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U.S. Technology Transfer to China: Problems and Perspectives

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U. S. TECHNOLOGY TRANSFER TO CHINA:
PROBLEMS AND PERSPECTIVES

A thesis submitted in partial fulfillment
of the requirement for the degree of
Master of Science

By

YALAN JIANG
B.A., Beijing Second Foreign Languages Institute, 1983

1991
Wright State University
I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY YALAN JIANG ENTITLED U.S. TECHNOLOGY TRANSFER TO CHINA: PROBLEMS AND PERSPECTIVES BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

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I wish to take this opportunity to express my gratitude to Dr. Robert Premus, Ph.D., professor of Department of Economics for inspiring me to write about the subject of technology transfer, providing me the necessary information of literature sources and continuous academic advice.

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December 11, 1991
The subject of technology transfer has been an area of wide-range interest and significance for many years, especially in the recent past, as Japan and the Newly Industrialized Nations (Hong Kong, Singapore, South Korea, and Taiwan) have set themselves as successful examples in area of technology transfer. Recognizing the importance of technology transfer to its national economic development, China started the unprecedented movement of technology transfer along with its economic reform in the late 1970s.

Great achievements have been made in the area of agriculture, industry, science and technology, and defense. However, many problems have emerged during the process of technology transfer, such as problems in identifying and selecting appropriate technology, in assimilating and diffusing the acquired technology due to shortage of skilled manpower, deficiencies in educational system, and inadequacy in infrastructure and institutional framework, which have posed great obstacles to effective technology transfer to China. The purpose of this paper is to explore the technology transfer issue concerning the United States and the People's Republic of China.

Technology transfer is a complicated issue. To understand and facilitate effective technology transfer, an efficient technology transfer model is presented and analyzed. To a large extent U. S. technology transfer to China has been successful. China has drawn up its blueprint for modernization in the 1990s, i.e., the Ten-Year Program and the Eighth Five-Year Plan (1991-95) for National Economic and Social Development, which requires much more new technology from advanced nations. To reach its goal, the Chinese
government should further strengthen the work of technology transfer by improving the business environment and better organizing and coordinating all of its efforts to assimilate and diffuse new technology efficiently. Moreover, policies such as pricing should be readjusted so as to encourage enterprises to develop and adopt new technology.

China has benefited from technology transfer from the United States and other advanced nations. However, technology transfer is also in the interest of the United States. With the further development of Sino-U.S. technology transfer, the two countries can not only strengthen their own economy, but also contribute to the economic progress of other nations.
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I INTRODUCTION

"A billion people! if they each buy just one ... 
If we give them technology, they will be just like Japan ... 
In a country that can launch satellites, why is the plumbing so bad ... 
All they want is technology, and they expect miracles from it ... 
It's completely different now. It's hardly even Marxist ..." 1

With the ambitious goal of becoming a super economic power by the year 2000, China, beginning from late 1970s, has been "carrying out perhaps the greatest experiment of our time - reform in a country with a 5000-year history".2 Impressive economic, technological, and military progress has been made since then.

In 1975, in his report to the National People's Congress Premier Zhou Enlai stressed the need for China to accomplish the comprehensive modernization of agriculture, industry, science and technology, and national defense. However, the official introduction of the Four Modernization Program was in 1978 with the passing of Mao and the downfall of the Gang of Four. It was not until then that China truly embarked on serious efforts at modernization. In the efforts to modernize and develop its national economy, China recognize the need to acquire new technology. Massive movement of technology transfer from advanced nations was started in the late 1970s. The result of the transfer has been remarkable over the past decade or so. According to statistics, from 1979 to 1988, 3,530 contracts for introducing technology were signed, the sum of these contracts amounts to 20.5 billion US dollars. About two-third of the introduced projects for technological transformation had been built up and put into production. It was estimated that those projects are able to increase production value of 61 billion US
dollars, to deliver profit tax of 14 billion US dollars, and to earn foreign currency of
1.7 billion US dollars.\textsuperscript{3} China has gained great benefit from technology transfer. In 1989,
China's export volume reached 43.28 billion US dollars compared to only 500 million US
dollars in 1950. By the same year, the industrial output value of China's five Special Economic Zones (Shenzhen, Shantou, Zhuhai, Xiamen and Hainan) had already reached 5.9 billion US dollars, a 14-fold increase over 1979, while export volume had reached 3.7 billion US dollars, 9 percent of China's entire export volume. Foreign-funded, Sino-foreign joint ventures and cooperative enterprises contributed greatly to the export increase.\textsuperscript{4} From 1978 to 1988, the country's GNP increased by 150\%, the national income by 140 percent, average per capita consumption by 110\% and foreign trade by 400\%. These growth figures surpassed by a big margin the comparable figures for the entire period from 1953 to 1978.\textsuperscript{5} One of the factors that contribute to the rapid economic growth and to the rise of people's living standards is largely attributed to the massive introduction of a large number of advanced technology from Japan, Europe, and the United States. In particular, such modern integrated industries as automobile, ship-building, and electrical and electronics have made a remarkable contribution towards accelerating China's economic development.

However, for a period of about three years from 1979 to 1981, China slowed down its pace of technology transfer. During this period China began its economic readjustment. The readjustment was aimed at countering some confusion existed in the work of technology transfer in the early period of economic reforms. Many large- and medium-sized projects which were originally included in the nation's economic modernization program were postponed or cancelled. Massive absorbing foreign investment was restricted for lacking necessary funds. The slowdown indicates that China has difficulties in absorbing new technology. Technology transfer depends not only on the transferor's ability to provide new and advanced technology, but also on the recipient's ability to
absorb the technology being transferred. As well described by Alexis Stungevicius, "technology acquisition involves identification, selection, procurement, and assimilation of foreign technology. It is through this process that a country develops a thorough understanding of the acquired technology so that it is able to modify and deploy the original technology in new ways and to advance the production capabilities of the enterprises it purchased for as well as to integrate the technology into other industries".6

The ability of a country to acquire, absorb, assimilate, and diffuse new technology is affected by many factors. One purpose of the paper is to explore the technology transfer issue concerning the United States and the People's Republic of China. "Technology transfer is an extremely complex issue, which encompass many dimensions. Some of the dimensions may work against each other".7 For instance, when a country needs certain technology for its economic development, the shortage of energy and/or human resources may obstruct the acquisition and/or adoption of the new technology. Government policies of both import and export countries may affect technology transfer as well. Following this introduction, the second part of this paper deals with the issue of technology transfer by first presenting a U.S. - China technology transfer model which is also applicable for technology transfer from the developed countries to the developing and the less developed countries. Discussion will also be focused on China's need for technology and the role of U.S. government policy in technology transfer to China including the recent disputes over the issue that if the U.S. should continue its most favorite nation treatment to China. The third part examines the technology transfer mechanism. Technology transfer to China takes various forms, they include direct import of goods and services, joint venture, licensing of patent and know-how, and compensation trade, and etc. The main channels for the inflow of technology abroad will be discussed in detail. Institutional and legal framework are fundamental for a nation to conduct the technology transfer, such as forming policies for regulating technology import; providing assistance in selecting,
assimilating and diffusing new technology. The fourth part turns to the issue of assimilation and diffusion of foreign technology. Whether a technology transfer is successful or not depends on how effectively the recipient country assimilates and diffuses the new technology. Finally, concluding remarks are made on the significance of technology transfer in China's national economic development and its success so far. Policy recommendations are made so as to enhance technology transfer in China and to accelerate its modernization program.

II ISSUES OF TECHNOLOGY TRANSFER

Technology, by definition, includes technical knowledge and know-how process, machinery, plants, products, and their accompanying software. The transfer of technology is the process through which science and technology are assimilated and diffused.

The success in technology transfer is related to its appropriateness. If the technology being transferred is not appropriate for the needs and conditions of the recipient country, no matter how sophisticated or efficient the introduced technology may be, the transfer is a failure. In order to have the appropriate technology to be transferred effectively, many factors have to be taken into account, such as the national policy of the recipient country and the government policy of the transferor's country, the ability of the recipient nations to absorb new technology, and such barriers to technology transfer as culture, education, economic conditions, infrastructure, availability of manpower and natural resources, and etc.

A A Basic Model

This section attempts to introduce a U.S. - China technology transfer model which is
also applicable for facilitating technology transfer from the developed nation to the
developing and/or less developed nations.

As A. C. Samli said, technology transfer is an extremely complex issue, and there is
no perfect model which can be adapted to all kinds of situations. However, to
understand effective technology transfer, it is necessary and important to develop an
efficient model.

The model introduced here is based on the general technology transfer model by A. C.
Samli, which provides insights into the key components of technology transfer. The
components considered in this model are described in the following figure.

The U.S. - China Technology Transfer Model
1. The Transferor

A country that is preparing to transfer its technology to another country must, first of all, have enough knowledge of the needs and capabilities of the recipient country, and, it must also have the willingness to transfer the technology. The transferor's needs and willingness must coincide with the that of the receiver's so that the transfer would bring about mutual benefits.\(^{11}\)

2. Technology And Its Transfer

As mentioned earlier in this section, technology covers hardwares like machinery and productive systems, know-how related process and products; and softwares, such as design and training. China classifies technology on a functional basis, i.e., technology covers production technology (production hardware and know-how), consumption technology (product design, features, and performance), and managerial technology (the firm's planning, operating, and control systems).\(^{12}\) According to Kosenko and Samli, “all of these should be addressed in an integrated and controlled manner, but they have been actually approached in a willy-nilly manner in China”.\(^{13}\) As transferor, U.S. firms often find it difficult to conduct technology transfer to China. Thus, decision on the type and level of technology to be transferred is extremely important.

Appropriate technology is not just something that can to be transferred bodily from one country to another, it must be appropriate in terms of cultural and economic conditions, the costs, manpower, and resources availability. That is, in the present discussion, the technology to be transferred by the United States should be best suited to China's cultural and economic conditions, social and political environment, and with low cost hardware, low maintenance and service requirement, available manpower and natural resources, and be widely adaptive. Only with this in mind, can the transferor has a better understanding of the appropriate technology to be transferred.
To ensure the success of technology transfer, one of the important considerations from the transferor is the provision of service and information. The higher the level of technology to be transferred, the greater the need for information and service support to be under consideration. Thus, people of the recipient country have to be trained to understand and use all information and service in a proper way. Training is an indispensable link to successful transfer of technology because "technology transfer involves learning and learning can be improved by appropriate training". Training may take various forms depending on the qualifications required for the job, the type of industry, and the level of the ability of the work force. For instance, the ability to absorb production process related technology is closely related to the ability to absorb required institutional technology. Among plant management, it is necessary to provide on-the-job training for production workers and clerical staff so as to improve the adaptability of rank-and-file workers to modern manufacturing production process. At beginning, most of the U. S. firms approached the China market with the intend to sell equipment and plants as pure products, but they finally found out that it is impossible for them to get access to the China market without providing technical training, services and information support. IBM has been very successful in selling computers to China. The success is largely due to the training program IBM specially designed for China on the use of computers.

3. Absorptive Capacity

Another important consideration in technology transfer is the ability to absorb technology. From 1980 to 1982, China had slowed down the technology transfer from abroad, which indicates that China's absorptive capacity for new technology appears to pose a serious problem in its economic development.

For centuries, China's economy has been predominantly agriculture. Since the founding of the People's Republic of China, the country has adapted the Soviet economic
development model, with all of its efforts on the development of heavy industry, which resulted in an unbalanced development of the national economy. There exists a severe gap between the present industrial base and the advanced technology being transferred. However, the existing level of industrialization has been neglected by many Chinese officials during their work of technology transfer, resulting in a major drain on hard currency, as well as the equipment and plants remaining idle. To improve the work of technology transfer, Chinese government officials had repeatedly underlined the problems existed in technology transfer and made a series of policy changes and adjustments. However, the key point is to improve the technology structure and the level of environment so that the technology transferred are appropriate and adaptable. Therefore, efficient technology transfer not only depends upon the policy changes or adjustments on the problems of the transfer itself, but also to a large extent upon a whole array of supportive and facilitating systems in the environment of the recipient country.  

4. Barriers to Technology Transfer

A country’s absorptive capability of new technology is “largely a function of barriers to technology transfer”. There are many factors that may cause problems in technology transfer, such as culture, education, government, resources, geography, and infrastructure. For China, the most likely barriers to technology transfer are education, energy resources and infrastructure.

a) Education

The availability of manpower is an important factor determining the ability to absorb new technology being transferred. If a country does not have enough human resources with relevant educational background like engineering specialities, management and business administration which are necessary in assimilating and diffusing new technology,
the transfer would be inefficient or even a failure.

In China, the rate of population receiving education and the level of education are comparatively low, though large scale of movements have been made to popularize and improve educational since the founding of the People's Republic of China. It is estimated that only 70 to 80 percent of the country's workers have acquired a junior middle-school-level education in 1979, two-third of the workers have only attained the rank of second- or third-grade workers (in China, workers are divided into eight grades according to the skill levels, with the eighth grade being the highest); and only 3 percent of the labor force were employed as technicians/engineers. Except for the quality of education, the structure of educational system is irrational and incomplete due to the serious damage during the years of the Cultural Revolution. There are too few colleges and vocational schools. By 1982 the rate of secondary school students going on to college was 10 percent. There were only 11.4 college students to every ten thousand people. Because of insufficient number of vocational schools and the small number of middle school students entering colleges, many young people do not have the opportunity to receive necessary training to enable them to do their work properly, less talking about absorbing new technology from abroad.

New technology and advanced machinery and plants requires highly skilled professionals to operate and maintain. To relax the manpower constraints on technology transfer, the main way, as suggested by Charles T. Stewart, Jr., "is to increase the number and/or quality of graduates", "because the ability to absorb new technology in human resources is created mainly by a country's educational system". The Chinese government officials have adopted a series of measures An example is diversified forms of higher learning through radio, TV, correspondence classes and evening colleges. There are also on-the-job training classes in factories, colleges for training managerial personnel, and education centers for adults. However, reconstruction and rehabilitation of the
educational system takes a considerable time, so there are still a great shortage of skill manpower. To meet the urgent needs of the modernization program, China has sent a large number of students and exchange scholars to the United States, Japan and other industrialized nations to absorb advanced technical and scientific, and managerial knowledge in as many fields as possible.

b) Energy Resources

The most obvious barrier to technology transfer to China is related to the energy resources availability. With the progress of science and technology, energy is playing a more and more important role in a nation's economic development. China's energy industry has grown rapidly over the past decades. In absolute terms, China is one of the world's largest producers of energy. Its coal output is greater than any country except the United States. Its oil production was fifth or sixth highest in the world in 1985. In per capita terms, however, China's performance is much less impressive. For example, per capita consumption of electricity in 1985 was only about 400 kwh. Despite massive development in energy industry, China has been facing serious chronic energy shortage due to the result of poor management, out-of-date equipment and know-how, and inappropriate usage patterns that had led to energy waste.

Coal has been China's dominant source of primary energy. Almost two-thirds of China's industrial fuels come from coal. China, with the outdated techniques, has been encountering great difficulties in increasing its coal production capacity. China has negotiated with foreign investors over the development of China's coal deposits. The largest project is a joint venture with Occidental Petroleum Company on the open-cast coal mine at Pingshuo in Shanxi Province. China has rich natural resources, the problem is how to tap the resources from ground efficiently so as to meet the increasing needs of the economic development. Therefore, there is an urgent need to improve mining technology.
and modernize mining equipment with the help of foreign technology. More attention should be given to the development of coal industry because of the fact that most of China's industries will continue to rely on coal in the years ahead.

Petroleum production is also not as high as expected. Since the opening policy China have been making great efforts seeking technological cooperation with the Western countries, especially with the United States in both onshore and offshore oil exploration as a quick way to solve its problem of energy shortage. For instance, to upgrade China's drilling capabilities, China has purchased drilling rigs, and new plants to manufacture oil drilling and field equipment from the United States, and contract with international firms for training. However, these efforts will not produce immediate results great enough to meet all of China's energy needs for its economic development.

The main energy shortage China has been facing is electric power. Power shortage exists not only in industrial sectors, but also in residential areas. With foreign technology and capital, China has been building nuclear power plants such as the Daya Bay Nuclear Power Station in Guangdong, a joint venture project with France; and has already built large-sized hydropower stations such as the Three Gorges Dam on the Yangze River. As a result, growth of electricity production is dramatic, the power constraint has been released to some extent. However, increased demand of industrialization will result in continued shortage of energy in the near future.

An equally important cause of the energy shortage results from large-scale waste by the inefficient factories and vehicles. According to the World Bank estimates, China's energy consumption per unit of output is three times of that of Japan. Even China's large and advanced factories tend to be energy inefficient in comparison to the industrialized nations. Recognizing this problem, Chinese policy-makers have put great emphasis on the energy conservation and improving efficiency.

Nowadays, most technology to be transferred is energy-intensive. If the technology
China selects to be transferred requires the energy that is beyond China's availability, then the transfer is a failure. The fact that many of China's large steel facilities have been greatly underutilized in recent years resulted from energy shortage. For example, the mill imported by one of China's largest iron and steel complex, Wuhan Iron and Steel Mill Complex, only operates at half of its production capacity partly due to the power supply shortage. During the feasibility study period, neither the transferor nor the receiver had considered the problem of energy supply, the problem was discovered only after the mill was put into operation. What is worse is that some of the imported modern production facilities have been remaining idle and are good as high-priced showpieces due to their feature of high energy consumption.  

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c) Infrastructure

Infrastructure is a country's "necessary institutional makeup as well as the necessary physical conditions for technology transfer." The development of infrastructure is an integral part of the progress in industrialization. It plays an indispensable role in the economy development of the nation. If a country is willing to import satellite telecommunications equipment, but doesn't have the necessary institutional structure to generate and disaggregate the information supporting the technology to be transferred, the transfer of such technology would not be realized.

China's infrastructure is backward. China has realized the need to improve its transportation, and post and telecommunication services before China can adequately absorb substantial levels of new technology. The development of transportation has been neglected. As a result, the transport capacity lagged far behind other sectors of the national economy. Now the transport capacity of a number of major trunk lines can meet only about 70 percent of the aggregate demand. The limited capacity of transportation have resulted in inefficient handling of large quantity of goods, and made timely loading and
unloading of imports and exports impossible.\textsuperscript{30}

China's transportation structure is rather irrational. In the past, all emphasis is on the development of rail transport, while the development of road, sea, river and air transport was neglected. This creates a transport pattern in which railways were consistently overloaded while the potential for other modes of transport was largely ignored. To meet the increasing needs of the economic development, a plan should be made to develop all the modes of transport at the same time.\textsuperscript{31}

As important as transportation, telecommunications also plays an indispensable role in technology transfer. As recognized by Chinese economists, "with electronic computer coming into wide use in recent years, information has become an important factor second only to materials and energy".\textsuperscript{32} Speedy, accurate and timely transmissions of large amounts of information can greatly facilitate technology transfer. Since reform, international telecommunication service has been greatly expanded. The outdated short-wave communication has been replaced by satellite communications. However, the telecommunications service still remains a weak link in the nation's economy. The communications capacity is still limited, and therefore can not meet the aggregate demands; the equipment and circuits in use are not only small in quality, but also backward in technology.\textsuperscript{33} The above-mentioned situation has caused an unfavorable condition for efficient technology transfer.

5. The Receiver

Each recipient country has different needs for new technology. To determine if the technology to be transferred is appropriate or not, the Chinese government has set certain standards. The technology to be transferred should be able to maximize China's export capabilities, be useful for generating foreign exchange, and improve China's scientific and technological level. Furthermore, the technology to be transferred should
be accompanied with training and service, and use Chinese raw materials and parts if possible.\textsuperscript{34}

\section*{B China's Need For Technology}

China already has substantial technological capability compared with that of the other developing countries, especially in military sector and area of sophisticated technology.\textsuperscript{35} For example, the successful launching of AsiaSat-1 this April has proved China's enormous technological capabilities in sophisticated technology. China has not only built and launched its own experimental communication satellites, but also has offered to launch foreign satellites. However, the technological development is rather unbalanced. This is evidenced by the fact that technological progress in China's civilian sector is rather slow. Much of China's civilian technology is outdated, or even obsolete. Beginning from the early 1980s, with the new direction of China's economic development strategy, China has shifted its development stress to civilian sector. The nation's Sixth Five-Year Plan (1981-85) clearly pointed out that one way to develop the national economy is to rely on foreign capital and technology. This point is further stressed in the Seventh Five-Year Plan (1986-90) which has set the acquisition of technology as a high priority, especially in areas of transportation, electronics and computers, telecommunications, and energy.\textsuperscript{36} Recently, Chinese government officials have repeatedly underlined the technology transfer issue as important to the nation's economic development and more funds will be located and greater efforts be put in the introduction of modern technology. There is no doubt that China could develop some of the technologies independently, but the progress would be much slower and development much less efficient than acquiring them directly from the technologically advanced nations. The road to modernization would therefore be slow and costly.
China's mission to transform the country from a predominantly rural to an industrialized nation within more than two decades is not an easy task. China's officials have recognized that technology transfer is a shortcut to accomplish its modernization goals. Technology transfer can not only help China to increase its production capability, but also bring about modern managerial skills which has been an obstacle to technology absorptive capability in China. China's modernization program requires a wide range of capital equipment importation and technological introduction from the advanced nations. The United States is one of the main suppliers. In areas such as offshore exploration and development, computers, aircraft, construction, and management, the U.S. firms have a competitive advantage. The most successful areas of U.S. technology transfer to China in the early 1980s has been in petroleum exploration, drilling, and production equipment.

China's "open door" policy is closely linked to the nation's economic reforms and is intended to facilitate technology transfer and international trade. Under this policy, Special Economic Zones and coastal cities have been opened to foreign investment, and joint ventures, and cooperative manufacturing have been encouraged. Now "Learning from other countries" will no longer be criticized, instead, it has often been encouraged.

C  U.S. Government Policy

After twenty-two years of hostility that divided the U.S. and China, Sino-American trade has grown rapidly, jumping from few million dollars before 1972 to $16.9 billion up to 1982 with the issuance of Shanghai Communiqué by President Richard M. Nixon and Premier Zhou Enlai in 1972. By 1979, with the normalization of the U.S. - China diplomatic relations, U.S. has loosened export controls on technology and equipment transfer to China, particularly for items of civilian use, and widened the scope of science and technology exchange so as to encourage the American businessmen to have more
involvement in China's modernization drive. Generally speaking, the U.S. government policy has been in support of technology transfer to China. Normalization of relations and the continued extension of the favorable tariff of the most-favored-nation status to China have made American firms to be able to compete with foreign suppliers from the equal position. However, the conditions attached to this extension, i.e. the export of components and spare parts for the telecommunications satellite will be greatly reduced, are likely to retard China's progress in sophisticated science and technology.

The United States and China have quite different political and economic systems. While they may share mutual interests in some areas, they have disagreement in other areas. The most sensitive issues between the U.S. and China are those related to the transfer of high technology. When transferring technology to China, especially the due-use technology, the major strategic concern for Washington is that China might use the technology supplied by the United States against the U.S. interest and/or against the interests of other countries who are friendly to the U.S. when China's military capabilities become strong. Another concern is from business point of view. There is no doubt that it would not be long when China become a newly industrialized country and may then compete with the United States in a number of industries.39

During the early period of China's modernization program, the U.S. government practiced a tight control policy on issues of technology transfer to China. The U.S. Department of Commerce controls technology transfer through the Commodity Control List which is a 800-page book containing items of products and technologies marked for control. The Defense Department also has its own technology control list called the Military Critical Technologies List.40 Recently, however, there have been almost continuous debates over the export control policy to China among the U.S. government officials as well as the executive agencies. While the Department of Defense supports the export control policy in practice, the Department of Commerce stresses the importance and
benefits to the U.S. on expanding export control to China. The United States has strong economic reason to loosen its export control to China. The U.S. has been losing its export competitiveness to Japan and Germany in a number of industries, but remains strong in high technology items such as computers, aircraft and telecommunication equipment, and these are the kinds of technologies China mostly needs from the United States for its modernization program. So, to help to solve its balance of payments problem, it is necessary and beneficial to promote transfer of high technology to China.\textsuperscript{41} Recognizing the benefits the U.S. could get, in 1983 the U.S. government revised its export regulations. The policy change shifted China's trade status to a "friendly, nonaligned country" so as to "encourage American businessmen to participate fully in the China market while retaining controls on truly sensitive technology".\textsuperscript{42}

From 1986, more important changes have occurred in the U.S. export policy to China. 30 items under the control list were expanded to "green zone" for export. The license review process for export which are considered to be less sensitive from a military perspective has been simplified. Another significant development in U.S. export control policy was the decision to permit exports to China on a case-by-case basis of items on the Munition Control List.\textsuperscript{43}

Apart from U.S. export control policy, the export promotion policy also plays an important role in affecting technology transfer to China. China's regulations on foreign business and investment make it difficult and costly for foreign investors to set up business there. The difficulty of dealing with the complex Chinese bureaucracy pose another obstacle to technology transfer to China. These problems have affected all exporters to China, not just the United States. However, confronting with these problems, Japanese corporations have invested considerable resources, and the government have provided large amount of official financing to support China trade. Japan is now China's number one aid donor, and the Japanese firms have greatly benefited from their business with China. On
the contrary, the United States has no formal aid program for China. Official financing through the Export-Import Bank has been rather limited.44

Despite many problems existing on the issues of technology transfer between the United States and China, U.S. - China economic relations have been in good terms. Over the past decade, China has made remarkable economic progress, and the United States has clearly made some contributions to the growth and development in China.

III TECHNOLOGY TRANSFER MECHANISM

Since the late 1970s, the Chinese government has increasingly come to realize the importance of technology transfer from abroad. The use of Western technology as a complement to the technology required for China's national economic development is an important aspect of China's modernization program. It is obvious that a country can only develop its economy to a limited extent by relying on its own technology, but transfer of appropriate technology from technologically advanced nations is an effective measure to achieve its economic and technological progress. The Japanese and the newly emerged industrial nations' experience have proved that their national economic development have been benefited from proper use of foreign technology. Over the past decade, China has been making great efforts to promote technology transfer. Various channels have been opened for technology inflow; a series of institutional changes have been adopted to create necessary legislative environment for foreign business operations.

A Channels For Technology Inflow

There are various forms of technology transfer. They include complete-plant import, licensing of patents and know-how, compensation trade, counter-trade, and contribution
of technology to joint ventures. Before 1980s, the major form of technology transfer to China is through complete-plant import. But China's past experience suggests that the transfer of technology and know-how will sometimes be more beneficial than just buying the hardware in terms of saving foreign exchange and future development. Prior to 1978 the import of 'pure' technology (i.e. in the form of licences) to China only made up to 2.3% of total its imports, and import of equipment 90%. However, in 1984 the former rose to 59.9% and the latter fell to 40.1%.45

The variation of the forms of technology transfer partly depends on the type and the level of technology to be transferred.

1. Complete-Plant Import

In the early 1950s, the predominant form of technology transfer China adapted was the complete plant import. The transfer were mainly Soviet-aided projects. Following the Sino-Soviet split, China's imports of machinery and plant dropped brutally. It was not until 1978 that imports of equipment and plant rose sharply. According to the U.S. government estimates, the 1987 purchasing of equipment and plant "skyrocketed to an unprecedented level totalling $6.787 billion (and possibly more)".46 The advantage of this form of technology transfer is obvious. The importer can get access to the new technology quicker under the supervision of the transferor, and thus save time. However, beginning from late 1979, disadvantages of relying on complete-plant import have emerged. First, the cost is too high. This is due to the nature of China's system of planning and management prior to the reform. To reach the quantitative-output targets, the easiest and the most "efficient" way for enterprises was to import complete-plants. Since the state has been responsible for any profit or loss, the cost of importing complete-plants were never taken into consideration. Secondly, and the most important of all, is the problem China has in its ability to absorb new technology. Though the transferor will make trial runs and
show the importer how to operate the plant until the importer is able to take over, however, the importer may not be able to absorb the new technology thoroughly, therefore, when problems occur with the imported package later, they may not be able to handle them.47

To improve this form of technology transfer, it is suggested that a number of features or ingredients be added to the complete-plant package. For instance, the technical service and maintenance can be extended beyond the start-up stage. The extended service may enable the Chinese to meet various contingencies long after the complete-plant has been set up. In recent years, China has set up many service centers for a number of foreign suppliers with products ranging from machinery to watches.48 For example, China National Technical Import & Export Corporation, the largest complete plant import and export company in China, has set up a large number of service centers and warehouses for the equipment and plant imported in different industries, which has greatly facilitated this form of technology transfer to China.

2. Joint Venture

The 1979 National People's Congress enacted a law permitting the setting up of enterprise to be owned jointly by the Chinese and foreign capital. Joint venture includes equity joint venture and contractual joint venture. The closest cooperation between China and foreign investors is usually in the form of equity joint venture which is governed under the Law of Joint Ventures Using Chinese and Foreign Investment. The law stipulates that foreign partnerships, companies of other entities must make a minimum of 25 percent capital investment in a joint enterprise and sets no maximum limit on the capital holdings. Investment of less than 25 percent will be permitted under the conditions that advanced technology is involved.49 Regarding the issue of joint venture, the Chinese government has a strong desire to utilize foreign capital to produce more goods for export. Therefore, joint ventures would be welcomed in only a few sectors of the economy which can produce
quick results. This is stated in the following principles for the use of foreign capital in China by Bu Ming, former President of the Bank of China:

"Foreign capital should be used for the development of agriculture, light industry and heavy industry, in that order of precedence. It should be used to strengthen the weak links and national priority should be given to medium or small size export-oriented projects which yield returns in a short time with very little investment. Financing should be given to tap the production potential old factories rather than building new factories".  

Over times, however, the set order of precedence is no longer applicable. Almost all of China's provinces have launched local promotional policies to attract foreign investment. Investment are welcomed in every sector of the economy, from Sheraton Hotel in Shanghai to offshore oil fields in the South China Sea, from Pepsi-Cola bottling plants in Shenzhen to automobile manufacturing in Beijing. Up to the mid-1980s, about 100 joint ventures had been concluded in China, of which about 35 are in the four Special Economic Zones in Guangdong and Fujian. Over 100 of these ventures involve investment by the U.S. companies with total equity investment of about $150 million. These enterprises, with foreign investment accounting for a minimum of 25% to a maximum of 40% of the total capital, are distributed in about 15 provinces, municipalities and autonomous regions, and are engaged in various industrial sectors - machine-building, electrical appliances, pharmaceuticals, textiles, food-processing, animal-breeding, tourism, computer, and oil-rig services.

An important advantage of joint venture is that is can bring about continuous flow of technology and management expertise from the foreign party. In order to attract foreign investment and encourage technology transfer to China, a great degree of autonomy is
allowed in joint ventures. In a statement at the China Investment Promotion Meeting, in June 1982, Wei Yuming, China's Vice Minister of the Foreign Economic Relations and Trade, spelled out the rights of joint ventures which include: 

(1) the rights of joint ventures to decide on their own development program, production management plan and labor-wages plan; (2) the rights to buy inputs directly from the domestic and international markets; (3) the rights to sign various economic contracts with domestic and foreign companies and enterprises; (4) the rights to raise RMB (Chinese currency) and foreign currency funds from internal and external financial institutions; (5) the right to establish their own financial management and other management systems, and to determine their own profit distribution program; (6) the rights to hire and fire employees and to adopt the system of pay scale, wage-form, bonus, and allowance appropriate to themselves for rewarding and punishing employees. Therefore, joint venture enterprises enjoy more privilege and have more autonomy than other Chinese enterprises. Recently, under the encouragement of the Chinese government more and more joint ventures are being established.

3. Joint Operation

Under this form of technology transfer, all the enterprises are run jointly by domestic and foreign partners with the foreign partners' cooperation limited only to production and operation. Sites and housing are usually provided by the Chinese side while the foreign partner supplies the equipment, technological know-how, and personnel for training Chinese workers. For example, the contract between Bell Helicopter and China to produce twin-engine helicopters is this type of arrangement. There is no equity investment on the part of Bell helicopter. A substantial portion of the technology transfer involves the training of the Chinese management and engineers in Bell Helicopter's Fort Worth, Texas branch. Some Bell Helicopter managers and engineers are also sent to train Chinese
personnel in Harbin, China.  

Other forms of economic cooperations under joint operation include assembly and material processing. Under assembly, the foreign investor provides all raw materials and equipment, while the Chinese side supplies the labor force. In some cases, it is necessary that foreign investor provide personnel to train the Chinese workers. The Chinese side will be engaged in production according to quality and specification as required by the foreign investor and will deliver the finished products for them to sell. Majority of this type of enterprises are in China's coastal cities where they have large skilled labor force and have easy access to overseas market.

4. Compensation Trade

As defined by Zhang Yennain, Deputy managing Director of the Bank of China, Beijing/London, the concept of compensation trade is:

"Foreign companies or institutions will be invited to provide technology, equipment and essential capital goods with which our enterprises will exploit mineral resources, develop the production of agriculture, forestry, animal husbandry, fishing, light industry or other industries. Output of the above sectors will be used to re-pay imports value of technology and equipment by foreign suppliers".  

This is the kind of economic arrangement where payment for Chinese purchasing of foreign equipment and technology will be made in the form of products of the supplied equipment and technology. One of the early projects in the form of compensation trade is the Beijing Xuanwu Radio Components Factory for manufacture of carbon-film resistors. Capital and equipment were provided by the foreign partner, while the Chinese side provided the factory and fuel. The capital cost of the equipment and interest would be paid
off within three years from the date of operation with money earned from the processing.\textsuperscript{57}

Compensation trade is an especially popular form of technology transfer in Chinese coastal cities where transportation arrangement is much more convenient than in the other parts of China. Compensation trade ranges from oil exploration and coal mining to the assembly of calculators, cassette recorders and televisions. China's technology transfer policy has been in support of compensation trade. The advantages are obvious, "jobs are provided, skills acquired, management experience gained, and at the end China is left with a paid-up factory or enterprise".\textsuperscript{58} Another major attraction is that the payments made in the form of products to foreign investors are generally exempted from tax in China.\textsuperscript{59}

5. Licensing

Of the various types of technology transfer, licensing is probably the most flexible form. With more and more emphasis being put on the transfer of advanced technology by the Chinese government, licensing is becoming increasingly a common practice.

Technology licensing may include patent, know-how, technical assistance, trade mark and copyright, and other softwares. Typically, under this form of technology transfer, the licensor would receive an initial fee for the technology and know-how supplied, and then regular payments thereafter for licensee's continued use of the technology. In some cases, the fees and royalties are paid in a lump-sum.\textsuperscript{60}

In addition to the "pure" technology licensing, China is also interested in combining licensing with sales of equipment and plant, and with joint operation type of technology transfer. In this case, technology recipient country has a wider choice and more opportunity to accommodate its own needs. McDonnell Douglass MD-82 commercial aircraft coproduction is an example. In 1985, McDonnell Douglass and Shanghai Aviation Industrial Corporation (SAIC) signed a $1 billion contract for coproduction of 25 MD-82 twin-jet transports. This is the largest technology transfer project concluded since China's
"open door" policy. The contract will take ten years to implement.  

However, like other forms of technology transfer, technology licensing also has its own problems. The most frequently occurred problem is the one relating to the technical documentation the licensor is expected to deliver. The Chinese licensee expects the foreign licensor to provide all technical documentation concerning the technology and know-how transferred, while some of the documentations the licensor usually does not supply to the licensee.

Despite the problems, technology licensing is preferred by the Chinese government and welcomed by the enterprises over the complete plant and equipment import. In the form of licensing, technology transfer requires less foreign exchange, so it saves money, and thus, is easier to get approval from the authorities concerned. Another benefit is that local entities whose purchases are usually financed by the Bank of China may obtain their licensing permits independently and thus may get international financing at below-market rates.

B Institutional Framework

With the development of the nationwide reform, China's economy has been facing the need for changes in the institutional framework. In order to facilitate technology transfer to China, the Chinese government has adopted institutional changes which include decentralization of its decision making power, the establishment of the Special Economic Zones and financial institutions such as China Investment Bank, China International Trust and Investment Corporation (CITIC) for inducing and facilitating foreign capital and investment in China.

In the past all foreign trade activities were conducted through national foreign trade corporation (FTC) under the direction of the Ministry of Foreign Economic Relations and
Trade (MOFERT). With the government's decision to expand foreign trade, changes have been made to the structure and management of foreign trade.

1. The Decision-Making System

China's past experience suggest that its decision-making system has been one of the major obstacles to the transfer of foreign technology. The process of choosing, importing and assimilating technology has been much influenced by the lack of coordination among various levels of decision-making institutions.\textsuperscript{65} For instance, some new technologies transferred by state enterprises are imported again by local enterprises, or even enterprises in the same regions. In order to prevent the phenomenon of duplicative import, in 1985 the State Council set up the Department for Technology Introduction so as to coordinate the technology introduction departments at various decision-making levels.

The most important decision making organizations for technology decision-making in the central government level are the State Planning Commission (SPC), the State Economic Commission, the Ministry of Economic Relations and Trade (MOFERT) and the State Science and Technology Commission (SSTC). The decision-making procedures vary according to the size of the project and the type of control over the project. If the project, for instance, exceeds $5 million, it must be submitted to the SPC for approval. The decision-making also varies according to the form of technology being transferred. Decision-making concerning joint venture, for instance, will involve different procedures and regulations from those involving licensing.\textsuperscript{66}

MOFERT is the central administrative agency for foreign trade. The main responsibility is to coordinate all the foreign trade activities of the industrial ministries and local administrations. The agency makes national foreign trade plans and provides policy advice on China's needs for certain technology, and ensures that technologies transferred by the industrial ministries, local administrations are consistent with the national
development priorities. MOFERT is the cooperating partner with the U.S. Trade and Development Program. It plays a major role in the technology transfer in China.

The decision making system in China is very complex. Sometimes it does not work the way it is designated to be. As Frankenstein and Chao remarked in their survey that "of all the mysteries of the China trade, none appears more obscure than the Chinese decision-making process", and that "decision-making is colored by both administrative and personal interests". Despite the government's efforts to revise policies and establish institutions for technology transfer, serious problems still remain. After the decentralization of decision-making on technology imports was implemented, more autonomy is given to the local authorities in their decision-making on technology imports. While the decentralization results in more efficiency in conducting technology transfer, it also creates some problems, such as inappropriate import decision-making and high cost import. However, for China, it is not easy to find an effective institutional formula due to the fact that China's present economic system is a mixed one - traditional Soviet-type central planning and the market socialism. This mixed economic system may persists over a lengthy period. Nevertheless, China has made impressive progress in its institutional reform.

2. Foreign Trade Corporations (FTCs)

The foreign trade corporations are the national import/export corporation organized according to industrial sectors. They have monopoly over imports and exports of particular categories of goods. Their basic responsibility is to carry out foreign trade business under the direction of the Ministry of Foreign Economic Relations and Trade. FTCs are responsible to make detailed import and export plans, conduct negotiations, draft and sign contracts, and represent China's producers and endusers. All FTCs' head offices are located in Beijing, they have a number of branches offices in certain foreign trade
concentrated regions. Since 1979, under the policy of decentralization in foreign trade FTCs' branch offices have been given great autonomy in conducting foreign business. In addition to the FTCs at the national level, foreign trade corporations and import/export commissions have been set up at the provincial and municipal levels to trade directly with foreign exporters and investors. The policy change has facilitated technology transfer to China in terms of efficiency.

3. Financial System

Until the time of economic reform since 1979 China's financial institutions had been under the system of central planning and unified management, it was hard for banks to play their financial role. Before the reform, all the financial transactions concerning foreign trade activities are administered by the Bank of China under the direction of the People's Bank of China. In order to meet the growing volume of foreign trade, reform was made to the banking system. In 1979, the Bank of China was designated as the specialized foreign exchange bank under the direct leadership of the State Council. Its main responsibility is to organize, utilize, accumulate, and manage foreign exchange, and its business scope includes raising funds to finance state projects, making loans and deposits with international financial institutions, and entering into joint ventures with overseas banks and companies. For example, in the early 1980, the Bank of China formed a financial company with the First National Bank of Chicago and the Industrial Bank of Japan. Each of the three partners contributed 30 percent. The remaining 10 percent is held by Hwa Yun Company, a Chinese foreign trade institution in Hong Kong. The number of China's financial institutions allowed to conduct foreign business are growing rapidly. Other financial institutions like investment banks which have been formed between Western commercial banks and Chinese companies have been playing an
active role in foreign business. They are particularly helpful in financing joint ventures. China Investment Bank is the one designated for financing construction projects from abroad and handling foreign exchange investment credits. The People's Insurance Company of China (PICC) is responsible for various insurance operations. Its branches, the insurance company of China and the Pacific Insurance Company are specialized in insuring foreigners' business and trade transportations. Among financial institutions of increasing importance is the China International Trust and Investment Corporation (CITIC).

CITIC was established in 1979 with the authorization of the State Council. The main objective in establishing CITIC is to promote foreign investment in China. Over the past decade, CITIC has been making every efforts to contact foreign investors, raise fund, and bring in up-to-date technology and equipment to form joint ventures and other form of economic cooperation in China. One of the projects CITIC concluded in the early 1980s is the formation of the China Oriental Leasing Co. - a project involving the Japanese Oriental Leasing Company, China National Technical Import and Export Corporation and CITIC itself, which is the first leasing agency in China. It is also engaged in raising loans abroad so as to finance domestic enterprises.

4. Special Economic Zones

Perhaps the most radical measure China has adopted since its "open door" policy is the permission of foreign direct investment in China and, in particular, the establishment of the Special Economic Zones (SEZ). The SEZs are designed for the purpose of attracting foreign investment, stimulate technology transfer, facilitate exporting to the developed nations. The regions which have been designated as SEZs are along China's Southeast coast. They include Shenzhen, Zhuhai, Shantou, Xiamen, and the recently established Hainan. In these SEZs, foreign investors enjoy more preferential treatment than elsewhere.
in China, such as ungraded infrastructure facilities, favorable customs regulations, low rates of corporation tax, or even tax exemptions in some cases, low land rents, and flexible administrative procedures.72

The concept of SEZs is similar to that of the "Foreign Trade Zones" or "Free Trade Zones" in Taiwan, South Korea, and other developing countries. But China's SEZs are unique in its additional responsibilities which are well described by Harry Harding:

"They are bridges linking China to Hong Kong and Macao, and through them to the rest of the world; laboratoritories in which new management techniques and economic policies can be tested before being adopted in the rest of China; filters that can screen out those aspects of foreign technology and culture that are not considered appropriate for Chinese needs; ..".73

Beginning in late 1980s, as a further step in the process of "opening to the outside world", more costal cities were opened. The costal cities along with the Special Economic Zones have played a special role in China's economic development and technological progress. For example, since 1983 Guangdong Province alone has imported over 33,000 sets of various equipment and plants, and used foreign capital in more than 188 projects.74 By now, the province is already exporting one-fourth of its gross product and receiving one-fourth of its capital investments abroad.75 The performance of the SEZs and open cities not only have contributed to the technological progress in China, but also have served as "living laboratories for new managerial and economic systems and as classrooms where managers from other parts of China could learn the way of international business".76

C Legal Framework
Until the time of reform in 1979, China did not have any laws governing international business transactions. The following statement by Philip Wik well described Chinese legal status prior to the reform:

"China's legal system is a combination of native concepts, civil and common law, and communist theory. It evolved over a millennia, uninfluenced by foreign jurisprudence. China's legal tradition is the largest of any enduring community. In the early years of the People's Republic, it experimented, with varying degrees of commitment and intensity, with a Soviet-style legal system". 77

However, significant changes have been made in this respect since 1979. To induce and protect foreign investment in China, the Second Session of the Fifth National People's Congress passed the Law of the People's Republic of China on the Joint Venture Using Chinese and Foreign Investment (JVL) in July 1979. The law states that "the Chinese government will protect, by the legislation in force, the resources invested by a foreign participant in a joint venture, the profit due him pursuant to the agreement, contracts and articles of association authorized by the Chinese government as well as his other lawful rights and interests", 78 and "a joint venture equipped with up-to-date technology by world standards may apply for a reduction of or exemption from income tax for the first two to three profit making years". 79 The promulgation of the JVL shows that the Chinese government have great concern over the technology transfer through the form of joint ventures. Following the Joint Venture Law, more than one hundred laws and regulations have been promulgated to improve upon the 1979 statute, reflecting the feedback and experience of the Chinese and foreign parties. 80

China has taken an important step in its effort to develop a tax system so that its tax system is consistent with international tax principles and practices. On September 10,
1980, the Income Tax Law of the People's Republic of China Concerning Joint Venture with Chinese and foreign Investment was enacted. China's efforts to improve its tax system are also reflected in the tax treaties concluded with a growing number of countries concerning the avoidance of double taxation.81

During 1985, Laws pertaining to foreign investment such as corporation laws, patent laws, and a copyright law, standard accounting procedures, and a foreign economic contract law are adopted subsequently. Of these laws the Patent law has been well received both domestically and abroad. According to official statistics, China's Patent Office handled more than 63,000 applications for patent registration between April, 1985 and February, 1988, of which 14,700 were from abroad. The applicants from the United States account for 28.4 percent. By April, 1988 more than 12,200 patents had been granted to Chinese and foreign applicants.82

At the same time, the State Council promulgated a series of laws to establish procedures for the negotiation and approval of licensing agreement. The regulations of the People's Republic of China on Technology Import Contract Administration and the Approval of Technology Import Contracts are another step in China's efforts to attract technology transfer and reassure potential licensor that transferred technology will be protected. The new laws require that technology to be transferred must be advanced and appropriate, can develop and produce new products; improve product quality; lower production costs and save energy or materials; increase export and foreign exchange earnings; further the full utilization China's natural resources; benefit environmental protection; improve production safety; further the improvement of managerial skills; and assist in raising the level of science and technology.83 The new law ensures foreign licensors that the technology transferred will not be diffused within China and/or passed to other parties outside China by setting a maximum period of ten years for licensing agreements with exceptions considered on a case-by-case basis.84
Up to now, China's legal system is still incomplete. There are still many complaints from foreign businessmen, such as, the provisions in China's law and regulations concerning technology transfer are simple and ambiguous, which can not accommodate the needs of the increasing diverse and complicated technology transfer agreements. Therefore, to induce more foreign investment and stimulate technology transfer, China still needs to continue its efforts to improve the legislative environment for business operation in China.

IV ISSUE OF ASSIMILATION AND DIFFUSION

According to OTA study of 1987, acquiring technology is only half of China's problem in the process of technology transfer, another half exists in China's ability to assimilate and diffuse the technology acquired. China overlooked this respect in its past practice. As a result, quite a number of advanced technologies transferred have been remaining idle or at the stage of laboratory experiment.

China's past experience suggests that many factors may affect effective assimilation and diffusion. These factors include the irrational economic structure, unqualified technical personnel, inadequate R&D resources, and unavailability of necessary funds. To effectively assimilate and diffuse the technology transferred, as proposed by some Chinese economists, China must reform its economic infrastructure and the system of science and technology, readjust economic policies, solve the problems of fund and personnel, and encourage enterprises to conduct technical reform and make technological progress.

This section, while analyzing the current problems of assimilation and diffusion, will also discuss the strategy that the government has adopted for technological development.

A Technical Manpower
The first constraint China faces like many other developing countries in technology assimilation is the shortage of qualified technical and managerial personnel. The workforce in 1985 numbered 499 million out of a total population of over one billion, of which, 16.7 percent are in the industrial sector. Overall, there are about 2.4 million scientists. The figure seems large, but for China, a country with a population of more than one billion, the number of technical specialists is far from enough, especially when taking into account the quality and distribution of these technical personnel.

Most of China's technical personnel are strong in theory, but poor in practice. This is due to the deficiencies of the Chinese educational system which places too much emphasis on training narrow specialists. In addition, China's employment distribution system have caused serious manpower constraint. Most of China's technical personnel are concentrated in research institutes rather than in the production enterprises where skilled manpower are mostly needed for technology absorption. Traditionally, China's research institute has been separated from the production enterprise, so there has been a lack of close link between the two units. The rigidities on the mobility of technical personnel creates another obstacle to effective assimilation and diffusion. Enterprises and research institutes regard technical personnel as their own property, it is difficult, or even impossible for them to transfer from one units to another.

Recognizing the serious shortage of technical manpower, China has been making every efforts to solve the problem. One way is to expand its technical manpower ranks through its own new educational policies. And another way is to make full use of the educational and training opportunities offered abroad by institutions of higher education, companies, and foreign governments.

B Management
One of bottlenecks in China's work of technology transfer has been the relatively low level of the managerial skills. The problems is particularly acute in the field of industrial operation and high technology.

The problem of management expertise emerged during the second stage of technology transfer - digestion or assimilation after new technology being acquired. The problem is especially acute in Sino-foreign cooperative ventures where high level of interaction between workers and hardwares are required. These cooperative ventures, according to China Business Review of 1986, account for about 80 percent of the almost $9 million foreign investment in China at the end of 1984.\(^9\) Since the cooperative ventures not only provide China with capital equipment, but also bring about technology and know-how, so lack of management skills in the cooperative ventures will result in "enterprise where the task structure (technological subsystem) is out of synchronization with the management structure (social system)".\(^9\) Therefore, it is not surprising that some of the imported plants suffered start-up and subsequent productivity problems due to lack of management know-how, and that some of the joint ventures fail to reach a return on their investment due to shortage of qualified managers.

The problem existed in management is largely due to China's irrational educational and political systems. Universities and colleges are only focused to produce qualified personnel in science and technology, while neglect to train management personnel. Traditionally, the Chinese have prejudice against business. Management is not regarded as a science. However, recently, with the Chinese opening to the outside world, there has been evident changes of people's attitude toward business and management. More and more colleges and universities are expanding their curricula, offering business-related courses such as accounting, finance, and industrial management.\(^9\) With the increasing role of technology transfer in China's economic development, a critical challenge has been to educate and train a large number of qualified managerial personnel who would be able to
use up-to-date modern management techniques to achieve economic efficiency with limited resource. Over the past decade, the government have sent a large number of students and scholars to the United States and other advanced countries for absorbing modern management techniques, at the same time, new business schools and programs have been planned to offer Western-style management courses to high school graduates, as well as university students majoring management and business administrations. To help factory managers, government officials, and university educators understand Western-style management, several management training centers have been established in China. The one in Chendu is offered by the Canadian International Development Agency, and another one in Dalian, is jointly sponsored by the State Economic Commission, the State Science & Technology Commission and the Ministry of Education on the Chinese side, and by the Department of Commerce on the U.S. side. Their management training programs have been very successful in China.

Another reason for China to be short of qualified managers is due to the fact that the existing Chinese political system is not synchronizing with its economic reforms. There are too much political interference in enterprise activities. From top-down, ideology is regarded to be more important than skills. Based on socialist ideology and the practice of China's management system, the criterion for a manager has been loyalty to the party rather than skills or knowledge. In China, of the 11 ministries, every one owns an institute of management and administration for training its own cadres. However, none of these training institutes places emphasis on the training of their cadres' managerial skills, but on ideology. The government is well aware of the limitations of the present enterprise managers. Reform in management has been encouraged by policy changes such as reducing the party's role in the operation of enterprise, and providing greater incentive and flexibility in organizational design.
C Research And Development

A critical bottleneck obstructing China's technological advancement is the constraint of its research and development necessary for technology assimilation and diffusion.

It is obvious that the higher the R & D capability a country or an enterprise has, the more efficient it will be in the process of introducing, assimilating and diffusing new technology transferred.\textsuperscript{98} Compared to many developing countries, China has a comprehensive industrial structure and an extensive R & D network. Most of China's industrial sectors have their own research, design and educational institutes, and many of them had experience with technology transfer from the Soviet Union in the 1950s. This R & D system, however, was severely disrupted during the Cultural Revolution. Scientists were not properly employed, and development of research infrastructures was neglected. The situation became worse due to the fact that there is lack of close link between research institutes and production units.\textsuperscript{99}

The current reform in China's science and technology management system has been directed to change this situation. Some research institutes that used to be engaged in research under the national plans are now encouraged to do contract research, offer consulting services for production units. Some research institutes have been emerged into large production enterprises to create an even closer link to help them solve production problems.\textsuperscript{100} For example, Beijing Iron & Steel Research Institute who used to concentrate most of its efforts on the projects under the state plans are now actively engaged in pursuing contract research for local industries. The institute has helped a number of both state and local enterprises design and import equipment and plants. In 1988, the institute together with other research units and foreign trade corporation successfully made a transaction on steel plant import for Wuyang Steel Plant in Henan Province. The R & D helps to promote technology transfer not only through technology
introduction, but also technology assimilation by solving subsequent problems for endusers.

It should be noted that the availability of funds may be an important factor causes constraint on R & D. In China, funds provided for R & D are only once a year rather than periodically. Because of the limited funds, many technical innovation projects can not be carried out, some of the projects have to be stopped halfway. Recently, with the government's emphases on science and technology, more funds are available for R & D, and funds constraint has relieved to some extent. However, it remains a obstacle to effective technology transfer.

Another focal point related to R & D is the diffusion of new technology. As Chinese economists has noted that quite a number of advanced technologies transferred are unable to be put into use and/or to be popularized due to delay in the immediate or industrial experiment though these technologies are urgently needed by production enterprises. They suggest that one important way of diffusing technology is through transference within the country:

"... There is a big gap among advanced, middle and backward areas. .... Advanced areas are in an advantageous position to assimilate foreign technology because they have the necessary digesting and coordinating capacity. Such being the case, we may perhaps envisage the setting up of a network for spreading advanced technology in which foreign technology is first introduced into advanced areas and then transferred to middling and backward areas after it is duly digested, or rather, properly adapted to China's condition. By integrating introduction and transference into an organic whole, we will be able to make advanced technology to blossom throughout the country within the shortest possible time".
The strategy seems to be effective. Over the past few years, the advanced areas like the SEZs and some open coastal cities have played the role of frontiers in technology transfer. Almost all the central ministries and provinces have established their branch enterprises and representative offices in these areas, especially in Shenzhen, through which information, advanced technology and managerial skills are to be diffused into the interior China.

V SUGGESTIONS AND CONCLUSIONS

China's economic achievements over the past decade have proved that technology transfer is a short-cut to the progress of a nation's industrialization since it saves time and energy by sparing the trouble of having to start from scratch. China's modernization program has been closely related to technology transfer. There are numerous examples of successful technology transfer from industrialized countries to China. From U.S. firms, for example, American Motor Company and Commins Engine have successfully transferred automotive and diesel engine technology, Westinghouse and G.E. have transferred power generation technology successfully, and Boeing and McDonnell Douglas has transferred aircraft technology successfully.

Though great achievements have been made in China's economic development, given the broad range of modernization goals, its limited financial resources and technical manpower, China still have a long way to go before it can become an economic power. China has drawn up its blueprint for modernization in the 1990s, that is, the Outline of the Ten-Year Program and the Eighth Five-Year Plan (1991-95) for National Economic and Social Development. To achieve its second strategic target in the whole process of modernization in the next ten years, the Chinese government should continue its "open door" policy and further strengthen the work of technology transfer by improving the
business environment, and, at the same time, better organizing and coordinating all of its efforts to assimilate and diffuse new technology efficiently. By doing so, more decentralization of authority should be granted, flexible mobility of technical manpower be allowed, and a bigger step should be taken toward market economy so as to stimulate domestic demand for new technology.

Of all existing policies to be readjusted, the most important two is the domestic pricing and taxation policies which must be improved so that enterprises who develop and adopt new technology can be benefited.

Under China's centrally planned economy, prices are fixed by the central decision-making authorities. They have no reflection on production costs and market conditions. And because of the production quota system, the fixed-price system benefits some enterprises, while hurts others. In China, more than 90 percent of commodities are priced and distributed through certain channels set by the central planning system, enterprises do not have to conduct market research and advertise their products, marketing functions are ignored. Industrial goods are usually relocated to producers of final products according to state plan, and the majority of commercial goods are sold in state-owned department stores, where price is fixed. Though since late 1970s above-quota sales are allowed at floating prices for some industrial products like coal, chemical materials and fertilizer, petroleum products, rolled steel and nonferrous metals, the production quotas and fixed prices are still a serious problem for most enterprises. These enterprises have little room to exercise their product price control to achieve cost effectiveness and profit targeting. To solve the problem, the government has imposed differential taxes on profits enterprises made so as to compensate for profit differentials that are not related to performance. However, compensating taxes levied on the existing profits may again benefits only those enterprises whose fixed prices are more favorable. Under this fixed-price and taxation system, it is impossible to stimulate enterprises' demand for new technology to improve production
efficiency. To remedy the price distortion and irrational taxation system, the government should take a bigger step in reforming its economic structure, allow more functions of market mechanism, and enterprises should be given the autonomy to price their own products according to market demand and supply so that all the enterprises can compete on an equal footing. Only in this way, can enterprises control their own profits and have the incentive to expand their production, and thus have the demand for introducing and adopting new technology to achieve greater production efficiency.

Technology transfer is conducted in two ways. From the Chinese side, great efforts have to be extended to establish a favorable business climate for effective transfer, while from the U.S. or foreign side, the government should create a better condition to support the technology transfer through export control policy and export promotion measures. For example, the U.S. government can learn from the Japanese experience, that is, supporting their exporters by providing programs to help shape development projects at an early stage, and if necessary, providing financial support to their business firms seeking opportunities in China.

Technology transfer will continue to be a major ingredient in China's Modernization Program within the rest of the century. Due to political and military considerations, the United States are still exercising great control over technology export to China. Nonetheless, the U.S. government should realize that a strong and modern China can contribute to the growth and stability of the Asia-Pacific region. Helping China to achieve its modernization goal is also in the interest of the United States. With the further development of Sino-U.S. technology transfer, the two economies will not only be complementary but also contribute to the economic growth and political stability of the whole world.
ENDNOTES


4. Ibid.


11. Ibid.


14. Ibid.


18. Ibid.


29. Ibid.


31. Ibid.

32. Ibid, p.211.

33. Ibid, p.212.


44. Ibid.


48. Ibid.


52. Ibid.


63. Ibid.

64. Ibid.


79. Ibid.

80. Ibid.


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