CHINA'S REFORM OF S&T, THE MANAGEMENT SYSTEM AND THE STRATEGY OF S&T FOR DEVELOPMENT *

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BACKGROUND

Since 1978, China has embarked on a more correct path. Rural economic reforms have proved to be a great success, bringing about prosperity. Reforms in urban areas are gaining momentum and doing well. In 1984, China's gross national product (GNP) exceeded US $455 billion with an increase of 13 percent over the previous year. Industrial and agricultural output amounted to about US $400 billion, showing a growth rate of more than 14 percent. National income went up by 12 percent. Such high rates of growth were seldom seen in China's history.

China has made significant progress in recent years, but its level of development is still low in comparison with that of many other countries. At present, China's GNP per capita is only US $450, placing her in the group of low-income countries.

REFORM

At present, China is in an era of all-round reform. Science and technology, economy, education and other areas are being rapidly reformed. This is really a structural reform on an unprecedented scale, with numerous facets and comprehensive characteristics. In all these efforts, reform of the economic structure is the leading factor. It determines the objectives and fundamental contents of all other reforms. The fundamental purpose of economic reform is to gradually replace the rigid, overcentralized planned economy by a relatively flexible socialist commodity economy.

Chinese scientists have succeeded in mastering nuclear technology, launching a number of space satellites, and synthesizing bovine insulin. But their contribution to economic growth and to the production of consumer commodities cannot be considered satisfactory. Apart from the historical, political, and ideological constraints, an important cause of such performance is the rigid management of the techno-economic system. Until last year, the state exercised excessive control over research institutions and economic enterprises. No attention was paid to commodity production, and the role of the marketplace was neglected.

The advancement of science and technology and economic growth are twin sisters that reinforce one another. Advanced science and technology have already become the driving force for modernizing the Chinese economy.

The majority of more than 9300 research institutions in China are supported entirely by the state. They have done some praiseworthy work over the years but have not contributed much to invigorate the economy and bring about prosperity to the people. They pursue sophisticated technologies but are unable to translate them into social wealth. That science and technology are not tailored to the needs of economic growth constitutes the most serious defect in our R&D management system. The Chinese government has, therefore, decided that research and development management will also undergo reform at the same time that the economic system is restructured. This reform is intended to create an environment in which most of the research institutions, especially those intimately involved in technology development, will have a market orientation. Research undertakings will be geared toward economic development and judged by their economic contributions. Thus, society will show more respect for those who contribute to the acceleration of economic growth and reward them accordingly.

The S&T management system is one of the derivations of the economic set up. The purpose of S&T management reform is to strengthen the weak link between S&T and the economy; change the traditional bureaucratic approach to S&T management; and utilize the market mechanism of socialist commodity economy to motivate and promote the coordinated development of S&T. A new technological revolution is emerging on a global scale, leading to rapid changes in international economy and social structures, and giving strong impetus to the advancement of human beings everywhere. The newly emerged technology is characterized by its highly interdisciplinary, rapidly changing, highly competitive and risky nature. It is necessary for us to organize and manage the new technology with greater flexibility and adaptability.

MAIN SHORTCOMINGS AND WAYS TO REFORM

In order to demonstrate the urgent need for S&T management system reform, we need to recount in general the four major drawbacks of the system as follows:

1. The S&T system employs a backward administration. All the research institutions are state owned; their projects are state assigned; and funds and personnel are appropriated and controlled by the government. They have very little autonomy, are not responsible for benefits or losses and are generally slow and inefficient.

2. The research institutions are largely closed units, independent of productive enterprises. S&T efforts have very little connection with the economy. A number

of researchers concern themselves mainly with writing papers, with less attention paid to contacting the production units to solve practical problems.

3. The research institutions are isolated from each other. Lack of coordination among them results in divergence of human, material and financial resources. Duplication and repetition of low level research is common.

4. Research workers have no autonomy and power within the system. Although their jobs and qualifications do not always match, it is hard for them to move about and relocate themselves because governmental controls do not allow such mobility. There is egalitarianism in the remuneration system which is not conducive to rewarding the diligent, punishing the idle, and giving more to those who have made greater contributions.

Up to now, these conditions have posed serious obstacles to the development of S&T, as well as to the transfer of research results to production.

In the past few years, some reforms have been introduced on a trial basis in many places. They include the establishment of combined entities for research and production, a centre for technology development, technology trade fairs, compensative transfer of S&T results, and a research contract system. These new measures to link science and technology with economy have already laid the foundation for the all-round S&T management system reform announced by the government earlier this year. The proposed reform lays particular emphasis on solving the following four problems:

1. Commercialization of technology
2. Reform of the national R&D funding system
3. Linkage of S&T with productive sectors
4. Mobility of S&T personnel

THE BREAKTHROUGH POINT OF THE REFORM

The S&T management system reform is basically aimed at promoting transfer of technology, commercialization of technological achievements and development of the technology market. These are to be the breakthrough points of the overall reforms.

Why do we say that commercialization of technology is the breakthrough point of the reform? This is because the circulation and exchange of commodities in a commodity economy are the prerequisites for development of the social economy. A technology achieves social recognition and a self-developing capability only after it has been

materialized in the form of a commodity for exchange. If we are to grasp this key link, we should make sure that technological achievements continue to flow into production.

Socialist economy is also a kind of commodity economy under public ownership. In the socialist society, technological achievements are the same as the material goods. They possess the character of a commodity. In the past 30 years, the development of commodity economy has been limited in our country due to some man-made obstacles. Our technological achievements have been state-undertaken and state-controlled. They have been transferred and applied *gratis*, without considering the costs and benefits. As a result, connections between the users and producers of technology have been neglected, greatly prohibiting the diffusion of technological achievements.

In practice, commercialization of technology includes two aspects. First, technological achievements are conditioned by the market, to be freely bargained and to have the payable transfer. Second, the research results are converted into commodities and commercialized, instead of being displayed as samples and exhibits. Technological achievement, therefore, must be judged not only qualitatively, but also from the point of view of their practicability and economic feasibility. Commercialization of technology through market competition can help break down departmentalism and segregation between different sectors or regions, transfer technology in right directions, motivate transformation of enterprises, and encourage mobility of S&T personnel.

Recently, the scope and scale of the technology markets have grown to some extent. The first National Technology Trade Fair took place in Beijing in the second quarter of the year. (1985) The number of visitors reached to 310,000. The number of contracts signed was about 15,000. The total volume of technology transactions was more than 8 billion yuan.

The technology market is an important organic part of socialist commodity economy. Although some major projects of national priority will still be arranged by mandatory planning, large amounts of work concerning technology development, applications, transfer and diffusion will be more and more regulated by market forces.

THE ORIENTATION OF RESEARCH ORGANIZATIONS

In light of the decision to reform the economic structure, it is necessary for us to reorganize the S&T system as well. This means that research organizations, which have been "eating from a big pot" and have been appendages of their leading government bodies, should be operated independently and oriented toward the society. Government departments will henceforth be allowed to retain control of only the most comprehensive, as well as the service-oriented research institutes. As the research institutes are decentralized, they will be required to register with the local authorities. But they will have necessary autonomy over personnel, salaries, planning, financial resources, and business relations. Along with the

tasks assigned by the government, the research institutes will be allowed to independently undertake economically attractive research activities, develop lateral relationships within the scope of law, and advance through competition.

Separation of research from the administrative organs of government should give birth to favourable conditions for strengthening the S&T capabilities in the forefront of production. After the research institutes have been decentralized, they may be regrouped, on the basis of voluntary participation and mutual benefit, into new organizations. The following types of regrouping may be considered: merging into big enterprises to form their R&D departments; joining production units to form combined units of research and production; establishing joint centres for technological innovation, trade and industry; and forming technology service centres for small and medium-sized enterprises.

After the reforms, the main task of government departments connected with S&T management will be to formulate general and specific policies to promote science and technology through economic, statutory and administrative means.

MAJOR CHANGES IN THE FUNDING SYSTEM

One of the most outstanding reforms is change in the R&D financing system. Gratuitous government funding of all the administrative and research expenditures in R&D institutions will be eliminated. There will be different funding channels for different types of research institutions, e.g. grants from science foundations and academies; special project contracts from the research contract system and government appropriation for a given task within a limited budget.

Science foundations will be introduced to support basic research and some applied research projects. A unified and multi-level National Science Foundation will be established. The Foundation will be largely funded by government appropriations. Proposals for research will be invited and evaluated through peer review on the principles of proficiency and expertise. Basic research will be emphasized to further strengthen the connection between S&T and the economy.

Research institutes engaged in technological development will be funded through the contract system. Within the next five years, their operating expenses, paid by the government, will be diminished year by year, and finally eliminated. Thus they will be forced to orient themselves to the economy and society. They will gradually become financially self-reliant through technology transfer, technical services and contract research with the government or enterprises. S&T projects of national importance will continue to be assigned by the government to the relevant research institutes through contracts or outright grants.

Institutes involved in research in medicine, environmental science and other areas of public benefits will continue to be provided through government appropriations of fixed amounts for current expenses. A venture capital investment system is also to be established. By means of this system, the necessary capital can be ensured for the development of high-risk, high-technology sectors.

Changing the S&T funding system does not mean that there will be a decrease in national S&T investment. On the contrary, the investment will continue to increase year by year. Measures taken to diminish or wholly eliminate government funding of current expenses for R&D institutes are designed to orient them toward production and promote the close connection of technology with the economy.

It may take a lot of effort and be a painful process for those lifeless institutes to change their direction. Yet it is a process full of promise and vitality.

Reform of S&T Personnel Management Systems

The reform of S&T personnel management consists of three aspects:

1. To overcome the "leftist" tendencies of belittling knowledge and talented people and rude interference with scientific and academic freedom. Much progress has already been made in this direction during the past several years.

2. To change the earlier system of job assignment and centralized control by the government, giving S&T personnel opportunities to select jobs according to their specialization and abilities. In this system, the employer units will be allowed public announcement of vacancies, as well as open dismissal of personnel, while the employees will have the right to resign. This kind of a flexible personnel policy is a necessary measure to invigorate science and technology and overcome the bureaucracy.

3. To promote capable young people among the cadres and encourage them to lead the research work with a view to rapidly changing the old-age phenomena in the leading groups of research institutes and S&T departments.

In view of the fact that China is a country of unbalanced development, the differences between geographical regions, and between urban and rural areas are rather big. In order to prevent the flow of people into large cities, there must be a set of policies to ensure a rational pattern of migration of S&T experts. Generally speaking, the policy is to encourage the people to go to the rural areas from the urban areas, to the distant or border areas from the inland, to the productive units from the research institutes, and to the under-staffed departments from those that are over-staffed. By this policy, unplanned mobility

will be decreased and the number of S&T experts working in rural areas or hardship places will be kept relatively stable. The government will give preferential treatment to S&T experts who opt to work in rural areas and distant regions.

The direction and targets of the reform are clear and firm, yet the measures must be taken in a prudent and flexible way. We are trying to jump out of the rigid bureaucratic management designed in past decades, turning to the new track of management which is regulated by the market mechanism and economic levers, and is full of vitality. To accomplish this kind of transition is not a very easy task. There are lots of interim links in the process. Any link which is not so well dealt with will lead to problems. We lack experience in this regard. Especially, we have not experienced the evolutionary stages of a highly developed commodity economy. Both the cadres and masses are lacking in knowledge and experience about such economic systems as banks, credit and loans, taxation, markets, pricing, venture capital, stocks, etc., to stimulate the development of S&T and economy.

While carrying out the reform, we should try to avoid excessive social shocks. We should take full account of all the possible problems and implications so that we have the necessary measures to face and solve them.

Our guiding principle is that the reform must proceed according to the actual conditions, and that everything must be checked by practice. We must avoid the harmful tendency of using only one method to be applied everywhere regardless of the actual conditions.

The Strategy for R&D

At the moment, there are a variety of strategies for development. Each strategy has its own characteristics, and each is assessed differently by different people. There is the strategy which assumes the exploration of high technology to be the key point in S&T for development. Several developed countries have adopted this strategy for the growth of their production enterprises.

The U.S. government is strengthening the SDI (Strategic Defense Initiative) projects. Millions of dollars will be spent on these projects every year. The western European countries have linked together to establish the "Eureka" project to explore high technology and promote European unity and joint economic development. The Japanese have also put forward a "three-year movement program," making high technology the key element in their drive toward industrial growth and leadership of the world economy.

The member countries of CMEA (the Council of Mutual Economic Assistance) have also formulated a similar policy. The Soviet leader, Mikhail Gorbachev, has attached enormous imporantce to that. When he took charge in the USSR, he called upon the CMEA countries

"to accelerate S&T progress and develop national economy." The strategy for high technology is supported by economic forces and technological levels of a country.

Is it necessary for China to adopt high technology as the key point of her development? After considerable discussion and study of this issue, we have concluded that it is not appropriate for us to adopt and implement a high technology strategy as present. First, our financial resources are quite limited. Second, our S&T capability is at a low level and cannot meet the requirements of high technology development. Third, reforms of the economy and S&T management system have just begun in China and many relationships have not yet been straightened out. Even if we consider high technology to be the key point, it will be hard for us to draw much economic and social benefits from it. Only some fields of high-tech will be selected for exploration with limited objectives.

The second kind of strategy is called "Analogous Strategy," or the so-called "Tracing Strategy." This strategy was adopted by Japan for a long time. It was characterized by the introduction, absorption and upgrading of foreign technology in Japan. Japan has been transformed into a strong country with real economic power by means of this strategy. In recent years, Japan has changed this strategy and formulated a new strategy: "To step up self-exploration as the guiding principle."

China has abundant human and natural resources. We have evolved our own model of development. But it seems necessary, at this stage, to adopt the "Tracing Strategy" whereby we utilize all the favourable conditions of our country to absorb foreign technology and innovate at the same time.

The third kind of strategy is the "Adaptive Technology Strategy." It emphasizes a middle ground between backward, or traditional technology, and advanced technology. This strategy has been adopted by some developing countries. There are two absolutely different viewpoints about this in China. One is that attention must be paid to the exploration and application of adaptive technology because it is consistent with China's condition of limited financial resources and low level of technology. The other is that if China were to implement the adaptive technology strategy, it would never get rid of the existing situation and will continue to lag behind the developed countries forever. Both of these viewpoints have their own merits and demerits. China needs the adaptive technology. At the same time, advanced technology can be considered as a part of the strategy but it cannot be the key point.

The fourth kind of strategy is a "composite strategy" for development. This strategy is formulated according to the existing resources and socio-economic needs. It is necessary for China to combine high technology and adaptive technology, and apply each of them selectively to different types of projects. Such a composite strategy may be the correct approach for China's S&T for development at the moment. The main goal for China is that, by the end of the century, the level of industrial and agricultural technology will have

reached the equivalent of developed countries' level of the 70s, or even the 80s. Some high technology fields may even reach the most advanced level by then.

In order to meet these goals, a new policy of S&T for development has been formulated by the government of China:

1. To modernize traditional industry with new technology and reinforce the existing S&T capability for this purpose.

There are very few modern enterprises in China. Over 90 percent of the gross national product comes out of traditional industry. The government of China plans to raise the annual gross national product to over US $500 billion by the year 1990. Out of this, over US $300 billion will be produced by traditional enterprises.

It is, therefore, decided that the guiding principle in the coming five years will be to invest heavily in technological innovation and extensive reconstruction of existing enterprises. This will be done primarily through local R&D as well as assimilation and absorption of imported technology. The existing capability of R&D institutions to innovate and absorb foreign technologies will be upgraded in order to serve the primary sectors--energy, transport, materials, etc.--and the traditional enterprises, such as agricultural and food processing industries. These efforts will be augmented by establishing a large number of centres for experimental development mainly related to the needs of traditional enterprises.

Technological policies for more than ten vital fields have already been formulated. Other fields will soon be covered by similar policies to reflect the contemporary wave of S&T for development.

In the renewal of industry, priority will be given to modernization of basic equipment and technology in order to improve quality, cut costs, and increase economic benefits.

2. To selectively explore high technology for the purpose of establishing new enterprises.

Selective development of high technology is considered necessary for the progress of Chinese economy and society. The main high-tech targets will be micro-electronics, information, and bio-technology. Research and development in new materials, space technology, lasers, and oceanography will also be strengthened with applications as the basic aim.

For the sake of supporting the development of high technology and new enterprises, the government of China proposes to introduce special policies on taxation, loans and pricing.

3. To reinforce the development and diffusion of adaptive technology with a view to serving the rural economy.

China's countryside is widespread and abundant in resources. Close to 800 million Chinese live in the rural areas. Capital worth several deca-billion yuan is in the hands of peasants. In recent years, rural township enterprises have been rapidly developed. This development constitutes one of the most important aspects in the all-round prosperity of China's economy.

However, many problems remain in the provincial and township industrial sector, such as backward technology and lack of technical expertise and equipment. But once these enterprises get the required technical input, they will be like "tigers with wings." A number of projects have recently been launched to help the technological development of small and medium-sized industries in rural areas. At the same time, it is proposed to support and strengthen a number of provincial research institutions and enterprises. Then they will be able to develop and diffuse adaptive technology and manufacture specialized equipment.

4. To strengthen basic and applied research and their impact.

China considers basic and applied research vital to the long-term development of national economy, production technology and natural resources. Following the development of China's economy, the allocation of funds to basic and applied research institutions will be increased each year at a rate more than the increasing rate of national income. After government gradually decreases the administrative funding of research institutions, it proposes to adopt different ways to support basic and applied research (as explained earlier). The government has also decided to build a number of new laboratories to gradually change the existing state of basic and applied research in the country. Additionally, a number of older scientists in China have made great contributions to the development of basic research. We will make all our efforts to help them continue their work while we recruit younger scientists to constitute first class research teams

To accomplish these goals, we will carry out unified programs to combine technology with commerce, import advanced technology and advanced management, organize S&T policy in research institutions and manufacturing enterprises and link technology imports with domestic R&D. To carry out our strategy of S&T for development, it is necessary for us to be supported by the international community. We are pursuing an open-door policy to promote scientific and technological cooperation with other governments and civilian organizations all over the world.

Finally, I would like to say something about S&T policy analysis in China. We have not done much quantitative research in this field. The policy process is generally informed by extensive debate and discussion.

China is a big country, and if one goes looking, one can find as many examples of excellent R&D institutions as bad ones. In the absence of quantitative indicators, it is difficult at present to correctly assess the soundness of our policies. We have done some preliminary work toward compiling S&T indicators. Data on S&T personnel and institutions is now being collected through census and sample surveys of about 3,000 units.

Science policy and research is a big challenge for us. We would like to accept this challenge through international cooperation.