or they had important omissions" (Guo, 1959). The Soviet experts offered many specific suggestions.

the USSR and Chinese scientific and technological research

Before the end of 1957, the main focus of scientific and technological cooperation between the Soviet Union and China was industrial projects built with Soviet assistance, the work of Sino–Soviet STCC, and communication between the academies of sciences and other research institutions in the two countries. Only a few scientific conventions on science had been developed.[26] By enacting the "Twelve-Year Long-Term Program" in

[26]For example, the "Convention on Soviet Union's Helping China Develop Research on Atomic Energy and Nuclear Physics as well as Make use of Atomic Energy in National Economic Need" was signed on 27 April 1955; the "Convention on Soviet Aid to Manufacture New Weapon and

1958, the scientific and technological cooperation between the two countries expanded into many research institute and large enterprises. Typically, such cooperation involved Chinese and Soviet experts participating in joint research projects.

The 122-Project Convention on Scientific and Technological Cooperation. On 11 December 1957, Chinese science and technology delegations headed by Moruo Guo signed a 5-year agreement, "The Protocol on the Scientific and Technical Cooperation between the Academy of Sciences of the Union of Soviet Socialist Republics and Chinese Academy of Sciences" (1958–1962) and "The Convention on the Scientific Cooperation in 1958 between Soviet Academy of Sciences and Chinese Academy of Sciences." The protocol dealt with 92 cooperative projects in 9 fields, including natural science, technology, philosophy, and social science. More than 300 institutions participated on both sides, equally divided between the two countries (Zhongguo Kexueyuan & Sulian Kexueyuan, 1958).

On 18 January 1958, the two governments endorsed "The Convention on Soviet Union and China Cooperating and Soviet Union Helping China with Significant Scientific and Technical Research" (also known as the "122-Project Convention").[27] Covering the second 5-year plan of China (1958–1962), this agreement (1) stipulated that the Soviet Union and China would undertake extensive scientific and technological cooperation, and realize China's "Twelve-year Long-term Program for Developing National Science and Technology" of China; (2) strengthened direct contacts between the scientific research institutions of the two countries; (3) stated that scientific communication generally would involve short-term academic trips rather than extended visits; (4) created institutions to solve problems related to supplies of commodities not traded, such as equipment for scientific research, instruments, samples, and reagents; and (5) founded oversight institutions. The Chinese institution was the Science Planning Commission of State Council (later the State Science and Technology Commission); the parallel Soviet unit was the State Science

(*continued*) Military Equipment and Began All-General Atomic Energy Industry" was secretly signed on 15 October 1957, between the Soviet Union and China. The Soviet Union helped China with aeronautics, guided missiles, and nuclear technology to varying degrees.

[27]Beside these conventions, both countries signed many other agreements of an economic and academic nature from 1958 to 1960, such as the "Convention on Cooperation of Science and Technology of Sino-Soviet Academies of Agricultural Sciences" (18 January 1958); the "Convention on Cooperation of Scientific Research of Sino–Soviet Ministry of High Education" (18 January 1958); the "Convention on Cooperation of Scientific Research Between Chinese Water and Electric Department and the Soviet Electric Power Department" (July 1958); and the "Convention on Cooperation of Important Medical Problems Between Two Countries' Academic Medical Science" (10 June 1960). All were cancelled before they could be completed.

and Technology Commission of the Council of Ministers. The "122-Project Convention" identified 16 fields as most relevant to the 12-year program, with 122 contracted projects divided into more than 600 mostly technical tasks (Guowuyuan Kexue Guihua Weiyuanhui Bangongshi, 1958). More than 600 institutions in the two countries were enlisted in this cooperative effort.

The Implementation of the Sino–Soviet 122-Project Convention. In spite of the disturbance of the "Great Leap Forward,"[28] the 122-Project Convention was carried out under relatively normal circumstances during its first two or three years. By July 1960, most research tasks had moved forward to some extent; at least some were complete or nearly complete. For example, Soviet institutions and experts sequentially helped China to establish research and design institutions in such important areas as nuclear energy, computing technology, radio and electronics technology, automation, semiconductors, electric power, electrotechnology, precision machinery, optics, and dynamics. The majority belonged to the CAS and helped the Chinese to research and develop industrial technologies, and transfer basic technology to China for industrial construction projects. The CAS took on 38 of the cooperative projects between the Soviet Union and China,[29] and also participated into many other tasks identified in the convention.

The Soviet Union played an important role in the founding and development of new technologies in China. One example of this assistance was computing technology. At the time of its inception, the People's Republic of China completely lacked expertise in this field. Scientists at the CAS first proposed undertaking computing research, followed by government officials. In 1953, the first computer research group was set up under the guidance of Mr. Luogeng Hua (superintendent of the Institute of Mathematics of the CAS). In January 1956, Mr. Lazarenko indicated that cybernetic research required computer calculations, and urged China to launch computer research (Secretariat of the General Office, 1956). This suggestion at once drew attention. According to the recollection of Ms. Peisu Xia

[28]During the "Great Leap Forward," the number of scientific research institutions increased quickly. However, there were not enough well-trained professionals to fill these institutions. Therefore, some skilled workers were promoted to technicians or engineers. Researchers tried to complete large numbers of scientific studies, with higher goals at the "leap forward" speed. The research institutes in the CAS, the scientific research institutions of other ministries, and colleges and universities all proposed unrealistic targets. Soviet experts had reservations about these developments.

[29]As to Soviet assistance to the development of the institute for computing technology of the CAS, see Jiuchun Zhang and Baichun Zhang (2003).

and Mr. Xiaoxiang Zhang, by March 1956 the Central Government began to attach importance to the development of the computer and decided to initiate a long-term development program (Xia, 1985, p. 12–18).

At the same time, the Central Government invited Mr. С. А. Леъедев, an academician and superintendent of the Institute of Precision Machinery and Computing Technology Research of the Soviet Academy of Sciences, to China to take part in planning computing technology development (Zhang, 2001). The Soviet Academy of Sciences invited representatives of the CAS to attend an international conference on "Soviet Manufacturing and Development Approaches for Mathematic Machines and Mathematic Instruments" held in March 1956. By attending the meeting, Chinese scholars gained an opportunity to learn about the general developing situation of computing technology, Soviet institutions, and the thoughts of Soviet experts about establishing institutes for computing technology and training scholars. Specifically, suggestions from the final symposium by Леъедев were adopted in the "Long-Term Program of Computing Technology" and the "Urgent Measures to Develop Computing Technology."

The principles put forward by Luogeng Hua for developing computer technology won general acceptance: "First combine to surmount difficulties and then separate to develop" (Xia, 1985, p. 6). That is, at first those involved in computing technology in different departments and units were collected and then gathered into the new Institute of Computing Technology. Then as more cadres developed, researchers were separated gradually to establish new research beachheads. During the preparation of "Long-Term Program of Computing Technology," Д. Ю. Панов (superintendent of the Institute of Information and deputy superintendent of the Institute of Computing of Soviet Academy of Sciences) arrived in Beijing. He lectured to Chinese experts and the Military Commission of the Central Committee of the CPC, and shared information concerning the situation, experiences, and lessons learned from Soviet computer development. He brought six copies of information related to the БЭСМ computer and one copy of program design information and indicated that the Soviet Union would help China manufacture computers as soon as possible.[30] He also offered many helpful suggestions about computing technology and the electronics industry. He talked about which projects should be arranged, purchasing Soviet electronic computers, and sending people to the Soviet Union to study. He also suggested to Luogeng Hua that a delegation of teachers be sent to the USSR to visit and study as soon as the plan was adopted.

[30]Peisu Xia and others translated these documents into Chinese, and used them as teaching material in training courses (Fan, 1986, pp. 45–52; Zhang, 1956).

After approving the "Long-term Program for Developing National Sciences and Technology between 1956 and 1967," Chinese officials organized scientists into four groups to develop Computing Technology, Semiconductor Technology, Radio Electronics, and Automatic and Long-Distance Control Technology. These focuses provided technological support for missile and nuclear weapons development programs.

In September 1956, the CAS sent an investigation group to the Soviet Academy of Sciences to consult about specific steps for establishing computing technology. The investigation group visited research and educational institutions engaging in computer research, design, trial manufacturing, and production to learn the theories and techniques in detail and to learn about Soviet management of research institutes. They further defined technical approaches and tasks for establishment of a Chinese institute for computing technology. By the end of 1957, China and the Soviet Union were discussing how to help China develop its first large computer. In early 1958, cooperative conventions mentioned that the Soviet Union would provide China with research institutes. China decided to use Soviet drawings, and with help from Soviet experts copied a БЭСМ-II computer in China.

Copying Soviet computers required suitably trained personnel. For this purpose, the CAS held four training classes for 684 computing technology graduates, led by Chinese and Soviet experts during 1956 and 1960 (Xia, 1986, pp. 56–70). After 1956, the Soviet Academy of Sciences and several Soviet universities accepted Chinese graduate students, college students, and students attending advanced studies. These people played a pivotal role in copying the Soviet computer.

Chinese experts successfully manufactured the first Chinese computer in August 1958, the 103-mini-type electronic computer, based on specifications for the first-generation Soviet M-3 computer. Chinese engineers enhanced the original design in many ways. A magnetic core memory was added to the original computer's EMS memory that used a vertical memory drum. The original input device was a teletype keyboard, but the Chinese designers added a photoelectric tape reader. The original output device was teleprinter, which the Chinese replaced with a high-speed printer. These changes increased the speed of calculation from 30 operations per second to 1,800 operations per second. Input speed was increased from 52 digits per minute to 1,250 digits per minute, and output speed went from 24 digits per minute to 650. In 1959, Chinese manufactured the model 104, a large universal digital electronic computer that was only slightly different from the Soviet БЭСМ-II computer. The 104 computer had a binary system, 39-word-length, and an instruction of three

address. It was comparable to the large IBM 704 tube computer built in America in 1956.[31] The machine was inferior to newer machines being produced in the United States and the Soviet Union, but it was better than the equipment coming out of England, Japan, and West Germany.[32]

The Institute of Computing Technology of the CAS was officially founded on 17 May 1959. Many people who participated in the preparation of this organization went to other ministries or departments to establish new research and education institutions, which further diffused Soviet computing technology. In the following years, the other institutes also emulated Soviet computers. The computers developed by the institutions such as the CAS Institute for Computing Technology played an important part in developing nuclear weapons and missiles, as well as supporting other scientific research projects, engineering designs, weather forecasting, and transportation.

Overall, the Soviet Union played a very important role in transferring computing technology that the Chinese could not develop on their own. The Soviet Union provided all technical drawings and data, as well as key electronic components, and parts for the early computers. In addition, Soviet experts guided test modeling and the establishment of the Chinese research institute. Of course, the Soviet Union could not grant everything China requested, and there were definite limits in the most advanced areas of technology. For instance, the Soviet Academy of Sciences did not want China to know secrets about man-made satellites. The CAS used Soviet equipment and built 26 satellite tracking stations, 22 of which could supply the Soviet Union with observational data. Some Chinese scientists suggested that China should construct its own satellites. In May 1958, Zedong Mao agreed, and the CAS launched a satellite research program. In October 1958, the Soviet Academy of Sciences refused a promised visit to Soviet satellite laboratories, for reasons that remain unknown. However, by that time diplomatic relations between the two countries had begun to erode. On 31 July 1958, Krushchev secretly visited Beijing to negotiate with Zedong Mao, who refused an offer to establish a joint Soviet–Sino submarine fleet and to build a military broadcasting station in China. Mao would not allow shared foreign control over China, and Krushchev's visit to Beijing proved fruitless.

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[31]Institute of Computing Technology. The History of the evolution of the Institute of Computing Technology. Kept by The Institute of Policy and Management of Chinese Academy of Sciences.

[32]Institute of Computing Technology. The Momentous Science and Technology Achievement-104 high-speed digital electronic computer. Kept by The Institute of Policy and Management of Chinese Academy of Sciences keep.

TECHNICAL EDUCATION: REFORM, EXCHANGES, AND SOVIET EXPERTS IN CHINA

the reform of technical education

During the 1950s, China copied the technical training pattern of Soviet higher and secondary education while it was launching its economic planning efforts. The goal was to rapidly train professionals for industry and construction.

During the first half of the twentieth century, Chinese colleges and universities generally were run as copies of the schools in Europe, the United States, and Japan. This meant these schools educated generalists. In 1949, as the CPC began to take over the colleges and universities, they attempted to learn from Soviet experiences. Soviet science, technology, and education models generally were linked to visions of a planned economy. Thus, the Soviet government planned science and technology according to the needs of industry, agricultural, the military, and society. Higher and professional education was therefore planned according to the needs of different economic sectors. The Soviet communist party insisted that Marxism and Leninism provided guidelines for education, and held that socialism and teaching must be coupled with work. Soviet universities were to serve specific goals, follow good plans, reflect high levels of specialization, and emphasize modern teaching methods and management. The advantage of this approach was that Soviet universities cultivated professionals who directly served economic growth (Dong, 1997, pp. 520–529).

Between 1949 and 1951, the old universities and colleges in Beijing, Shanghai, Tianjin, and elsewhere were reorganized and new engineering colleges and universities were set up. In 1951, the Ministry of Education issued the "Adjusting Scheme of the Engineering Colleges of the Whole Country," and held presidents' meetings for every engineering college in the nation that November to discuss the changes. On 24 September 1952, according to "The Decision on Reforming Educational System" enacted by the Government Administration Council, the Ministry of Higher Education, acting with Soviet experts' direct participation, adjusted the schools and departments in colleges and universities, choosing two regions, North China and East China, as the first to change. The Chinese government adjusted its policies to fit the Soviet educational model of preparing industrial professionals and teachers. The reforms included developing academies and colleges, streamlining and strengthening universities, and gradually originating correspondence schools and evening colleges to provide

higher education to a mass of workers and peasants ("Adjust college and department," 1952; Party Literature Research Center, N.D.). By 1953, the adjustment of colleges and universities in China was three fourths complete (Zeng, 1953). Outside those universities in which arts and sciences were the dominant subjects, the main method of reforming schools and departments was the organization of special and professional colleges of engineering, agriculture, medicine, and teaching to meet the needs of specific fields, and the rearrangement of specialties, with teaching plans then drawn up to meet the needs of these specialties. Consequently, China basically replaced the European and American pattern of generalist training with a Soviet model based on specialized education. Most provinces had a university of arts and sciences and special colleges of engineering, agriculture, medicine, and teacher training. Colleges and universities tended to reach equilibrium in their regional arrangements.

One important aspect of education reform was the development of engineering education. By classifying and combining schools, departments, and specialties, special colleges for steel, mining, geology, machinery, aeronautics, and so forth were set up. They reported to the various ministries or commissions of industry of the Central Government or to the Ministry of Higher Education. After 1957, some key universities and colleges expanded some specialties, including radio, hydrodynamics, and solid mechanics, and launched new ones, such as computing, aerodynamics, and computing mathematics to meet the needs of the most advanced technologies. By 1960, there were 32 engineering colleges or polytechnic universities among the 64 key colleges and universities in the whole country (Zhonggong Zhongyang, 1996).

China tried to copy the Soviet graduate education system as well. In 1955, China tried to develop a program of advanced degrees. The CAS and some universities recruited graduate students to pursue a program similar to that of associate doctors in the Soviet Union. At Beijing Aeronautical College, Harbin Institute of Technology, and other colleges, Soviet experts guided these graduate students. The largest number of experts were at Harbin Institute of Technology and Beijing Aeronautical College.

After the reform of the education system, the number of engineering undergraduates increased greatly, growing from 18.9% of all undergraduates in 1946 to 35.4% in 1952 (Zeng, 1953, pp. 11–15), and the percentage of engineers increased continuously. By the end of 1955, the number of university and college graduates exceeded 210,000 (Bo, 1991, p. 500).

The goal of these engineering universities is well depicted by the philosophy of Qing Hua University: "An engineer who is familiar with basic theory and can apply all kind of industrial technology and knowledge in

practice" (1996, p. 92). Students must be able to perform immediately after joining the work force and yet have potential for the future. The students take both theory courses and others providing practical knowledge. Production design and research are coupled with a graduation project linked to factory needs. The industrial department adopted more than half of these projects.

A new educational institution, the State Science and Technology Commission, was charged with placing graduate students and students abroad. The central government or provincial departments were responsible for recruiting students and assigning graduates. Students were required to follow a specialty and assigned to relevant industries to national development needs after they graduated. These students quickly adapted themselves to work and industrial circumstances.

Because China needed a large number of secondary and primary technicians for industrial construction during the 1950s, secondary technology schools and technical schools were established, also based on the Soviet model. Graduates and technicians from these schools later assumed very important positions in Chinese Industry and research.

In Soviet universities, teaching and researching sections (Кафедра) directed activities below the department level. One of the quite important reform measures in China was the widespread establishment of this Soviet-style teaching and research section. In the second semester of 1952, the Chinese government pushed for uniform teaching plans, curricula, and teaching syllabi on the Soviet model for the whole country. They requested that every college learn this Soviet teaching system. These teaching plans prescribed the teaching calendar for an academic year, the courses to be taught, the sequence of presentation, and the class schedule for each day and week. Syllabi prescribed specific teaching goals, listed educational subjects, and identified the academic calendar for each semester and academic year. Many teaching plans and textbooks used in Soviet colleges were translated into Chinese and widely adopted as textbooks or as reference books. Chinese publishers went to great efforts to translate and publish these Russian books and other documents. Between 1953 and 1957, books on Soviet heavy industry accounted for 93% of all books published by Beijing Heavy Industry Press and Beijing Metallurgical Industry Press. After 1957, Chinese colleges modified the teaching plans and textbooks based on Soviet experience, but the basic teaching model remained the Soviet style.

Broad communication and cooperation developed between Soviet and Chinese colleges or universities. Since 1949, 66 colleges in China and 85 colleges in Soviet Union exchanged scientific information and other data.

And the colleges of the two countries cooperated in 124 scientific research tasks (Baolisuofu & Keluosikefu, 1982). Educational reforms sought to train workers to accommodate the construction of industry and national defense. That students accepted technology from the Soviet Union made this easier to implement.

Chinese students in the Soviet Union

In 1952, the Chinese and Soviet governments endorsed a convention allowing Chinese students to study in the Soviet Union. An office to administer student exchanges was set up in the Chinese embassy in Moscow. The "First Five-Year Plan" projected that within five years, China would send 10,100 students abroad (9,400 to the Soviet Union) and approximately 1,300 trainees to the Soviet Union and other socialist countries (Jiwei, 1993).

Chinese approaches to student exchanges went through three stages (Guojia Kewei Dangzu, Jiaoyubu Dangzu, & Waijiaobu Dangzu, 1996). During the first stage (1950–1953) the policy was "select strictly and emphasize quality instead of numbers." As a result, 1,708 students were sent abroad. From 1954 to 1956, the policy was to "strictly check up and strive to send more students" with priority given to science and engineering "while giving attention to all needs." During this stage, 5,853 students were sent abroad, 1,213 of whom were graduate students, along with 6,802 trainees and 135 teachers who undertook advanced studies abroad. China adjusted the specialties studied three times, moving some from the social sciences, sciences, and general engineering to specialties related to advanced subjects that industry and national defense. The third stage (1957–1958) was guided by the policy of "sending more graduate students, not undergraduates." About 1,654 students went abroad: 544 graduate students, 60 college students, 176 teachers, and 874 trainees. In 1957, the government required that graduate students should have completed their degree and have two years of work experience so that that they encountered real-world problems and mastered the technology. The final stage (1959–1965), saw a reduction in exchange opportunities, with only a small number of students traveling abroad. After 1960, the number of the students sent annually to Soviet Union ranged from a handful to some dozens of people.

According to official Chinese statistics from July 1959, a total of 16,152 students studied outside China; 14,798 studied in the Soviet Union. Of these, 9,074 finished their program of study and returned; the remaining students left school because of illness, problems with the Russian lan-

guage, or difficulties of cultural adjustment. China clearly was most interested in engineering and technology; of the 7,778 college and graduate students who attended universities in socialist countries, 5,179 studied engineering (Guojia Kewei Dangzu, Jiaoyubu Dangzu, & Waijiaobu Dangzu, 1996).[33] It was obvious that most students who were sent to the Soviet Union studied engineering and technology.

Chinese students sent to the Soviet Union fell into four groups: (1) graduate students or undergraduates; (2) trainees; (3) students seeking advanced studies; and (4) short-term trainees. The period of study for graduate students was typically three years, resulting in an Associate Doctoral Degree. Undergraduates spent from three to five years abroad, and those working on advanced degrees and trainees programs generally stayed for one or two years. Short-term training usually lasted 6 months. Most graduate and undergraduates students as well as those earning advanced degrees generally attended Soviet colleges and universities or scientific institutions. Usually they focused on specialties for three or four years, whereas trainees usually joined the research institutes of the Soviet Academy of Sciences or factories, where they also studied the most necessary specialties.

Students abroad studied technology in various applications, such as industry, agriculture, military affairs, geology and mining, water conservation, medicine, telecommunications, railroads, and aviation so they might address pressing practical problems as soon as they returned to China. Technicians and administrators at various levels were trained in Soviet colleges and universities, industrial enterprises, design institutes, and scientific research institutions. Those who went abroad included factory directors, engineers, workshop directors, heads of workshop sections, regular workers, and those building enterprises.

Very few Chinese students possessed several years of work experience. It often proved difficult for workers to leave their jobs and study abroad. Moreover, their Russian was often poor. For this reason, Chinese scientific research institutions chose to send trainees to institutions such as the Soviet Academy of Sciences to be educated and trained, and people with work experience to the Soviet Union and Eastern Europe. There they could take part in research work for a year or so and study Soviet research methods.

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[33]According to figures in Soviet publications, more than 20,000 Chinese students studied in the Soviet Union, which includes people practiced in Soviet enterprises (Baolisuofu & Keluosikefu, 1982, p. 152). According to Chuyuan Cheng's statistics, the number of Chinese educated in the Soviet Union totaled 38,000 between 1950 and 1960:8,000 technicians, 1,300 scientists, 1,200 teachers, 7,500 students, and 20,000 workers (Cheng, 1965, p. 196).

The process for selecting students to travel abroad (Soviet Union) was very strict. Those chosen had to meet the following conditions.

1. *Political requirements:*
   A. Have a clear background, with complete political reliability and progressive ideas;
   B. Work and study hard and actively, with good qualities and educational potential, and volunteer to study in Soviet Union; and
   C. Family members and relatives could not have counterrevolutionary problems (this was checked by the Ministry of Public Security).
2. *Academic requirements:* Must have a university degree and be engaged in research work or have participated in tasks related to one's specialization for more than one year, and possess good achievements and exhibit a desire to study intensively.
3. *Health condition and age requirements:*
   A. According to various criteria for physical examinations, one must be examined by the hospital appointed by public health departments and meet all standards; and
   B. Be under the age of 35.
4. *Examination of courses:* After political review and physical examination, must have taken and passed examinations relevant to graduate student courses.

If all were satisfactory, one then could study in the Soviet Union (Gaodeng Jiaoyubu, 1954). Trainees and short-term students had to meet the same political conditions, foreign language requirements, and health expectations. Ordinary trainees did not have overly strict academic requirements. The checkup mainly focused on one's political background and health conditions. Before going abroad, students spent a year learning Russian in Russian schools in Beijing or in Dalian. The government kept political tabs on these students.

After 1958, many students returned to China after finishing their studies. In general, short-term students or trainees had the most immediate impact on technology transfer. The application of knowledge gained in the Soviet Union was one of the most successful examples of technology transfer. Graduate or undergraduate students spent more time gaining systematic education in advanced technologies. After returning to China, they played important roles in the diffusion of Soviet technology. Some became leaders and organizers of national science and technology affairs and

industries. For example, Ganchang Wang, a famous Chinese scientist, worked in the Dubna Joint Institute for Nuclear Research in the Soviet Union. Guangzhao Zhou, the former president of the CAS, was responsible for the theoretical design of an atomic weapon after returning from the Dubna institute in the Soviet Union. Yongzhi Wang, who was responsible for designing the Shenzhou spacecraft, studied missile and rocket design with the famous Soviet space technology academician, ВасилиЙ Павлович Мишин between 1955 and 1961. Yilian Jin, winner of China's highest award for science and technology in 2002, studied computing technology in the Soviet Union from 1956 to 1958.

Soviet technology experts in China

Clearly, students educated in the Soviet Union made a substantial contribution to the transfer of advanced technology to China. But after 1949, the task of founding the regime, reconstructing the economy, and promoting science and technology was limited by the small number of qualified professionals and administrators at every level. As a result, experts and consultants that USSR sent played a necessary role in transferring technology.

Before the Chinese Communist Party took control of the mainland, the Soviet Union responded to an invitation from the CPC and sent 300 engineers and technicians to Northeast China. These experts helped build to railways to revive the economy in 1948. When Shaoqi Liu, the second leader of the CPC, traveled from Moscow back to China, Ковалёв, an official of Soviet Communist Party, led another party of 220 technology experts in August 1949.

On 27 March 1950, the two governments privately endorsed "The Convention on the Conditions of Soviet Experts to Work in China" in Moscow (Haiyincixi, 2001, pp. 702–703). After Khrushchev assumed power, important departments of the Soviet government began sending additional experts and consultants to China, to assist with industrial development, the construction of important bridges and railroads, and scientific and technological research and education. The Soviet Central Committee oversaw the selection of experts and consultants for China and checked carefully to ensure that each had the "correct political viewpoint." As economic consultant for Chinese government, the chief representative of the General Bureau of Economic Liaison of Soviet Union in China, И. Архипов, provided much help and many suggestions about the invitation of experts.

Sources do not agree about the number of the experts who worked in China from 1949 to 1960. In an essay published in October 1959, Enlai

Zhou reported that over the previous ten years, the Soviet Union had sent more than 10,800 economic, cultural, and educational experts to China, most of them in technical fields (Zhou, 1959). According to statistics in official Chinese documents, more than 8,000 technical experts from the USSR and Eastern Europe worked in China (Peng, 1989). Soviet documents suggest that the number of the experts working in China increased steadily between 1952 and 1954 and stood at more than a thousand annually from 1955 to 1959. In addition, 615 Soviet teachers worked in China from 1948 to1960 (Baolisuofu & Keluosikefu, 1982, pp. 150–151, 177).

Soviet visitors ranged from technical consultants and engineers to technical workers.[34] They came from all types of Soviet enterprises, including design and research institutions. After 1953, during the period of the "156 Projects," various experts worked on every site targeted for Soviet assistance, installing equipment, conducting workshops and training classes, as well as supporting related technical, design, and scientific research institutions. These people were the manpower that enabled Soviet technology to take root, grow, and bear fruit in China.

Many Soviet experts also worked with the CAS, the scientific research institutes of industrial ministries and commissions, and the institutes of national defense.[35] They were involved in the institutions for heavy industry in metallurgy, machine building, chemistry, as well as in other technical fields such as electronic technology, automation, national defense, aviation, and natural resources prospecting. Their work included theoretical technological research and experimentation as well as the study and development of practical technology. For example, Soviet experts helped the CAS to establish more than 40 labs or research groups and made important contribution in such fields as atomic energy and physics, computing technology and mathematics, and chemistry and applied chemistry. Lanthanon and other rare elements, electronics, precision optical instruments, mechanics research, oceanography, and comprehensive survey equipment also were supplied by the Soviet government. To varying degrees, specialists from the USSR provided aid to other fields such as astronomy, automation, electrotechnology, and organic chemistry. As mentioned in the "Ten-year-work Summary on Soviet experts to the CAS":

[34]Yamamoto Ichirô's impression was that "whatever their positions or whether they had experience or not, the administrators, researchers, engineers, technicians, and workers etc. were mixed together and called 'Soviet experts', were worshiped as gods" (Yang, Zheng, & Xu, 1995, p. 125).

[35]For example, between 1949 and 1960, the CAS engaged more than 60 Soviet consultants and experts, and invited over 820 experts to visit the academy (Shen, 1990).

> Scientific research in computing technology was a blank in our country previously. Soviet assistance played a huge part in our development of computing technology. We invited seven Soviet experts in succession. They put forward instructive and comprehensive opinions to us on how to start computing technology research and systematically taught the theory and methods of programming, which opened the first door for computing technology (in our country—the words added by translator). When we developed the M-3 computer and the first large-sized computer 104, the experts helped us resolve crucial problems such as the manufacture of magnetic cores, the adjustment of core storage, the adjustment of operation control, the research and adjustment of peripheral equipment as well as the entire assembly of a computer. [AUTHOR'S NOTE: the computer had been assembled before Soviet experts helped with adjustments.] Within such a short time, without the Soviet experts' help, it would have been impossible to try to manufacture such a complex machine. (Chinese Academy of Science, 1961)

Consultants at a higher level had solid professional backgrounds, knowledge of management, and rich experience. Their main tasks were to help China strengthen its scientific and technical systems and economy, plan the construction of Chinese scientific and technological enterprises and industry, put forward research subjects, and join with relevant experts to solve various important problems. For example, Лазаренко Борис Романович (Lazarenko), the vice secretary general of the Division of Technical Sciences of the Soviet Academy of Sciences, arrived in Beijing in November 1955 to act as consultant to the president of the CAS for two years. He developed a 15-year program for the CAS, as described in the "Long-term Program for Developing National Sciences and Technology between 1956 and 1967." He offered important suggestions about how best to establish and reinforce research in new technologies, especially in important areas where China had little previous experience. Furthermore, he helped train to researchers in electrotechnology (Zhongguo Kexueyuan Lianluoju, 1958, p. 85).

After March 1950, an agreement between the two countries provided that Soviet experts in education would assist Chinese colleges and universities, secondary schools, and technical worker training programs, with special emphasis on engineering colleges. These Soviet experts generally were associate professors or higher and possessed strong professional abilities. They helped China to establish many new specialties; developed teaching units, researching units, and laboratories; taught new undergraduate and graduate courses; introduced textbooks; and prepared young teachers. Some Soviet visitors served as consultants to the government or to college administrators and exerted great influence on the construction and planning of school systems.

In general, China approved the efforts of Soviet experts. On 31 July 1958, Zedong Mao told Khrushchev that 90% of the suggestions from Soviet experts were sound; he also stated that China needed experts in technology and had no complaints about the economic consultants (Fei & Fei, 2001). In 1958 Zedong Mao praised the Soviet engineer who assisted in the construction of the Wu Han Yangtse River Bridge. As he told the Soviet ambassador:

> The Soviet expert working on the Yangtse River Bridge is an excellent comrade. His method of building the bridge had never been used in your country . . . when he came to China we also thought that his method is rational. In any case, we know nothing about building bridge, we let him to do so at his convenience. His work succeeded when he tried and the bridge is one of the best in the world.
>
> I have never seen him. When I talked to many managers of Yangtse River Bridge project, they told me that he was an excellent comrade. . . . By the time the bridge had been finished, Chinese comrades had learned much from him. (Mao, 1958, pp. 322–23)

The acceptance of the ideas of outside experts also had a political dimension. Because of the Chinese political policy of "leaning to the side of Soviet Union," Chinese administrators and engineers could not express opinions that differed substantially from those of Soviet experts; usually they followed the Soviet experts' opinions. The small number of Chinese experts and engineers who challenged Soviet experts on professional issues were subject to criticism or persecution. At first, because of the Chinese government's propaganda that Soviet technology was the most advanced in the world, some Chinese became dependent on Soviet experts and their technology. But, as Enlai Zhou emphasized, "As to Soviet experience, we can't follow it completely but must use it by combining it with Chinese reality. The problems of policies must depend on us to make a decision. We must think, make judgments and make decisions, and can't rely on Soviet experts. About technical problems, we can obey the experts' opinions a lot" (Li, 2001, p. 51). By the time of the "Great Leap Forward," however, Chinese experts were challenging Soviet experience and even unreasonably refusing to accept both the opinions of Soviet experts and Soviet technical regulations, technical criteria, and process formulas. This turn of events caused confusion, and most Soviet experts, obviously, did not agree with the approach of the "Great Leap Forward."

THE END OF ASSISTANCE FROM THE SOVIET UNION

The escalation of the ideologic conflict between the two countries (and parties) finally resulted in the rupture of relations. The symbol of the break in Sino–Soviet relations was the Soviet Union's decision to withdraw their experts and consultants from China in July 1960.

withdrawal of Soviet experts

After 1956, Soviet leaders unofficially mentioned withdrawing or reducing the number of experts in China several times, but had taken no action. Beginning in the latter part of 1958, however, the USSR began to decrease its technical assistance and withheld or delayed transfer of the newer "high technologies." On 20 June 1959, the Soviet Union informed China that they were postponing plans to help China develop nuclear weapons for two years because they had launched negotiations with Western countries about limiting nuclear testing. Whether China would receive this technology would depend on the international situation.[36] In October 1959, when Khrushchev participated in the celebration of the tenth National Day of the People's Republic of China, he told Zedong Mao, "As to making atomic bombs, we have decided to withdraw our experts" (Li, 2001, pp. 191–192).[37] In view of Khrushchev's speeches against China during September and October 1959, some Chinese leaders felt that the Soviet Union might soon renege on the aid conventions. In January 1960, Rongzhen Nie, a vice premier in charge of scientific and technical affairs, reported to the Central Committee of the CPC that the USSR intended to reduce or even stop their assistance, and suggested that China should prepare for this possibility (Nie, 1984, p. 805).

In April 1960, on the occasion of Lenin's 90th birthday, China published three articles that implicitly criticized Soviet policy. Thereafter, the Soviet Union gradually took measures to pressure China to slow its efforts on important and key projects, and delayed or failed to execute many conventions. On 16 July, the plenary session of the Central Committee of the

[36]In Khrushchev's memoirs, China's request for territory from the Soviet Union persuaded Soviet leaders not to provide China with the design for atomic bombs in early 1958 (Kelaimo, 2002).

[37]Some Soviet experts returned to their country went on holiday and came back. In this way, the Soviet Union almost unilaterally abolished the "Convention on Soviet Aid to Manufacture New Weapon and Military Equipment and Began All-General Atomic Energy Industry" signed in 1957. In August 1962, the Soviet government informed China that they would not transfer nuclear technology to a country without nuclear capabilities.

Communist Party of Soviet Union discussed relations with China and announced the decision to remove all Soviet experts (Luan, 2003a). On July 25, the Soviet embassy in Beijing informed the Chinese Ministry of Foreign Affairs that the first group of Soviet experts would leave China on 28 July, and all experts would withdraw by 1 September. Within a month, the USSR withdrew 1,390 experts (Wang & Yu, 1988, p. 7),[38] and halted plans for another 909 experts' visits. This action unilaterally halted 600 agreements and contracts, of which 343 conventions were about experts.[39]

When Soviet experts withdrew in 1960, they took designs, drawings, and technical data with them. The Soviet government stopped supplying China with necessary equipment and materials. Many projects simply could not be completed; some unfinished factories could not start on time. Certain design and research projects were forced to stop. Two hundred fifty-seven cooperative science and technology projects were abolished or cancelled (Wang & Yu, 1988, p. 7). Obviously, the nature and scale of cooperation decreased greatly. More seriously, the already weak Chinese economy was damaged, and because of China's heavy dependence on the Soviet Union, science and technology undertakings were especially hurt. When the two countries broke off relations, the "Long-term Program" sank into confusion that prompted a great deal of waste and damage to Chinese resources. For example, China had retained a Soviet expert to assist in the development of a light range finder (optical instrument used to measure distance). Preparing for this project cost China a significant sum of money. All was wasted when the expert was withdrawn two months into the project. In short, China failed to build a mound for want of one final basket of earth (Shen, 1990, pp. 49–50).

the decline and rupture of Soviet technology transfer

After July 1960, the China and Soviet Union fought a war of words over doctrine. Each distrusted and pressured the other. The Soviet government stopped sending indispensable equipment and material to China.[40] In

[38]Accounts differ as to how many Soviet experts were in China at that time. *Yueran Li's Memoir* (2001, p. 53), reported about 1,230, but the authors of *Soviet–Sino Relationship (1945–1980)* said that in August 1960, there were over 1,600 people working in China (Baolisuofu & Keluosikefu, 1982. pp. 209–10). Задерскав, *The Reason and its Influence why Soviet Union Called back its Experts from China*, reported that on 1 July1960, there were 1,929 Soviet experts working on 34 systems for Chinese ministries and departments as well as other institutions in 44 cities (Luan, 2003a).

[39]Between 1961 and 1967, only about 100 experts in science and technology were part of exchanges between the Soviet Union and China, mainly through attendance at academic conferences.

[40]In September 1958, a decision was passed at the Soviet Council of Ministers. It was about the

October 1960, the Chinese government warned the Soviets that China would not honor contracts calling for the export of agricultural products and minerals, would revoke orders already placed with the Soviet Union, and would adjust other export plans. Both China and the Soviet Union paid a heavy price for this dispute.

Because the growing dispute prevented the two countries from carrying out their technology transfer agreements, in October 1960 China suggested modifying the various conventions on economic, technical, and scientific cooperation. During the spring of 1961, the Chinese government sent a delegation on economics, science, and technology to negotiate with Soviet officials. On 19 June 1961, the two sides endorsed "The Protocol about Dealing with Every Convention and Related Documents Signed between the Two Sides about Soviet Union Technically Helping China Build and Expand Industrial Enterprises and Other Projects" as well as "The Convention on the Scientific and Technical Cooperation between the Union of Soviet Socialist Republics and the People's Republic of China." These documents replaced all previous agreements. "The Protocol about the Scientific Cooperation between the Academy of Sciences of the Union of Soviet Socialist Republics and Chinese Academy of Sciences" was endorsed by two academies in Moscow on 21 June 1961. The new documents reflected the Soviet Union's increased unwillingness to transfer military and high technology to China.

The new protocol governed industrial enterprises and other projects. It stipulated that 89 projects that had been planned with complete equipment from the Soviet Union and 35 workshop-or-device projects would be cancelled. Another 66 construction projects set for completion between 1961 and 1967 were to continue. However, both Soviet and Chinese officials were deeply ambivalent about how this would happen. Because they could no longer gain access to Soviet equipment, technical data, and experts, some assisted industrial projects ran into trouble and had to be shut down. Some newly constructed factories and mines could not open on schedule. In 1964, the CPC refused a request from the Soviet Communist Party to end the controversy between the two nations and negotiate an agreement governing trade and technical assistance. Then in April 1965, the Chinese government announced it would terminate all industrial projects described in the June 1961 protocol. By that time, Soviet facto-

(*continued*) output between 1959 and 1965 that Soviet Union would provide equipment and material to the broad enterprises that they supported and intended to support. However, on account of the deterioration of the relationship between Soviet Union and China, this plan could not continue (Gangchalianke, 2002).

ries shipped only 1% of the complete equipment sets that had come to China in 1959 (Baolisuofu & Keluosikefu, 1982, p. 289).

Scientific agreements also were affected by the tension between the two nations. By late 1960, Chinese research institutions were forced to cancel most items listed in the "122 Project Convention," disturbing progress on the "Long-term Program for Developing National Sciences and Technology between 1956 and 1967" (Zhongguo Kexueyuan, 1960).[41] During negotiations about scientific and technological cooperation in the first half of 1961, China still sought to continue cooperation in some scientific fields. The new convention on the scientific and technical cooperation between Soviet Union and China did not define any specific projects. Moreover, the Soviet Union no longer sent scientists on technical assistance visits, and restricted shipments of equipment, instruments, samples, reagents, and material needed for scientific research. The flow of scientific information also was restricted to works and papers that had already been published. In short, activities under this cooperative convention were severely reduced. By 1965, the volume of scientific and technical cooperation between the Soviet Union and China was only a few percent of the effort witnessed in 1959. And relations then worsened. In July 1965, all Chinese scientists left the Dubna Joint Institute for Nuclear Research. By 1967, the cooperative relationship in science almost completely ended.

the end of educational cooperation

Even before Soviet experts withdrew in 1960, Soviet officials tried to limit the number of Chinese students at Soviet universities and research institutes. In March 1960, the Soviet Ministry of Foreign Affairs sent the Chinese embassy in Moscow a note asking for a new agreement on undergraduate and graduate study to replace the convention endorsed in 1952. The Soviet Union proposed that students would be exchanged in a peer-to-peer fashion. Thereafter, Soviet Union actively restricted the number of Chinese students in Soviet Union, as well as their field of study (Wang, 1998, pp. 244, 257). In 1960, the Chinese sent 522 students, but the Soviet Union accepted only 411. Of the 111 students who were refused, 51 specialized in engineering physics, 27 in war industries, and 1 in atomic propulsion for ships. After that time, the Moscow Engineering Physics College and Moscow Aeronautical College refused to accept any Chinese students. In 1961, Soviet Union accepted only 83 of 111 Chinese students. Again, the same pattern was evident in the rejections; 15 who hoped to

[41] The second attached table listed the 22 projects that the CAS had taken charge of.

major in engineering physics, 3 in aeronautics and radio engineering, and 3 in radiology were among the 28 refused entrance. Similarly, Bauman Moscow Higher Technical School and Leningrad Precision Optics College joined the list of schools refusing to accept Chinese students. In 1962, the Soviet Union only took in 59 of 104 students China had hoped to send out. In 1964, the Soviet Union responded so slowly that no students could study in the USSR, and in June 1965, the Soviet Union proposed a reciprocal agreement by which every Chinese student in the USSR would be balanced by a Soviet student in China. The result of this approach was to reduce even further the number of Chinese students studying in the Soviet Union.

On 20 September 1966, the Department of Foreign Affairs of the Ministry of Higher Education of China informed the Soviet embassy in Beijing that it was not convenient for Chinese colleges to offer lessons to the foreign students because the colleges and universities were fully participating in the "Great Cultural Revolution" (1966–1976). Therefore, the Chinese government decided to suspend the schooling of all foreign students in China for one year, and asked Soviet students in China to return home within 10 to 20 days. By 7 October, the Soviet Ministry of Higher Education responded by informing the Chinese embassy in Moscow that all Chinese students in Soviet Union also had to leave the Soviet Union before 31 October. Then in January 1967, all Chinese students were called home to take part in the "Great Cultural Revolution." The exchange of students between the two countries had ended.

With the relationship between the Soviet Union and China steadily deteriorating, China had to adjust its strategy for the development of industry, technology, and science. The Central Committee of the CPC held many meetings in late July and early August 1960 to discuss Sino–Soviet relations, estimate the possible consequences of withdrawl of Soviet experts, and work out countermeasures and solutions (Li, 2002). Chinese officials decided to replace the technology that had been coming from the Soviet Union and Eastern Europe with self-reliance, and, at the same time, seek Western technology. Chinese scientists and engineers solved many technology and engineering problems, and other issues related to scientific theory. For instance, they continued to build the 66 projects for which the Soviet Union had halted the full equipment packages, and many of them reached, or almost reached, original design expectations (Peng, 1989, p. 53). Efforts related to research and manufacturing the most advanced weapons also proceeded without Soviet assistance. A great breakthrough came on 16 October 1964, when a Chinese-manufactured atomic bomb was exploded successfully. Similarly, on 27 October 1966, China successfully launched its first guided missile.

THE IMPACT OF TECHNOLOGY TRANSFER FROM THE SOVIET UNION

It is clear that the massive effort to transplant technology, knowledge, and scientific and technical information from the USSR to China during the 1950s did not work out as originally planned. Even so, it is also apparent that the consequences of this effort were far from small.

Soviet technical assistance during the 1950s and 1960s was the most systematic, complete, and effective effort to promote technology transfer in Chinese history. First it brought basic manufacturing, materials, and energy technology that filled significant gaps in fundamental technologies. More important, perhaps, this program laid the foundation for the development of other technologies and industries, increasing production capabilities by introducing working technology in complete, ready-to-operate factories in such areas as iron and steel making. Second, the Soviet transfer program provided technology that China had never developed or that was available in only primitive stages of development. Some needs were especially urgent, and the Soviet programs helped to fulfill or reinforce certain very weak technical fields, such as computer technology, nuclear power, and particle accelerators, that made important contributions to Chinese missile and nuclear weapon development. Third, the Soviet program promoted not only the systematic development of modern technology in China, but also the creation and support for institutions of technical research and design. Fourth, improved education in technological sciences, and the improvement of scientific and engineering research both followed in the wake of this transfer program. In education, China focused on developing colleges and specialties in technology and engineering, and eventually fostered a more integrated technical system that included research and development, as well as design, education, and training. By the early 1960s, China was approaching the point of possessing the basic ability to develop technology on its own. By 1960, expenditures on scientific research, compared with those for 1952, had increased nearly 60 times (Bo, 1991, p. 508). Similar improvements were evident in the numbers of experts engaged in science and technology; the proportion of Chinese-built machinery reached 85%, and the proportion of steel from Chinese mills rose by 93%. China could now design large-scale coal mines, integrated iron and steel mills, power stations and heavy machine building factories (Zhou, 1997). Clearly, Soviet technology assistance was effective.

Yet aid from the Soviet Union also had its shortcomings. Soviet officials were reluctant to provide certain forms of technology, such as atomic weapons information. In addition, some of their assistance took the form

of immature or obsolete technology, such as the factory design used in the Baotou Iron and Steel Factory. This situation stemmed in part from the fact that China had a weak economic base. Therefore, its leaders initially focused on the development of technology that helped to construct the foundation of a modern economy and supported national defense. Moreover, Chinese enterprises did not make great efforts to improve the technology from the Soviet Union; indeed, the updating of products and production technology alike was slow and original products were produced for a long time. This situation forced China to confront and resolve some technology problems after the break in Sino–Soviet relations. But much of this progress slowed or disappeared during the period of the "Great Cultural Revolution," when an even larger gap developed between the advanced technology used in other nations compared with China.

Soviet technology also exerted an important effect on China's planned economic system and the developing model of the technology in the closely related fields of production, scientific research, and education. Building on the Soviet experience, China's leaders adopted a highly centralized economic planning system during the 1950s. The advantage of this system was that the central government could utilize administrative methods and centralized national finances, material, and technical power to construct the economy, arrange significant projects in important fields, industrially and technologically weaker areas, and underdeveloped fields, and adjust the relationship between areas and fields. The disadvantage of this system was obvious, too. For example, the planned economy caused investment inflation in some sectors and resulted in imbalances in the national economy, which dampened the enthusiasm of enterprises and local governments and produced lower economic benefits.

The problems of a planned economy directly affected research and development of technology. Because of the plans made by higher authorities, Chinese enterprises organized production and devoted less to research and development. They usually lacked the extra energy or resources for significant technical innovation. Scientific research institutions outside business enterprises tackled key problems assigned by the superintendents at national ministries and commissions. Guided by their administrative leaders, scientific research institutions and enterprises established contact and built cooperative relationships, but neither firms nor ministries felt the direct market pressures.

In the early 1950s, the reform of colleges and departments along Soviet patterns ensured that an education system set up along regional lines could meet national needs—especially in terms of economic development—by training a large number of professionals. However, this reform

also produced certain disadvantages, such as the overly narrow specialization of engineering. In addition, Soviet patterns restrained the development of technology and industry to some degree. This is not to blame the problems surrounding the development of modern technology and the economic system on Soviet influence; China chose to follow the Soviet pattern and copy Soviet experience from the beginning. From 1956 to 1970, China tried to undertake partial reforms several times, adopting such measures as "putting politics in command" and organizing political mass movements. But the contribution of these steps to an improved situation was not obvious and sometimes these actions actually made the situation worse.

All circles of society gradually realized the disadvantages of the Soviet pattern and saw the mistakes that China had made. In December 1978, the Third Plenary Session of the Eleventh Central Committee of CPC announced a reform of the economic administrative system and the introduction of advanced technology from other international sources, a step that brought China into a new era.

COMPARISONS WITH OTHER TECHNOLOGY TRANSFER PROGRAMS

Can we learn anything by comparing this massive exercise in technology transfer from the Soviet Union with other large-scale transfer programs? It is certainly significant that China's main partner in this effort during the 1950s had itself relied extensively on transferred technology to help make its own big leap toward modern industrial technology after 1925. Especially intensive transfer activities occurred in the USSR between 1928 and 1937 (Sutton, 1973; Holliday, 1979). Technology introduced from the West accelerated the Soviet economy and began closing the gap with developed Western countries. The technology transfer program from the Soviet Union to China, on the other hand, was a large-scale venture within the socialist family. Beyond that, there are a number of other differences, as well as a few similarities in the two technology transfer efforts.

By the early 1950s, the United States and other Western capitalist nations had agreed to prohibit the transfer of strategic goods, materials, and technology to the Soviet Union as well as to China. But because this program limited the markets (and thus the profits) of private corporations in the West, internal opposition frequently surfaced. Often companies sought to influence their governments' decision making in ways that allowed trade with the Soviet Union, and thus the transfer of technology.

As a result, prohibitions on trade often had limited effects and some of the most advanced civilian and military technologies reached the Soviet Union (Sutton, 1973). In fact, the Soviet Union could choose technology from different countries and compare different possibilities available in international markets. Soviet officials introduced high-quality, low-cost technologies that met their needs (Sutton, 1973, pp. 409–410; 1980, pp. 426–428).

China, on the other hand, had only a single choice for technology (communist countries in Eastern Europe), given the international circumstances. Once the Soviet Union decided to reduce and then stop the flow of technological assistance to China, Chinese leaders faced severe difficulties in securing any technology that the Soviet Union chose not to offer. China could not acquire advanced technology from American or Western European sources. The large volume of technology transferred from the Soviet Union to China fell into two categories: technology that China did not possess at all and that which China possessed in only a limited capacity, such as metallurgical and machine-building technologies. Some transfers supported advanced areas such as computing, missile technology, and nuclear technology, but many transfers involved outdated technology, as in the case of steam locomotives. Thus Soviet technology brought the level of Chinese technology overall to the level of the world during the 1940s, with only a few fields reaching a higher level (Guojia Jihua Weiyuanhui Duiwai Jingji Maoyi et al., 1992, p. 2). If the technical assistance conventions adopted in the late 1950s and lasting into the mid-1960s had been put into practice completely, the basis of technology and industry in China could have been stronger.

China and Soviet Union also experienced different problems in the areas of patents and intellectual property. When the Soviet Union copied Western products, Western countries always complained that the Soviet had pirated the design. In the end, however, the West had to accept such behavior if they wished to maintain commercial ties (Sutton, 1980, pp. 442–44). However, China had no patent problems because its relations with Soviet technology suppliers had been solved by treaty from the beginning. While selling technology and equipment, the Soviet Union also transferred related immaterial knowledge—the right to use a particular technology, its design, technical experience, educational and training methods, and managerial knowledge. The Soviet Academy of Sciences transferred not only their computing technology, but also the experience about establishing an institute to the CAS without any strings attached; they also supplied their newest computer for China to study and imitate. This allowed China to launch an independent initiative concerning an entirely new technology. Technology transfer from the Soviet Union to

China generally was labeled "technical assistance." In fact, it involved compensation from China, so that the terms *technology exports*, *technological trade*, and *technical cooperation* more accurately describe the process.

Western technology imports mainly affected Soviet technology and its economy. Because of different economic and political systems, Soviet government officials often doubted Western motivations in allowing the transfer of technology and allowed only limited interaction between Soviet and foreign industrial specialists. This limited the impact of outside technology, as the USSR feared political contamination from the outside (Holliday, 1979, pp. 4, 23, 175–176, 185). However, the influence of Soviet experts on China society was more extensive, touching the scientific research and higher education systems. With institutions and ideologies that were similar to those of the Soviet Union, the Chinese allowed extensive interaction between state's specialists to gain Soviet know-how.

The Soviet Union and China both made important innovations in advanced weapons. Both countries wanted to develop military industrial capabilities and gathered together extensive human and material resources, including some of the best scientists (Sutton, 1973, pp. 357, 372). However, after 1917 Soviet scientists made great contributions to scientific theory but few fundamental industrial innovations (Sutton, 1973, pp. xxv, 362). One of the most important reasons lay in the Soviet's centrally planned economy, in which enterprises were not the principal elements, thereby creating a lack of the motivation for innovation (Sutton, 1973, pp. xxvi, 362, 372, 409, 422). China confronted similar issues. Although both countries emphasized technological progress and argued that that theory should be integrated with practice, the statement alone could not produce results (Sutton, 1973, p. 423; 1980, p. 22).

These efforts resulted in some interesting ironies. Soviet officials quietly emphasized the need to assimilate Western technology, even as they publicly emphasized the independent development of their own technology, often diminishing or even concealing the importance of Western technology (Sutton, 1973, xxvi, 410, 420, 401). China, on the other hand, publicly praised advanced Soviet technology, downplayed the importance of Western advanced technology, and criticized Chinese specialists who were favorably disposed to advanced Western technology. Yet in the long run, such outlooks not only hurt the development of Chinese specialists, but also worked against the acceptance of Western technology.

Significant similarities also mark the tech transfer programs of the two countries. Western scholars have argued that technology from the United States and Europe made important contributions to the Soviet economy (Sutton, 1973, p. 381). An examination of the increased design and man-

ufacturing capabilities of China that appeared after Soviet technological assistance suggests that Soviet technology played a similarly important role in the Chinese economy.

To increase the pace of industrialization and the introduction of foreign technology, the USSR relied on a variety of methods, including squeezing the farm population to accumulate the capital for rapid industrial development (Dorn, 1979, p. 337; Sutton, 1973). Problems requiring urgent solutions in China, such as national security and economic construction, influenced the selections of technology and priorities given to specific fields. Above all, the government emphasized the development of the national economy and the construction of national defense, and adopted the pattern of "task promoting subject" to develop science and technology. However, during the 1950s, Chinese financial capabilities were limited. China therefore utilized the same method as the Soviet Union to finance heavy industry and defense technologies, hoping to reap economic and social benefits as quickly as possible.

Direct investment can have distinct advantages as a technology transfer mechanism (Holliday, 1979, p. 29). The Soviet government precluded foreign direct investment in its economy to minimize the political and economic consequences that inevitably followed the appearance of outside experts and developers (Holliday, 1979, pp. 175–176). Chinese leaders feared that Soviet capital might threaten Chinese sovereignty. Zedong Mao and certain officials opposed large-scale Soviet investment in China, preferring to import Soviet products, introduce Soviet design and manufacturing technology, and copy Soviet technology education. Supporters of this approach hoped the Soviet Union would provide technology and send consultants and specialists, but that that the Chinese would make decisions by themselves and eventually develop new technology and domestic products. After securing assistance from Eastern Europe and the USSR, Mao started to set his mind on the creation of a Chinese-styled socialist shortcut to communism. During this period, some inside China refused reasonable suggestions and advice from Soviet experts, and ignored the technical criteria and standards developed by Soviet institutions. As a result, the flow of technology was damaged for a time.

The history of technology transfer from Soviet Union to China showed three dominant approaches. One involved the transfer of industrial technology by aiding in the construction of industrial projects; a second called for helping China to develop science and technology through scientific and technical cooperation. The third approach was to help China to reform and construct technical colleges as well as recruiting large number of Chinese students to study in the Soviet Union. There were a number of

very specific transfer mechanisms used as well, including the transfer of complete technological installations, the retention of foreign specialists and consultants, and the travel of students to study abroad. Both China and the USSR considered the transfer of complete installations because it seemed better than others and produced the fastest economic and social benefits (Sutton, 1973, pp. 413–415). Ideology had always influenced the resolution of technological problems in the Soviet Union, and the same thing happened during the Chinese introduction and assimilation of Soviet technology (Sutton, 1980, p. 418).

Was there any connection between these two technology transfers? The answer seems to be affirmative for several reasons. First, the Soviet Union provided China with lessons it had learned during the experience of transferring technology from the West before World War II. Soviet officials were good at choosing advanced Western technologies, and they attached importance to the collection of all kinds of information as a key step in their success (Sutton, 1980, pp. 426–441). Soviet experts passed this insight to the Chinese. For example, they advised the CAS to establish an information institute, an organization that had never existed before 1949; the Soviets also provided assistance with its formation.

During the period of transferring Western technology, the Soviet Union also learned the danger that emerged when they neglected to fit Western technology to Soviet conditions (Sutton, 1980, p. 467). When the USSR began to transfer technology to China, it always emphasized that Soviet technology must integrate with Chinese circumstances. Soviet specialists and consultants provided many suggestions based on their experiences in choosing technology, the means of assistance, and the ways to train professionals. In general, both the Soviet Union and China developed and adjusted their technical programs and technical and product designs in response to the available resources and other conditions in China.

Similarly, Soviet officials detected a waste of professional effort during the transfer of Western technology to the Soviet Union because of a lack of trained technicians and prepared managers (Sutton, 1980, pp. 417–419). Therefore, when transferring Soviet technology to China, Soviet specialists and consultants emphasized the importance of training professionals. The Chinese responded to their lack of industrial professionals by adjusting and reforming schools and university departments, brining them into line with the Soviet model of higher education.

China was not the only nation to receive a significant amount of technology from the Soviet Union. India also was a beneficiary of Soviet transfer and assistance programs and therefore provides an interesting comparison to events in China. After achieving independence, India's leaders

adopted a policy of nonalignment in international relations. When Krushchev became the most important Soviet leader, he adjusted Soviet foreign policy and emphasized peaceful coexistence to reduce East–West tensions. Soviet officials considered India's stance of nonalignment a positive force in world affairs. But they also began to provide India with technological and economic assistance to weaken and perhaps supplant the Western influence in India (Stein, 1969, pp. xi, 37).

As had been the case in China, Soviet assistance focused on the development of industrial capacity through visiting specialists, the acceptance of Indian students, and scientific cooperation projects. The Soviet Union started its assistance to India with a steel plant and gradually expanded into other fields (Stein, 1969, pp. 42, 45, 269–270). As the Soviet–Sino rift widened and Soviet specialists and consultants were withdrawn from China in 1960, relations between India and China also deteriorated and an Indian–Sino border conflict developed. The Soviet Union apparently increased both technological and economic assistance to India in response, and even provided military technological assistance (Stein, 1969, pp. 125–126, 153, 271). The Soviet aim was to keep China within limits. Nevertheless, the scale and scope of Soviet aid to India was much smaller than had been afforded China.

These two technology transfer programs operated within rather different international political contexts. The ideology, social institutions, and conflicts with the United States and the West were the same in China as had existed in the Soviet Union. China chose the policy of leaning toward the USSR and developed a fraternal relation with the Soviet Union. In the context of a "friendly alliance and mutual aid" strategic relationship, the two countries attached importance to their common interests, values, and rules of an international, political "family" within the socialist bloc. The contracts between enterprises, academies and institutes, design institutes, and colleges and universities in the two countries assumed the general benefits were felt by both governments. The Soviet Union made real efforts to meet Chinese demands for civilian technology; its experts usually contributed their own technology and experience without constraint or haggling.

India had a different ideology and social institutions, most notably adopting elements of a capitalist economy. Although the shifts introduced into foreign policy by Khrushchev and the widening Soviet–Sino and Sino–Indian rifts brought the Soviet Union and India closer (Stein, 1969, pp. 250, 283), the Indian–Soviet relation could not compete with Sino–Soviet relation of the 1950s in terms of depth, breadth, or extent. Neither the Soviet Union nor India wanted their ideology to affect the other or to interfere with the transfer of technology, the acceptance of students, or the

exchange of specialists (Stein, 1969, pp. 194, 214, 226). In the area of military technology, however, the Soviet Union imposed some restrictions and constraints and was as unwilling to provide the most advanced technology to India as to China. For example, the Soviet Union originally intended to provide China with the manufacturing technology for its T-54 tank. After extended negotiation, China finally received the technology that allowed it to build T-59 tanks (actually T-54A tanks).

This comparison suggests, once again, that implanting and developing technology from any outside source requires the existence of supportive social systems, values, and conditions. Soviet technology, which originated from the West during the 1930s, was then transferred to China systematically, on a large scale and at a higher level. It laid a foundation for modern technology and industry in China, came to establish a more comprehensive system of modern technology and industry, resulted in the development of scientific research, and exerted a far-reaching influence on Chinese social and economic development during the second half of the 20th century. While introducing Soviet technology, China also built a social system similar to that in the Soviet Union, including a planned economic system, a scientific and technical system, and an educational system. These institutions accommodated Soviet technology transfer and enabled the Chinese to assimilate Soviet technology relatively quickly. By way of contrast, there were many differences in terms of politics, economics, and scientific, technological, and higher education systems between India and Soviet Union. When India borrowed or copied technology from the Soviets, she did not change her system as obviously (Stein, 1969, p. 257)—perhaps because the assistance was of a smaller scale. On the one hand, the difference in social systems meant that the technological ties to India were never as deep, nor as invested with meaning, as those between China and the USSR. Ironically, however, the very depth and geopolitical significance of Sino–Soviet ties meant that the connections between the two countries involved much more than a narrowly defined business or economic relationship. It was these intricate social and political linkages that guided and shaped many of the outcomes of this important case study in technology transfer.

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APPENDIX

Some important conventions of Sino-Soviet.

Date	*Location*	*Title of convention*
1950.2.14	Moscow	The Treaty of Amity, Alliance and Mutual Aid between Soviet Union and China
1950.2.14	Moscow	The Convention on Soviet Union's Granting a loan to the People's Republic of China
1950.3.27		Convention on the Conditions of Soviet Experts to Work in China
1953.5.15	Moscow	The convention on Union of Soviet Socialist Republics helping the Central Government of the People's Republic of China develop economy

1954.10.11	Bei Jing	The Convention on Science and Technology Cooperation between the Union of Soviet Socialist Republics and the People's Republic of China
1954.10.11	Bei Jing	The convention on Soviet Union helping the People's Republic of China build new 15 industrial enterprises and expand the supply of equipment to 141 primary industrial enterprises on the basis of technical assistance
1954.10.11	Bei Jing	The agreement on Soviet Union Government's Granting a long-term loan of 520 million Rubles to the People's Republic of China
1955.4.27		Convention on Soviet Aid to Chinese Atomic Energy and Nuclear Physics Research Undertaking and Atomic Energy for Chinese Economics
1957.10.15	Moscow	Convention on Soviet aid to manufacture new weapon and military equipment and began all-general atomic energy industry
1957.12.11	Moscow	The Protocol on the Scientific and Technical Cooperation between the Academy of Sciences of the Union of Soviet Socialist Republics and Chinese Academy of Sciences (1958–1962)
1958.1.18	Moscow	Convention on Soviet Union and China Cooperating and Soviet Union Helping China with Significant Scientific and Technical Research
1958.8.8	Moscow	The convention on Union of Soviet Socialist Republics helping the People's Republic of China build and expand 47 industrial enterprises on the basis of technical assistance
1958.9.29	Moscow	Complementary Convention On Soviet Union's Technology Aid to Atomic Energy Industry in China
1959.2.7	Moscow	The convention on Union of Soviet Socialist Republics helping the Peoples' Republic of China build and expand 78 industrial enterprises on the basis of technical assistance
1961.6.19		The Protocol about Dealing with Every Convention and Related Documents Signed between the Two Sides about Soviet Union Technically Helping China Build and Expand Industrial Enterprises and Other Projects
1961.6.19		Convention on the Scientific and Technical Cooperation between the Union of Soviet Socialist Republics and the People's Republic of China

Notes from the Field

M. GAMAL SABET

To understand the significance of the Sino–Soviet technological exchange and transfer program of the 1950s that is the subject of the article by professors Zhang, Zhang, and Fang, it may be useful to consider the experience of another country that drew upon the Soviet Union for technological assistance during the same time period—Egypt. As was true in the Chinese case, the historical relationship between Egypt and Russia reflects the evolution of both countries' political cultures and foreign policies. The Soviet Union provided technical assistance to Egypt as part of the global geopolitical struggle with the West during the Cold War. This commentary describes four major examples of this cooperation and discusses their long-term impact on Egypt's own development. The results differ rather substantially from those witnessed in China.

the Czechoslovakian weapons agreement

In the period immediately following World War II, the West, and particularly the United States, was the only supplier of weapons to Egypt. When Egypt's King Farouk was deposed in a coup led by Gamal Abdel-Nasser, the new president's ideologies as a nonaligned socialist led him to agree to purchase weapons from Czechoslovakia in 1957, prompting similar agreements between other Arab countries (like Syria) and the Eastern Bloc.

the High Dam at Aswan

One American response to this development was an attempt to regain political and economic control, working through the World Bank to finance construction of the High Dam at Aswan on the Upper Nile. American policymakers understood the symbolic advantage of being identified with a large technological project that contributed to economic development in a peaceful and positive manner. The Russians countered by trying to convince Nasser that they had more experience building dams; he agreed to assign them authority over the industrial part of this immense project. As construction began in 1956, Nasser attempted to increase Egypt's options by also asking the Chinese for help. Furious, the Ameri-

cans decided to withdraw from financing the dam and the Soviet Union stepped into their place. Thus, the building of the High Dam became Egypt's first exposure to Soviet construction machinery, experts, and thousands of technicians who worked on the project site. But because all resources were controlled by the state rather than the private sector, it was hard for innovations from the Soviet Union to be diffused and adopted in other places at that time. However, the Arab Construction Company, the Egyptian counterpart in the building of the High Dam, later used this technology to build similar dams in other Arab and African countries. The High Dam had a tremendous positive economic impact. It reduced seasonal flooding, allowed Egypt to reclaim more than two million hectares of irrigable land, fed its growing population, and provided hydroelectric power for industrial development. However, this came at an environmental price, for the dam blocked the annual alluvial flows of silt that had for millennia made the Nile valley one of the most productive agricultural regions of the world.

steel mill in Helwan

Beginning in the 1950s, another Soviet transfer project concerned the development of a huge steel mill at Helwan. Although the steel mill provided local vocational training to new workers and represented the first step in transferring heavy industrial technology to Egypt, it was not an unqualified success. Even at the time it was built, the mill relied on outdated technology. Losses were astronomical, and Egypt was forced to hire many highly paid technicians and engineers from the Soviet Union to maintain productivity. This experience is similar to the results from construction of a Russian-subsidized aluminum production facility in Upper Egypt during the same period. The Russians designed the molds of the produced aluminum to fit only Russian standards, all but ensuring that the product could not be exported to other countries. As with the case of the steel factory, the aluminum factory was also outdated, inefficient, and consumed large amounts of electrical power. Parts of the factory were recently sold to a foreign investor.

the nuclear reactor

In the early 1960s, the Soviet Union also provided Egypt with the first nuclear reactor in the Middle East. The building of the reactor helped to prepare a whole cadre of physicists and technicians to use nuclear technology. One of main benefits of that reactor was its use in agriculture, re-

search, and medical treatments, especially by production of iodine 31 and other isotopes for cancer treatments.

Just as the authors noted about India's dealings with the Soviet Union, these examples of technology that moved from the Soviet Bloc to Egypt were related to the Cold War conflict between East and West. They demonstrate the plight of nonaligned countries like Egypt as either pawns or beneficiaries in the larger conflict. By initiating the relationship with the Soviet Union in the 1950s, Egypt led the way for other Arab countries in the Middle East to develop similar relationships. Most of the technologies transferred to Egypt later were transferred to the many other Arab countries (e.g., Syria, Yemen, the Sudan, and Algeria). Moreover, many newly liberated, non-Arab African countries saw President Nasser's nonaligned socialist policies as a suitable path to development, and followed the same trend.

And in common with China's experience, these Cold War economic development projects had a large long-term impact on the Egyptian workforce. Egypt and many other Arab and third-world countries sent students to the Soviet Union and Eastern Bloc countries for undergraduate and graduate professional training. The Soviet Union built a special university for that purpose, and named it after the famous African freedom fighter Patrice Lumumba (1925–1961). However, the University's main objective was Marxist political indoctrination of students so that they would receive their degrees, return to their developing countries, and become change agents in the dissemination of communism. Russians were not allowed to study at that university. Its graduates came to plague many universities in third-world countries, and were the main cause of the deterioration of their educational systems in the postcolonial era.

By contrast, West Germany was the only country that provided Egypt with useful technology. With the help of the German government, German industrial conglomerates provided a great deal of technological assistance. The Bayer Corporation introduced pharmaceutical advances like aspirin, insulin, and antibiotics to Egypt. That industry proved vital to economic development and medical care. Egypt now has one of the best pharmaceutical industries in the Middle East, including more than 12 privately owned factories. Most depend on German technology and training. The Krupp engineering conglomerate has had a similar impact on highway and bridge construction throughout Egypt.

By introducing a higher education system that gave graduates practical skills rather than ideological indoctrination, Germany also contributed fundamentally to Egypt's development. In the late 1950s, Germany created over 20 agriculture, engineering, and business institutions. After intensive German language training, students studied two years in Egypt and

two years in Germany. Although that program lasted for only five years before Nasser severed Egypt's relationship with West Germany, the graduates of that program proved to be the best in their fields to the present time. They are leaders in their fields, and have transferred what they saw and studied in Germany to the Egyptian environment. So this kind of small-scale project was significantly important as administrative and technological innovation as well as it proved to be very useful economically. Because Egypt continued relations with East Germany, these types of exchanges continued with that country. For example, the Leipzig Institute for Physical Education and other East German institutes produced many of the coaches now active in soccer throughout the developing world.

In sum, Egypt and China's relationships with the Soviet Union had many parallels. Both benefited from the Soviet Union's desire for increased geopolitical influence during the Cold War. But the consequences for industrial and economic development were mixed. In the case of Egypt, macroeconomic benefits were often offset by the fact that Egypt was the recipient of both obsolete technology and a dependency on Soviet machinery and technicians to maintain its productivity. Also, by severing its relationship with the West during the Nasser era, the Soviet Union had no effective competitor in Egypt. In the long run, Egypt's smaller scale, long-term contacts with countries like Germany may have been more important for the diffusion and adoption of more sustainable and mutually beneficial innovations.