THE ROLE OF SCIENCE AND TECHNOLOGY IN THE MODERNISATION PLAN FOR CHINA*

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Science and technology have been promoted as one of the catalysts to create the new China. National planning seeks to consolidate and modernise the existing system. Such priority areas as energy, materials, computers and high energy physics have been distinguished. Much discussion has related to the difficulties of integrating science and technology policy with economic policy. Specific problems have been centralised control over research and development, the acquisition of technology from other countries, and the establishment of new industries using the new technology.

Keywords: science and technology, R & D, technology transfer, Chinese economy, policy problems

INTRODUCTION

In order to become an international power industrially, economically and militarily, the People's Republic of China has embarked on a modernisation programme. To achieve this, Deng Xiaoping, China's strong ruler, has promoted science and technology as one of the catalysts to create the new China.

CURRENT POLICY

In December 1977 at the Chinese People's Political Consultative Council conference, Fang Yi made a speech outlining Chinese Science Policy,[1] In this post-cultural revolution period, the revolutionary committees within the research institutes were to be abolished and professional scientists allowed to run their own organisations. Academic titles were to be reinstated and professional achievements recognised. Scientific conferences and membership of professional

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organisations were to be encouraged, with international ties being strengthened. Assurance was given to scientists that at least five sixths of their time would be for professional work. This new policy increased funds for salaries, capital construction and maintenance, and planned expansion in the field of training additional scientists and technologists. There were to be changes in the administration of research organisations with a greater degree of central control and co-ordination. Reform was planned for tertiary educational establishments with special emphasis on individual achievement and academic excellence rather than a person's politics. Highly gifted 14-16 year olds were to be encouraged by being specially tutored at the University of Science and Technology. Standard textbooks would be introduced, and science would be popularised at the grass roots level.

Hua Guofeng, Chairman of the Chinese Communist Party and Premier, at the Fifth National People's Congress, February 26, 1978, introduced his blue print for the future. It included a ten-year plan for agriculture which would double to triple production within eight years. Eighty five per cent of farm work would be mechanised within the decade, and output would increase by 4-5 per cent per year from 1978-1985. It was planned to increase industrial output by ten per cent per year. Fang Yi gave a paper 'Draft Outline National Plan for the Development of Science and Technology, 1978-1985' to this congress. This proposed that by 2000, China would approach the advanced industrialised nations in all major fields of science and technology, and science and technology was to be promoted as one of the four 'modernisations'.[2] It would be used as an instrument for the modernisation of industry, agriculture and defence. It was planned that in 1985, China would be at the same stage of development as the advanced countries were in the 1970s. The number of scientists would increase from 300,000 to 800,000, and with a corresponding increase of research institutions.

In the plan, the four priority areas of research were in energy, materials, computers and high energy physics. In energy, the policy dealt with mechanisation of key coal mines, research into gasification and liquefaction of coal, building of large hydro power stations and thermal stations close to coal sources, large national grids, super high voltage power lines, atomic power generation and geology of oil and gas. In materials, the emphasis was on beneficiation of red haematite, iron and steel industry, production of titanium and vanadium (where China was a major world producer), improved techniques of processing copper, aluminium, nickel, cobalt and rare earth metals, organic syntheses based on petroleum, natural gas and coal, and new structural and composite materials. The programme for the computer industry included manufacturing large scale integrated circuits, development of the technology for ultra-large scale integrated circuits, establishing a complete computer industry, and setting up a national data transmission network. High-energy physics concentrated on a proton accelerator with a capacity of 50 billion electron volts within the first five years. Altogether research would be in 27 spheres with 108 key projects.[3] Scientists would be project leaders, and all levels of government would be encouraged to do research.

This national plan also called for consolidating and modernising the existing system, so it would help able people advance without over-stressing qualifications, and train, test, promote, and reward scientific and technical personnel. In order to do this, it would be necessary to obtain new skills from other countries and encourage increased international academic exchanges. Those involved in science and technology would have to be given adequate time to carry out research and not be bogged down in politics. There was also a need to apply results and to popularise science.

The China Energy Research Society for 2000[4] set a number of strategic targets. They wanted to raise the standard of living, coordinate energy development, solve rural distribution problems and prevent the environment from being damaged. The society suggested that coal production needed to be doubled to 1200 million tons, and this required investment in transport and environmental protection. Although oil prospecting had been neglected since 1965, it was necessary for China to spend money in this area. Also, electricity production needed to be quadrupled.

DEVELOPMENT

This new policy developed by Deng Ziaoping was claimed by Chen to be "more pragmatic and liberal" than the former one of Liu Shaoqui.[5] At this particular period in time, the policy makers in the country were afraid of an invasion by an army with advanced weapons systems. Consequently, it was necessary to modernise for defence reasons. Chen says that the people were demanding better living standards, and that some scientists of Chinese origin in western countries had suggested new policies were essential for the country. China was also influenced by those countries where economists considered that science and technology was playing a decisive role in the development of a national economy. The argument went that if it could be done for those countries it could be used to modernise China.

However, there were groups that differed in their approach to science policy.[2] There were scientists who wanted to improve the role of the academies and were interested in long-term and basic research, and the political cadres who used science and technology as an instrument for economic development. A number of other groups had little influence. These included educationalists, who realised that the goals set were unworkable; engineers and industry as managers, who would stress the engineering problems; and social scientists and policy analysts who would call for the need for careful policy analysis.

At the May 1981 meeting of the Chinese Academy of Sciences presidium, some of Deng's plans were taking shape.[6] At this meeting, Lu Jiaxi was elected President and was the "first person to rise to this position through democratic elections", and also through the academic, not political, ladder.

By the end of December 1980, the Science and Technology Commission (STC) was worried that the announced science and technology policy was not being integrated into the economy.[7] Consequently, a conference was convened, and concerned itself with the elimination of still apparent leftist influence and impractical demands made by some of the proposals. These included "overtaking Britain and catching up with the US" and the policy of "having everything they have abroad". There had also been considerable exaggeration of existing research achievements. Scientists were "aiming too high and always thinking of making original achievements at an international advanced level". STC said that overseas techniques were being neglected. Successful military research had yet to be applied to other fields. There was a need to recruit advisors in policy making, and for applied research to enable the production of low priced well-made goods. These skills included design and manufacture which traditionally were weak links in Chinese products. Existing producers could not rely on the relatively few applied research institutes. Consequently, it was important to have these applied institutes specialise and attached to their corresponding industry. It was also important to get all production workers involved in introducing technical innovations. To improve products, basic research had to be encouraged, but this was dependent on having high education standards. This meant an improvement in research with theses being "strictly scientific" and having "precise proofs and data". It was important, so the policy announced, for scientists and engineers to solve practical problems. Chinese were to study foreign successful developments and apply them, if suitable, to the local scene. To implement these plans, the effort was to be in agriculture, light industry, energy, communications and transport, machine manufacturing, materials and new techniques. In developing a policy for agriculture, zones were set up for diversified crops, ecology, investment and rural construction. In energy, priorities were given for new plants. Rural supplies, exploitation and development of new sources, construction, local conditions, materials, environment, management and construction were important. In communications and transport, the major effort was concentrated on integrated and rational coordination and containerisation. Other policy areas included new technology.

To encourage transfer of research from institutes to industry a payment scheme was set up. National planning in applying research which required large capital investment with some effect on the economy was established. Other aspects such as publication of results, definition of rules for the STC, State Economic Commission and State Agricultural Commission, and pricing policy to benefit the research effort were part of the overall package. Imported technology and the role of the STC were also considered important. It was recommended that the state no longer support trial manufacturing of new products, other than for large scale research items. This left the manufacturing organisation to fund itself by using its own capital, administration and development funds.

The integration between pure and applied research was always mentioned in policy statements. Accordingly there was a need to reorganise research bodies and create "an atmosphere of seriousness and truth seeking to establish and perfect well ordered research work". Research was involved in "the exploitation of objective laws and the seeking of truth, based on facts". "No carelessness, boasting or falsification can be tolerated". Finance for any applied research would be available from a Science and Technology fund. Another clause, the need to popularise science through the media on education, was again referred to.

Deng Xiaoping released plans at the 12th National Congress of the Chinese Communist Party[8] which showed only three economic strategic areas. They were agriculture, energy and transport, and education and science. By 1985, the weakest link was said to be education. It was planned that the two-three year college enrolment would increase. Annual enrolment in regular colleges and universities would increase from 315,000 in 1982 to 550,000 in 1987, and the number of school students increase from 1.15 to 1.76 million. Other tertiary institutions which have part-time or correspondence course students would accept an increase in numbers from 0.29 to 1.10 million and the number of school students would increase from 0.64 to 2.37 million. Expansion was to take place in the high school system with more vocational and technical schools. Workers, both in the city and country, would be given opportunity to advance their education.

RESULTS

Results of any policy change might be measured by the Science Citation Index, SCI. It is limited to "important high impact science journals". Only 12 articles were indexed in the 1973 SCI as Chinese (first author who listed an affiliation in China). There were 88 for 1978 and 1,949 in 1983.[9] Of the 88 papers for 1978, 75 were published in Chinese journals and nine in American journals. 84 were published in English and the remainder in Chinese, French and German. There were 1,193 (608 in USA) citations of the 88 (1978) articles in other papers published in the period 1978-1982. A conclusion that could be reached is that US scientists do read Chinese papers.

Visiting China, Abelson[10] saw "no example of laboratory equipment that surpassed the western state of the art, and few places that even matched it". Much of the work was a "duplication or modest variation of western accomplishments". In the US, much of the frontier research was dependent on new technology including computers. This sort of development was not seen in China. According to Abelson, the country was lacking in computer skills. By 1980, some of these skills had been developed by the Chinese Academy of Sciences. There was also a critical shortage of trained personnel in China in both teaching and research supervision undertaking new initiatives.[11] A number of research projects were very elementary and "appear to have been undertaken without a true appreciation of the difficulties involved".

Carey[12] considered the goals of the four modernisations difficult to achieve without outside help. The policy was risky with a "preference for fast technological and industrial leaps and pressure for quick results from applied science". Higher education would be promoted with research. Because of this, Carey indicated that student exchange, importation of western experts for lecture tours, and building up libraries with foreign literature would be important. A real problem for China would be the lack of management skills. There was no central institute for this purpose.

Wang Chiwu[13], a critic of mainland China in Taiwan, argued that China had not concerned itself with the problems of capital, social discipline and individual motivation. Wang claimed that the 1978 National Science Conference was for restoration of pre-Cultural Revolution activities rather than for modernisation which was modelled after the Russia of the Stalin era. It had research in definite compartments whether it was development or engineering, with ridigity of planning, and lack of communication between institutions. He claimed that there was a lack of horizontal communication among technical peers. The highlight, according to Wang, was in the field of military research. Here "material rewards are among the best in the country". "Motivation stems from desire to stay in a position which was largely exempt from involvement in social and political upheavals".

The lack of horizontal communication might be more of a sociological phenomenon than an ideological one. When the median age of individuals in an institution increased, there was a tendency to be conservative, and not seek out new concepts and ideas. These Chinese institutions were essentially pre-Cultural Revolution and run by "old" people. The Cultural Revolution had the effect of destroying from one to two generations of scientists.

A way to gain skills is by technology transfer. This is defined as the transmission of technical information, procedures, or skills from one source to another, i.e., trade, license purchases, coproduction, turn-key projects and reverse engineering. Know-how was also transferred through non-commercial channels, scientific exchanges, scholarly publications, conferences, trade fairs and industrial espionage. In the case of Russian development,[14] the more technologically progressive the product, the greater the dependence was on imported equipment. Beneficial effect of western technology transfer to USSR was limited by the poor performance in the Russian economy in assimilating foreign technology and diffusing it broadly. Generally, it took Russian factories about 3-4 years longer to assimilate new equipment than in western factories. With chemical plants, production was 10-20 per cent below capacity, with worker productivity 20-50 per cent lower than in western plants. The strategy of relying on imports may have retarded growth of an indigenous industry by diverting research and development to other sectors of the economy.

Since the Fifth NPC Congress, China had sent a significant number of students abroad for training.[15] It was believed that the totals for 1978-1979 were: US, between 500-700; UK, 500-1,000; France, 300; West Germany, 420; and Japan, 425. Most students were professional research workers in science and technology, and obtained their education before the cultural revolution. The remaining ones were young, between 18-19 years of age and had started college abroad. Most students were in engineering, medicine, agriculture and applied sciences and studied for 2-7 years overseas. They were required to attend language training before formal studies and the majority did not even possess basic academic qualifications. Altogether the overseas student programme was a charge against the Chinese economy in terms of board and tuition, and was a burden on scarce foreign reserves. "What is more noteworthy is the possible influence of the democratic life style of the host countries on the thinking of mainland students, once they were exposed to a non-totalitarian way of life. But it is a risk the Beijing regime had to take in its frantic drive to achieve the four modernisations at any cost".[15]

ECONOMY

Statistics either obtained or estimated are available from 1976. A gross effect has been an improvement in the official rate of exchange from

1976 to 1980 when the currency became softer. All the indices available, whether they be prices for agriculture or consumer goods, or the cost of living, have increased.[17] While the population continues to grow, the production of most foods has remained constant, although pigmeat and chicken production have increased significantly. Manufacturing has definitely expanded in all sections, but most noticeably in consumer items like bicycles and wrist watches. Nitrogen fertiliser production has increased but production of insecticide has remained constant. With the limited figures available, it is difficult to argue conclusively. Even the amount being spent on defence is being reduced. The use of rail for freight transportation has remained constant, which probably reflects that it is running at full capacity. Rapid expansion has occurred with waterway transportation.

According to official estimates[18] for the first five months of 1983 the economy was performing well. The main problem was due to uncontrolled investment in capital construction. In 1983, it was 18.3 per cent higher for the first period than for the corresponding period in 1982. Because of this, there was a shortage of steel, timber and cement. Thus, heavy industry expanded at the expense of light industry supplying domestic and export markets.

In 1979, the national research and development expenditure was 5.87 million yuan which included both investments and wages and was about 1 per cent of the total production.[19] Academia Sinica used about 18 per cent of its budget for research and development with an average yearly budget allocation of about 12,500 yuan per person.

PROBLEMS

There are many structural problems in China,[20] such as a centralised control over research and development. These laboratories are very specialised and not flexible enough to tackle new problems. There is a lack of qualified manpower with only thirty institutes producing acceptable graduates. One way to improve research was to bring in foreigners to provide ideas, and to give specialised lectures. It would also be necessary to have joint projects.

For latecomers to industrialisation,[21] it was necessary to have close international contacts to buy directly the complex and large scale technology. This tended to dominate the developing country's economy, with the high technology imports being paid for by additional exports. Therefore, if rapid modernisation was required, the nation had to be a net importer of foreign technology. In the case of China, it was also being exposed to values and management systems that went hand-in-hand with advanced technology. Technical changes were occurring rapidly outside China, and as the country was being exposed to market forces, then by osmosis a similar change would probably occur within the country. This might cause associated social and political changes.

Since 1949, China had fostered education with an estimated 95 per cent literacy rate (up from 20 per cent) and an expanded higher education.[22] In the medical field infectious disease including VD have been eliminated. Great progress in the country had been made but because of continuing changes in ideology, the progress has been uneven. Abelson, editor of *Science,* asked the question, "Why hasn't China developed faster and more extensively?" It has vast quantities of natural resources, most of the country has a temperate climate, vast human resources, and in the US, Chinese youths do well in science.

China had revised its predictions of expanded production because of the reluctance of western companies to establish joint ventures.[23] One of the reasons is probably due to Chinese law which was vague on this aspect. Patent and management rules were also unclear, and there was no smooth system to settle legal disputes. Western companies have not shown a liking for swapping coal for technology, and were losing interest as China's capital investment plans oscillated with changing political leaders. In order to pay for modernisation, China would obtain foreign exchange by selling coal. The ambitious high energy physics programme, the 50 billion electron volt proton accelerator scheduled for 1983, was postponed to 1985 and the 400 billion proton accelerator postponed indefinitely.

There were a number of problems in establishing new industry using new technology.[24] A case example concerns the Baoshan plant in Shanghai where the latest Japanese technology has been used. Its coastal location was poor due to the lack of port facilities. Because of difficulties there was a continued investment in new plant. This was due to poor planning and the need to add additional but essential infrastructure. In fact, the final cost of Baoshan steel per ton may be greater than for the imported product. In running complex plants like Baoshan, China lacked qualified production and management teams. Indeed there were high costs involved in using foreign technology. To gain advantage, China needs to use its limited ability to earn foreign exchange to finance new foreign technology. Consequently, it must improve export earnings or find some other way of financing foreign purchases. Unfortunately, planners had found out the hard way that large plants required well-defined infrastructure with regards to transport, power, and feeder industries.

High technology industries really do not match China's capabilities. In a previous five year plan (1953-1957) which was based on importing Russian industrial technology, employment became a critical issue. The question revolved around whether it was better to import capital intensive technology or have more labour intensive technology either imported or manufactured locally. For political reasons, it was also important to improve the standard of living and provide more consumer goods. These limit the scope for expanding heavy industry. Sigurdson came to the conclusion that it is close to impossible to set in motion the kind of national policy for science and technology that was envisaged in early 1978.

Hu Yaobang, in his keynote address in March 1978 at the National Congress of the Chinese Science and Technology Association said of the 1978-1985 plan: "it must also be admitted that so far we have failed to bring about an upsurge in the movement to love and study science on a nationwide scale. Why is this?"[25] He answered by saying that the effects of the Cultural Revolution and China's level of under-development had been underestimated. He suggested that there was a need for training in political and bureaucratic leadership, the training of the lost generation of the Cultural Revolution and of those in the current school system. It was also necessary to support the limited science and technology talent.

NOTES AND REFERENCES

1. J.D. Baldeschwieler (ed.), *Chemistry and Chemical Engineering in the People's Republic of China,* American Chemical Society, Washington, 1979, pp. 1-5.
2. J. Sigurdson, 'China's tortuous road to autonomy in technology and science', *Endeavour,* 5, 1981, pp. 75-82.
3. Baldeschwieler, *op. cit.,* pp. 17-34.
4. Wang Qingyi and Gu Jian, 'How will China solve the energy problem'?, *Beijing Review,* 26(35), 1983, pp. 13-18.
5. Chen Yun, 'Chinese Communist policy on science and technology: changes and effects', *Issues and Studies,* 15(6), 1979, pp. 45-64.
6. Chemistry and Engineering News, 'Chemist to lead Chinese Science Academy', June 15, 1981, p. 5.
7. *Issues and Studies,* 'Policy document December 1980', 18(5), 1982, p. 84.
8. Yao Yilim, 'Report on the 1983 plan for national economic and social development', *Beijing Review,* 26, 1983, pp. 4-5.
9. E. Garfield, '1978 Science Citation Index', *Institute for Scientific Information,* private communication, 1983.
10. P.H. Abelson, 'Education, science and technology in China', *Science,* 203, 1979, pp. 505-509.
11. W.R. Scowcroft and A.H. Gibson, 'Report on plant sciences', in Aust. Acad. of Sciences, *A Progress Report on Scientific Exchanges between the Australian Academy of Sciences and Academica Sinica, Peking, 1977-1979,* 1979, Appendix 9, pp. 25-27.
12. W.D Carey, 'The Chinese scene', *Science,* 203, 1979, pp. 509-512.
13. Wang Chiwu, 'Mainland China's potential for industrial modernization in the context of its science and technology', *Issues and Studies,* 17(11), 1981, pp. 35-44.

14. G.B. Smith, 'Technology transfer and Soviet innovation', *Problems of Communism* 32(3), 1983, pp. 70-74.
15. Wang Lingling, 'Peiping's program for sending students abroad', *Issues and Studies,* 15(7), 1979, pp. 10-12.
16. *ibid.*
17. *International Financial Statistics,* 36, 6, 1983, pp. 124-125.
18. Yao Yilim, *op. cit.*
19. Sigurdson, *op. cit.*
20. *ibid.*
21. *ibid.*
22. Abelson, *op. cit.*
23. C. Joyce, 'Is China ready for the revolution?', *New Scientist,* 4 June 1981.
24. Sigurdson, *op. cit.*
25. *ibid.*