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MONITOR - SAST ACTIVITY

STRATEGIC ANALYSIS IN SCIENCE AND TECHNOLOGY

THE NEEDS AND POSSIBILITIES FOR COOPERATION BETWEEN SELECTED ADVANCED DEVELOPING COUNTRIES AND THE COMMUNITY IN THE FIELD OF SCIENCE AND TECHNOLOGY

(Sast Project N° 1)

COUNTRY REPORT ON THE PEOPLE'S REPUBLIC OF CHINA

by
Kurt Hoffman and Dr. Geoff Oldham
Sussex Research Associates Ltd

March 1991

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FOREWORD

This report has been prepared for the Strategic Analysis in Science and Technology Unit (SAST) of the Directorate-General for Science, Research and Development of the Commission of the European Communities. SAST activities are part of the MONITOR Programme which aims to identify new directions and priorities for Community research and technological development (RTD) policy and to help show more clearly the relationship between RTD policy and other Community policies.

For questions already identified as of interest for the development of Community policy, SAST projects provide an investigation of the perspectives opened up by science and technology. SAST projects thus serve as an input to the process of policy formulation. In the case of the SAST project to which this report contributes, "The needs and possibilities for cooperation between selected advanced developing countries and the Community in the field of science and technology", the context of policy questions includes the evolving economic relations between the Community and these countries, the interest to the Community of promoting international cooperation in science and technology with various types of countries, and the Community's role in European science and technology.

This report is one of a set of country studies carried out for the project. The set comprises the Republic of Korea, Thailand, other ASEAN countries, the People's Republic of China, India, Brazil and Mexico. An overall strategic review will also be available in 1992.

It should be borne in mind in reading the country studies that the fieldwork on which they are based was carried out almost entirely in the country concerned. The points of view of European industrialists/researchers/policy makers were not explicitly sought for this part of the project. (They will be sought as part of the work for the overall strategic review.)

SAST presents this report as a stimulus to reflection and debate within the European Community on the best strategies to adopt towards a group of increasingly important countries. It must be stressed, however, that the orientation and content of reports prepared for SAST cannot be taken as indicating the considered opinion of policy advisors within the Commission services.

NOTE

China** is used in this report as a synonym for the **People's Republic of China

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INTRODUCTION AND READERS' GUIDE

Charting the most appropriate path towards greater future collaboration in science and technology between China and the European Commission at the present moment is a task fraught with difficulties and uncertainties. The events of June 1989, their impact on China's international relations, and the resulting uncertainty about the country's stability and the future direction of policy are the most obvious complicating factors in this equation.

China entered the last year of the 1980s having accomplished a great deal through its much heralded reform process. Though the problems of reform were growing daily more difficult, the country had behind it ten years of solid economic growth and largely positive social change. This had been accompanied and heavily influenced by unprecedented levels of interaction with the world economy due to the Open Door policy. A series of sweeping reforms to the S&T system, also involving extensive international contact and exchange, had generated significant gains. More importantly, the S&T system exhibited a huge potential for making an even greater contribution to China's modernization drive in the future as well as marking out China as a force to be reckoned with in international S&T.

However, the situation following June 1989 when the government used military force to suppress the pro-democracy movement has thrown open to question the durability of these achievements and the future possibilities for continued change and reform. Opinions are widely divided between those who fear a permanent retreat from reform is underway and those who believe that reform has been slowed but not reversed and that after some time forward movement will become much more visible.

We tend toward the latter view and feel reasonably optimistic about the future prospects for renewed reform in the medium term. Two reasons for taking this position are of direct relevance to our concerns. Firstly, the current leadership has continued to stress the need to further develop China's S&T capabilities through increased domestic investment and enhanced international contact; while secondly, it has likewise emphasized the continuation of the favourable conditions governing foreign investment and international technology transfer.

These aspects of current Chinese thinking relate directly to the explicit interests of the SAST project. China, of course is a very large and a very poor country. In many respects it fulfils all the criteria to qualify as a developing country and therefore deserves to be treated as such in terms of the provision of aid and technical assistance on developmental and humanitarian grounds.

There are however other dimensions to China that must also be acknowledged. The country possesses formidable S&T capabilities and resources, it enjoys significant cost advantages in a number of sectors, it oversees a potentially vast market and, most importantly, it is fully prepared and capable of exploiting vigorously its domestic and international position to its own advantage. These characteristics make China an appropriate country with which to pursue S&T and industrial collaboration according to the criteria of mutual benefit.

This is the perspective adopted by this report. We have not set out to identify areas or fields where China needs technical assistance or aid-oriented development support for S&T. China's needs in this area are very great. China is the largest aid recipient for many agencies and countries including the EC, UNDP and the U.S. It was not our brief to focus on this aspect of EC relations with China. Rather, we explored, through our interviews and subsequent analysis, issues relating to S&T collaboration between the EC and China based on the concept of mutual benefit.

With this focus in mind, Part I of this report contains a strategic review of the key issues impinging upon the prospects for S&T collaboration with China. We begin in Sections 1 - 3 by setting the context for assessing the prospects for S&T collaboration with China by first reviewing briefly China's economic performance, the success and failures of its reform programme, and the current status of China's policy toward foreign investment. Sections 4 and 5 review key aspects of S&T reform and its effects while Section 6 discusses China's current initiatives to develop its high technology R&D capabilities. Section 7 presents proposals for the pursuit of greater S&T collaborative linkages between the Community and China.

Part II contains the "decision base" for this case study and consists of 11 sections containing background information and analysis of China's economy and its S&T system. Sections 1 - 5 cover various aspects of the recent performance of the economy and the economic reforms programme and its impacts. The remaining sections focus on various aspects of the S&T system with Section 6 describing the S&T policy institutions and policy-making process, Sections 7 and 8 on the S&T labour force and the R&D system. Section 9 reviews available information on S&T expenditure, Section 10 assesses China's international S&T relations and Section 11 focuses specifically on the development of China's high technology capabilities. Five annexes provide additional information.

EXECUTIVE SUMMARY

1. During the 1980s, China undertook an ambitious programme of reform that generated considerable economic benefits and gained acceptance of the country into the international community of nations. However, the events of June 1989 caused severe damage to China's international relations that are only just beginning to be repaired. And though it is unlikely the government will soon adopt a more relaxed political posture, there are good reasons to believe that forward movement of the reform process will resume in the medium term.

2. By any measure, China's economic accomplishments during the period of reform in the 1980s were impressive. During 1981-1987, real GNP grew annually by 9.8 per cent (reaching $329 billion in 1988) while real industrial output grew by 12.8 per cent a year over that period. Total trade rose from $44.2 billion in 1980 to $113.9 billion in 1989 (of which the Community accounted for 8.5 per cent) while exports increased at an annual rate of 16.8 per cent from $9.8 billion to $39.4 billion, bringing the country to 16th place in the world league of exporters (up from 32nd in 1979).

3. Foreign investment rose substantially as well due to the attractions of an expanding domestic economy, a more hospitable investment climate and the country's potential as a low cost exporter of labour-intensive products. For the 1980-88 period, real new foreign investment totalled $15 to $18 billion (of which Europe accounted for 3.4 per cent) spread across 22,000 joint ventures and wholly foreign owned subsidiaries. Moreover, through foreign investment and its own arms-length purchases, China absorbed $27 billion worth of imported technology between 1980 and 1989, with much of this coming from Japan and the U.S.

4. Partly because of the success of the reform programme and partly because the reform process didn't go far enough, China began to experience growing economic difficulties by the mid-1980s. These included high inflation, rising indebtedness, serious raw material shortages, major transport bottlenecks and the increasingly high costs of maintaining an unreformed and still massively inefficient state-run industrial sector. A severe austerity programme was imposed in 1989 (and is still in force) to tackle some of these problems. Inflation has been brought under control but many of the other worries will continue to bedevil the economy for some time to come. In 1990, China spent more money subsidising prices and bailing out inefficient state firms than the total budget for defence, education, science and public health.

5. Despite the current economic difficulties, the government has indicated clearly that it remains committed to achieving further progress in two areas that are of direct interest. The first involves improving the climate for foreign investment so as to attract greater inward flows of foreign capital and technology in the future. This has become necessary because of the damage done to investor confidence and to China's standing with the international financial community by the events of June

1989. A variety of long awaited measures have now been introduced including the passage of important new laws giving protection to intellectual property rights and software and easing the operational climate for foreign firms. These are positive steps and more changes are expected - though there are still grounds for keeping up the pressure for further improvement.

6. The strengthening of the government's public commitment to the "Open Door" policy could create genuine opportunties for European enterprises who understand how to do business with the Chinese. The prospects are particularly bright for firms operating in high technology sectors, for those able to put together technology-intensive projects in mainstream manufacturing sectors and for those able to guarantee that a majority of output will be exported. The opportunity is also there for the Community to play a more active role in promoting an expansion of European involvement in technology-intensive projects in China. Particular attention could be paid to developing joint ventures with the new forms of "scientific enterprise" that the government is promoting.

7. Beyond this, there is acknowledgement that China's reliance on Japan and the US as its main sources of industrial technology has to be moderated. Japanese reluctance to transfer technology was a particular source of irritation. There could be considerable trading advantages on offer for European firms prepared to undertake projects involving the effective transfer of technology. Again there is a role here for the Community to play.

8. Second, the leadership has continued to stress the need to further develop China's S&T capabilities through increased domestic investment in R,D & D and enhanced contact with the international S&T community. This commitment has been a staple feature of China's development policy since the mid 1980's as the leadership became convinced that success of the modernization programme was critically dependent upon China's ability to assimilate, generate and diffuse science and technology much more effectively than it had in the past.

9. Beginning in 1985, a pervasive reform of the S&T system was initiated in order to better link R&D to production and in general to make the whole system more market-oriented. This is no small matter since the Chinese S&T system involves approximately 8700 R&D institutions (1044 of which are directly under state control and form the core of the R&D network), over 600 universities and some 9.66 million S&T personnel, 800,000 of which are directly engaged in R&D. Despite the size of the task, significant gains were achieved by the reform that both highlighted the huge potential of S&T in China as well as marking out the country as a force to be reckoned with in international S&T.

10. The most important dimension of the recent emphasis given to S&T development by the government has been the vigourous campaign to develop and strengthen China's high technology capabilities via targeted R&D projects and applied technology development, the launching of new institutional innovations, and the acquisition of knowledge through international collaboration.

11. The activities undertaken have begun to create the necessasry starting conditions for rapid high tech development in China. If these R&D efforts are pursued in the 1990s with the same energy that accompanied their launch prior to June 1989, these could translate into a broad range of opportunities for collaboration in R&D and technology commercialization with China. Chinese officials interviewed felt

that these high tech programmes could serve as an ideal base for EC S&T collaborative initiatives.

12. Our judgement is that it is a propitious moment for the Community to explore further the development of a wide array of S&T and industrial collaborations with China. The benefits to Europe could be considerable and would derive from China's substantial pockets of world class R&D, its large S&T manpower base, ultimately enormous domestic market, and the potential for serving as a platform for the regional and global export of technology- and labour-intensive products. From a strict commercial perspective, however, it has to be acknowledged that benefits to Europe would only begin to flow strongly in the medium term.

13. The Community now enjoys a potential position of relative strength vis a vis China. The country's bargaining power remains weakened by the events of June 1989. The leadership recognizes that it continues to require good access to foreign knowhow and invesstment funds and sees Europe as a valuable counter to the Japanese and Americans as a source of technology transfer. It also believes that international collaboration in S&T is an important tool for developing its own domestic capabilities.

14. There were clear and strong expressions of interest on the part of the Chinese S&T leadership in the pursuit of further discussions with the Community to develop S&T collaborative initiatives. However some problems will need to be confronted directly if this opportunity is taken up. Chinese S&T officials will push strongly for being allowed to participate in the Framework Programme. Some will also find it difficult to operate under conditions of "mutual benefit" since they are accustomed to working in a dependent aid-dominated relationship with the international S&T community. The Chinese are also tough negotiators. None of these issues should present insurmountable obstacles.

PART I : STRATEGIC REVIEW

I.1. - THE MAIN ELEMENTS OF REFORM AND ITS ECONOMIC CONSEQUENCES

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I.1. THE MAIN ELEMENTS OF REFORM AND ITS ECONOMIC CONSEQUENCES

China embarked on a process of far-reaching economic and institutional reform in 1978 that aimed to double 1980 gross output by 1990; double it again by the year 2000; and finally to reach the per capita income levels of moderately developed economies by the middle of the next century. The reforms involved the phased introduction of fundamental changes on previous practice in four interlinked areas affecting every facet of Chinese economic activity.

Firstly, through the introduction of the "responsibility system" in the productive sectors, workers, managers and enterprises were given greater autonomy and offered incentives to increase output, improve quality and lower costs. Second, attempts were made to reform the price and wage system in order to give the market a greater role in determining the prices of commodities, products and wages in both the agricultural and industrial sectors.

The third component of the reform programme was the widely heralded "Open Door" policy which involved an unprecedented opening up of the economy to foreign investment, technology transfer and international trade. Finally, the fourth area of reform involved a fundamental restructuring of the country's science and technology system. This was necessary because the long term success of the modernization programme was seen as critically dependent upon China's ability to assimilate, generate and diffuse science and technology much more effectively than it had in the past.

I.1.1. INITIAL WAVE OF REFORM LEADS TO MAJOR IMPROVEMENTS IN ALL ASPECTS OF ECONOMIC PERFORMANCE

During the 1980s, the implementation of China's reform programme resulted in considerable economic gain for the country as a whole. For example, during 1981-1987, real GNP achieved an annual growth rate of 9.8 per cent, underpinned by annual increases in real gross industrial and agricultural output averaging 12.8 per cent and 7.2 per cent respectively, and a 9.5 per cent annual growth in real national income. By the late 1980s, rural reforms had created nearly 19 million township enterprises, whose dynamic growth powered the expansion of the whole economy and whose output in 1987 exceeded that of agriculture itself.

Trade performance was similarly impressive. Total trade grew from $44.2 billion in 1980 to $113.9 billion in 1989 while exports increased at an annual rate of 16.8 per cent from $9.8 billion to $39.4 billion. By 1989, Hong Kong was China's major trading partner with 21.2 per cent of two way trade followed by Japan with 12.7 per cent, the EC with 8.5 per cent and the USA with 6.7 per cent.

Levels of foreign investment rose significantly as well as foreign firms were attracted by the (reform-driven) expansion of the domestic economy, a more hospitable investment climate and the country's potential as a low cost exporter of labour-intensive products. For the 1980-88 period, real new foreign investment totalled $15 to $18 billion ($2.4 billion in 1988) and was bound up in the activities of some 12,000 joint equity ventures, 8000 joint production operations and 1500 wholly foreign owned subsidiaries.[1] As in trade, Hong Kong is China's leading investment partner accounting for 70.8 per cent of all approved projects involving foreign partners between 1978 and 1988 followed by the U.S. with 8.5 per cent ($2.4 billion) Japan with 4.7 per cent ($1.3 billion) and the EC with 3.9 per cent ($987 million).

[1]. An equally sizeable inflow of imported technology (embodied and disembodied) accompanied this inward flow of foreign investment funds Over the 1980-89 period, the government claims an expenditure for imported technology of $27 billion spread across 27,000 contracts.

I.2. INCREASING ECONOMIC DIFFICULTIES LEADS TO STALLED REFORMS, AUSTERITY AND RETRENCHMENT

Despite these successes, some very serious problems emerged during the implementation of the reforms, particularly in the post-1985 period, that eventually led to the present economic and political crisis. Simply put, the reform process floundered on the inability (and often unwillingness) of the economy, bureaucracy, enterprises and individuals to cope with the enormous pressures for radical change that were placed upon them by the leadership.

These problems became visible at both the macro and micro level. At the macro level, the most serious was undoubtedly the emergence of an unprecedentedly high rate of inflation that went from virtually zero in 1978 to an average of 10.3 per cent by 1985 and growing sharply to more than 20 per cent in 1988 and close to 30 per cent in 1989 before the imposition of draconian credit restrictions which should at least halve it by the end of 1990. Moreover, the unbridled demand for consumption goods and decentralization of control over imports stemming from the reforms resulted in a ballooning of the country's foreign trade deficit to $14.19 billion in 1985.

At the micro level, rural reform, after some early successes, ran into severe problems. On the one hand the pace of reform was deemed to be too slow while at the same time the rapid growth of township enterprises through the mid-1980s had placed the economy under enormous inflationary pressures. In the urban areas, apart from some successes linked to the establishment of high tech industries, it proved far more difficult than expected to implement even the most basic reforms among the vast majority of state-run productive enterprises.

Inevitably, reform of the price and incentive structure proved the most problematic with the consequence that the prices of most industrial products in 1988 still do not reflect their true scarcity value, while many state-run industries remained hopelessly inefficient. As a result, serious shortages of raw materials developed, major transport bottle-necks emerged and huge stockpiles of unsaleable, poor quality goods piled up through the latter half of 1987 and all through 1988.

I.2.1. ECONOMIC AUSTERITY AND SLOWING OF THE REFORM PROCESS

By mid 1988, it was clear that the problems faced by the Chinese economy were so widespread and fundamental that they could no longer be passed off as purely transitional. A political struggle ensued within the government between those advocating the hastening and deepening of the reform process as the only way to maintain forward progress and those calling for a return to centralization and strict control in order to reduce inflation and bring the economy back into line.

The net outcome of that phase of the struggle was that a strict austerity drive was instituted in early 1989 involving severe credit restraints, an abrupt slow-down in capital investment, and a sharp cutback on imports. While this austerity programme had some impact on the economic front, it exacerbated existing political tensions particularly in the cities. This unsustainable situation was ultimately resolved by the government's use of force in Tiananmen Square in June 1989.

Since then the economy has continued to struggle both with the restraining effects of the austerity programme and the continued imbalances caused by the earlier reforms and deep-rooted structural weakness. The availability of credit at all levels continues to be sharply reduced - with particularly severe (and intended) effects on the performance of the rural enterprise sector; in the urban sector state-run producers are being favoured over private and semi-autonomous firms in terms of access to investment funds, inputs, foreign exchange, etc.; the government is now relying more heavily on central planning to direct the economy; and, perhaps most importantly the pace of price reform appears to have been slowed sharply - at least for the time being.

It is virtually impossible to judge at this stage how long the current period of retrenchment will persist in China. Certainly, the struggle between different factions within the government leadership continues. Some argue that these conditions will remain for some time; others are more optimistic. However, there are two areas where it is clear that the Chinese government is committed to pushing forward and will not be reversing the reform process in a major way - the Open Door policy with regard to foreign investment and the strengthening of the country's S&T capacity. Both of these elements are critical to our interest in this strategic review because of the direct link and possibilities thus generated for mutually beneficial collaboration. We discuss direct foreign investment first in the next section and then move on to S&T issues.

I.3. THE "OPEN DOOR" AND POLICIES TOWARD FOREIGN INVESTMENT

The one area of policy where Chinese leaders avow there has been little change is in respect to the Open Door towards foreign investment and trade. Since June 1989 they have been constantly at pains to insist that nothing has changed and that the door is still open. The leadership feels the need to reiterate the openness of the Chinese economy to foreign investment for two obvious reasons.

First, given China's relative technological backwardness even after 10 years of reform, further pursuit of the modernization/rapid growth strategy will still rely heavily on access to foreign investment, technology and aid. The promised improvements in living standards (on which the regime's continued legitimacy now depends more than ever) simply cannot be delivered without massive inward flows of foreign capital and technology - particularly given the straitened circumstances of the current austerity programme.. Second, and more importantly in the short run, the authorities have to make clear to the international finance community, that China is still a safe haven for foreign capital so that it can reach an accommodation on its debt repayment problem in the next year or two.

As documented in Part 2, between January 1987 and June 1989, there had been a boom in foreign investment. By June 1989 the number of contracts signed grew by 400 per cent and their unit value by 67 per cent over the totals accumulated from 1979-86. In the first half of 1989, foreign investment was up by nearly 50 per cent. A major reason for this boom was that after 5 or so very difficult years, foreign firms had finally begun to have trust and confidence in the stability of the Open Door policy.

This confidence and trust, particularly that of Western and Japanese businessmen, was severely shaken by the shock of Tiananmen. This damage was reflected in a downturn of at least 25 per cent in the level of new commitments over the last six months of 1989. Moreover there is some evidence that these uncertainties have continued to restrain new investment activity during that year as it is reported that in the first six months of 1990, the foreign exchange value of negotiated foreign investments had in fact dropped by nearly 32 per cent.[2]

It is interesting to note that unlike their Western and Japanese counterparts, Taiwanese and Hong Kong entrepreneurs carried on investing in China with the value and number of Taiwanese funded projects doubling in the first six months of 1990. These investment actions are, however, of only marginal interest to the leadership since they primarily involved low tech projects not much in favour with Beijing. They were far more concerned by the apparent downturn in investment activity on the part of U.S., Japanese and European firms

[2]. There has also been a sharp falloff in foreign investment in capital intensive and high technology projects in Guangdong Province which encompasses many of China's most favoured economic zones and currently accounts for 43 per cent of all foreign investment. By the end of March, 1990, new investment projects were down by 20 per cent from a year earlier. Shanghai City reported an even more precipitous decline in new investment projects over the same period.

I.3.1. CONTRADICTORY SIGNALS AND ECONOMIC DIFFICULTIES

In response to these difficulties the government has been taking steps and sending out signals designed to restore confidence. One response has been the more rapid approval of export-oriented projects already in the pipeline. Others involved buying up unsold inventory from highly visible joint ventures (a practice now stopped) and continued insistence that the special economic zones, Open Cities and the open province of Hainan Island would still offer preferential terms for foreign investment. A new policy announced in January 1990 and related to these special zones was the first time authorization that land in these areas can be leased to foreign firms.

Also related, the government has, in recent months, launched what in effect amounts to a new development strategy focussing on the eastern part of the country in the Pudong area that will be heavily dependent on attracting in new foreign investment.[3] The original "coastal development strategy" is discussed in Part 2.

Most importantly, a major new piece of legislation relating to joint ventures was passed in April 1990 which gave guarantees against expropriation and eliminated any requirement that joint ventures be limited to a fixed time period. This was a surprise development because the government had previously been adamantly opposed to such measures.

Of a surprise has been the even more recent (September 1990) decision by the State Council to implement the long awaited Copyright Law which for the first time grants protection for intellectual works published in foreign countries if there is a reciprocal agreement in that country of if the country is a member of an international intellectual property convention or institution of which China is a member. Protection is granted to all forms of work and is extended for 50 years after the death of the original inventor.[4] Further legislation relating to the protection of software is expected soon.

The passage of these two measures, along with the promised legislation on software significantly improves the foreign investment climate in China and goes some way towards meeting the demands of the West and Japan for further reform in the critical areas of foreign investment and intellectual property rights. These moves along with the others mentioned above allowing land leasing to foreigners are indicative both of the degree of

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[3]. The Pudong New Development Zone is in the eastern part of China, includes an area of 350 kms with one million inhabitants and covers Shanghai and a large portion of the Yangtze River regions. There is a three-phase plan stretching 20 years into the next century with the first infrastructure phase taking place over the next ten years and costing $1.7 billion. A whole set of new policies more favourable to foreign investment than those currently in place anywhere in China are being formulated. The intended projects will cover export processing activities, petro-chemicals and energy and pollution-free high tech industries with most expected to be established by means of foreign investment. Pilkington's, the U.K. glass producer has already established a float glass joint venture there. See for example Elizabeth Cheng, "The East is Ready", Far Eastern Economic Review, 31st May 1990.

[4]. Additional provisions of the law cover the distribution of control over royalties which has been another sticking point in China's relations with other countries on this issue. These are now in line with the requirements demanded by the U.S., Europe and Japan.

difficulty the government was having in attracting new foreign investment post-Tiananmen and of its earnest intention to overcome these problems.[5]

These are significant measures designed, as indicated above, to demonstrate to the outside world (particularly foreign banks and aid agencies) that it is still possible for foreign enterprises to do business in China. However, the leadership's efforts to create a positive impression by these moves are tending to be undermined somewhat by the downstream actions of officials and agencies less visible to foreign observers.[6] Moreover there is still considerable suspicion that new legislation mentioned above will not actually have very much impact in practice.[7] Compounding these difficulties, foreign firms are, of course, also subject to the chill winds of the generalized downturn in domestic demand and the inadequacies of an overstretched infrastructure.

I.3.2. DESPITE POLICY CONTRADICTIONS, THE DOOR IS STILL OPEN

Many foreign firms have until recently been adopting a wait and see position with regards to their future investment plans in China. There are however signs of an upturn in interest and activity on the part of foreign firms. One of the most recent examples of this was the November 1990 announcement by VW that it intends to significantly expand its involvement in the domestic production of motor vehicles - with the aim of producing 150,000 cars per year by 1996.[8] From the Chinese perspective this is undoubtedly encouraging and they have gone to considerable lengths to publicize these successes.

However, with the possible exception of a rise in new investment "commitments" in Guangdong and Guangzhou province, there is clearly no evidence yet to suggest a

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[5]. For a recent review of the current situation with regard to related areas such as technology transfer contracts see the comprehensive discussion in Arthur Wolff, "Technology Transfer to the People's Republic of China", International Journal of Technology Management, Vol 4., Nos 4-5, 1989.

[6]. For example, despite being eased on specific projects, bureaucratic obstacles to new investments and expansion plans have in fact increased substantially in recent months. Foreign firms are also being deliberately squeezed on the credit side and being pressured to increase their capital contribution. See Richard Brechert, "The End of Investment's Wonder Years," China Business Review, January-February 1990.

Moreover, a variety of show-case joint ventures in the motor vehicle and consumer goods sectors were operating at least through the end of 1989 at well below capacity because of shrinking demand and a clamp-down on government spending while the infrastructure in certain foreign investment zones is severely constrained at precisely the time the government is cutting back on investment.

[7]. These suspicions have lead to a recent rise in tensions between the US and China over the trade issue. The US trade deficit with China in 1990 was $10.4 billion, up from $6.2 billion in 1989 and third largest after Japan and Taiwan. There is a remote possibility that the Congress will revoke China's "most favoured nation" trade status as a result of its displeasure over slow progress by the Chinese over intellectual property issues and irritation over charges that China is engaged in "dumping" in garments and other sectors. At the very least, action may well be taken under Section 301 of the Omnibus Trade Bill of 1988 if conditions do not improve.

[8]. Earlier in 1990, Courtaulds announced a $4 million joint venture to produce paints (the first such U.K. investment since June 1989), while in mid-1990, there was a renewed commitment from Philips of Holland to continue pushing forward with its sizeable programme of manufacturing investment - $200 million in nine manufacturing and assembly joint ventures in consumer electronics. Perhaps just as significant is a recent announcement by a major Japanese chain of clothing stores to establish a chain of menswear stores in China with the first opening mid-1991.

sustained return to the pre-June 1989 investment boom. Industrialists continue to insist that what they do vis a vis new investment will be very much affected by government policy. This message is being sent loudly and clearly to the leadership by the foreign investment community and by Japanese and Western governments.

Evidence from our research suggests that while there is still much that is contradictory in that policy - particularly as it is implemented at lower levels - the leadership is sincere about maintaining an open stance towards foreign investment. However, they do have a clear preference for the type of foreign investment they wish to welcome into the country. Recent decisions and policy statements make it clear that high technology investment projects involving the development and production of new and technologically advanced products, technologies or applications will continue to be given very favourable consideration.

Likewise foreign investments in some capital- and technology-intensive infrastructure projects such as nuclear power or telecommunications - will be treated favourably though many of these infrastructure projects will also revert back to a development financing format. Moreover it was made clear to us that China is keen to counterbalance its overwhelming S&T and industrial dependence on Japan and the US by further developing links with Europe.

Projects with foreign involvement that are deemed of national importance will now largely be handled by the centre rather than by provincial authorities. Local officials will ultimately retain a measure of decisionmaking power but will be "encouraged" to only enter into projects that address the key aims of the new investment policy which emphasizes movement into higher value-added export industries, the pursuit of essential import substitution and quick foreign currency generation and require minimal investment from central funds.

These indications of current attitudes of the leadership toward foreign investment and the differential ability and interest of different foreign governments and enterprises to exploit current conditions raise issues of considerable strategic importance both for the Community and more particularly for European enterprises either already present or contemplating entry into China. They are addressed in the final section of Part 1.

I.4. THE REFORM OF CHINA'S S&T SYSTEM

Though always considered important, the development and strengthening of the S&T system in China began in 1979 to be accorded a central role in the country's modernization strategy. Technological change and hence the capacity of the country's R&D system to generate innovations were identified as the main mechanisms for improving economic performance and maintaining economic growth. Indeed, in the early 1980s, the emphasis given by the leadership to the critical importance of S&T in China's new growth-oriented development strategy was so great that at times it was taken to the point of naivete. This concern with enhancing the state of China's S&T capabilities was greatly intensified by the leadership's fast growing awareness, and fear, of the implications of the developments in new technologies.

The emphasis given to S&T in the Sixth Five-Year Plan demonstrated this high-level commitment. 16.8 per cent of state expenditures were allocated to science, technology and education - appreciably more than the 11 per cent allocated during the previous plan. Thirty-eight fields of technology and 114 key R&D programmes were singled out for special attention and investment.[9] A special fund of 130 billion yuan was allocated for the technical transformation of China's 400,000 enterprises

Even more significant, the leadership recognized that even with greater resource allocation, China's highly centralized and rigidly controlled S&T system simply could not cope with the new demands being placed upon it. Fundamental institutional and organizational change was required. The leadership convened a powerful ad hoc group of the most senior officials, chaired by Zhao Ziyang, who were given the task of planning the reform and modernization of the S&T system.

This group, known as the Leading Group in Science and Technology, developed and launched in 1985 a programme of far-reaching S&T reform on a nationwide basis that in many respects was more revolutionary than that attempted in the economic sphere.[10] Certainly it was pushed through with a speed and boldness that was simply not achieved elsewhere in the economy - and in the process created new institutions and new nodal points of dynamic S&T capabilities that greatly enhanced the attractiveness of China as a potential partner in mutually beneficial S&T collaboration with the EC and Member States.

I.4.1. SPECIFICS OF THE MARKET-DRIVEN REFORM OF THE S&T SYSTEM

The basic objective of the reform programme was to link the performance and output of the R&D system much more tightly to the needs of the production sector. This was by far

[9]. These programmes were encompassed within the Sixth Five Year Plan for Key R&D projects and involved 1450 specific projects involving some 5000 institutions and more than 100,000 S&T personnel.

[10]. The Leading Group was disbanded in 1988 after its mission of designing and launching the S&T reform programme was deemed completed. Prime responsibility for S&T management was passed back to SSTC who worked closely with the SEC (State Economic Commission) and the SPC (State Planning Commission) to undertake further planning and to implement reforms. See Part 2 for a full discussion.

the greatest weakness of the old system and manifested in a variety of ways.[11] It was felt the best way to achieve this was to give the market a greater role in determining what kind of R&D should be carried out by the research institutes while at the same time reducing the level of state subsidy for operating expenses of R&D institutes. The creation of a system of paid contracts (between R&D units and user enterprises) along with fundamental changes in way central financial resources for R&D were allocated were the two keys to the reform of the S&T system.

Under the paid contract system, enterprises negotiate a contract with an R&D unit to carry out specific R&D work (or the provision of technical consultancy services) at an agreed price or else they could sell technology that they had already developed. In this way the institute could increase its outside earnings and become less dependent on the state while also orienting its research efforts to producing innovations actually needed by the economy. Such an approach may seem straightforward enough to western observers but in the Chinese context it was truly revolutionary.

Co-incident with these moves, the government also set up a mechanism to channel the funding and direction of basic research through one centralized body as well instituting a new system of funding for applied R&D whereby R&D institutions would compete for central government resources and the awarding of major R&D projects on the basis of competitive tenders and bids.

In parallel with these central reforms in the linking of R&D to production and the state funding of R&D, a large number of institutional innovations and other changes to established practice were introduced. Among the most significant were:

- the establishment of technology "markets" that encouraged R&D institutions to market their wares to user agencies and enterprises in order to stimulate production-oriented R&D and increase the rate and spread of diffusion of innovation;
- the strengthening of enterprise capabilities to articulate demands for innovations supplied by the S&T system and enhancing their abilities to absorb new technology. This strategy is linked to the economic reforms of state productive enterprises and to policies promoting the technological transformation of existing industries;
- the reorganizing of the training and career development procedures of scientific and technical personnel working in the state-supported S&T system thereby allowing the movement of personnel between institutions and tying promotion to merit and performance;
- the organizational and financial reform of the Chinese Academy of Sciences (and its associated institutes) and the research activities of the higher education system in order to give them greater autonomy, encourage them to forge links with the production sector and the local community and generate greater initiative on the part of research personnel;
- the creation of a wide variety of new research and scientific production institutions and organizations set up both to meet the specific R&D needs of specific sectors as well as to integrate scientific research and production. These institutions which take a variety of forms survive financially by meeting market demands for their work and are thus able to operate more or less independently from centralized control.

[11]. See the discussion in Tony Saich, China's Science Policy in the 1980s, Manchester University Press, 1989.

I.5. SYSTEMIC PROBLEMS EMERGE AMIDST RESOUNDING SUCCESS

Virtually every one of the substantive S&T reforms undertaken in the 1985-1989 period constituted a major and fundamental change on established practice. Consequently, they were inevitably bound to come up against a diverse array of difficulties and obstacles. This is particularly the case if one takes into account the size and complexity of the Chinese S&T system.[12]

Some were internal to the S&T system and centered on the reluctance of certain institutions and administrative personnel to relinquish their privileged positions. Other more serious problems arose because the slowness of the wider price and economic reforms, meant that many productive enterprises still did not find it in their interest to seek out technological advantages from the S&T system.

These sorts of demand determined difficulties were such that by mid-1988, there was widespread consensus that though the S&T reform programme had been successful, further real progress was dependent upon the rejuvenation of the process of economic reform. Needless to say matters have been considerably more complicated by the events of the June 1989 and the visible role in the pro-democracy movement played by leading members of the S&T elite. It remains to be seen how the current retrenchment will affect the future role accorded to the S&T system. Certainly, most of the evidence provided to us suggests that the government is still fully committed to the S&T reform process.

What we want to draw attention to here is the fact that despite the problems mentioned above, the rate and extent of the changes in the structure and performance of the S&T system that actually did occur in the 1985-1989 period is remarkable. For example, a new venture capital initiative[13] was launched to support start-up S&T enterprises and the SSTC embarked on a major programme of developing a variety of high technology zones, science parks and technology "incubator" units. Below we review only two aspects of these developments in detail - the growth of technology markets and the development of civilian S&T enterprises while the development of high technology zones is discussed in the next section.

[12]. In 1987, the number of all R&D institutions affiliated with government departments at different levels stood at around 9000, of which 5568 were above the county level and administered centrally. By the end of 1988, China had a manpower stock of 9.66 million people in these categories, up from 7.35 million in 1984. Of these 800.000 are scientists and engineers directly engaged in scientific research and technology development. By the end of 1987, there were 1063 full-time institutions of higher education and there were 1.959 million students enroled in this sector of which 106,185 were graduate and post-graduate students. See analysis in Part 2.

[13]. The China Venture Investment Corporation was launched in September 1985 to provide support for new technology development and production in existing and new enterprises. Through 1988, it had supported a total of 255 projects on a total investment of 730 million yuan. Few of these investments have actually been true venture style investments and most involved heavy purchases of equipment. More important is that prior to June 1989, the experience of CVIC had prompted the emergence of 2 or 3 other fledgling venture enterprises - though the future status of these experiments in venture financing at the current time is not clear.

I.5.1. THE EXPLOSIVE GROWTH OF TECHNOLOGY MARKETS

The development and growth of technology markets is a good proxy for evaluating the response of R&D units and enterprises to the paid contract system. In late 1984, the State Council gave approval to concept of treating technology as a commodity, thus allowing state R&D units and others to market their technology to industrial users.

Although informal exchanges had occurred before this approval, afterwards the scale of exchange increased rapidly so that by 1986 there were 1100 technology exchange centres and 3000 technical service and consulting organizations at prefectural and city level nationwide compared to just 146 exchange centres a year earlier. Beginning from a value of technology transactions of only 50 million yuan in 1983, ($10 million) the first year of the technology market experiment, total technology market transactions leapt to 720 million yuan in 1984, 3.20 billion yuan in 1985 and over 4.5 billion yuan (nearly $1 billion) - based on over 150,000 separate transactions in 1988 and equivalent to more than 40 per cent of China's total R&D expenditures in that year.[14]

Three other aspects of the Chinese technology markets are worth noting. First, the concept has been introduced in a highly flexible manner. Relationships between R&D units and enterprises have included joint development efforts, long-term co-operation, joint bidding, multiple players - including foreign firms - as well as a variety of payment formats such as royalties, flat fees, etc.

Second, numerous institutional innovations were developed in order to provide the structures to allow the markets to operate. These ranged from the passage of patent and technology contract legislation (which also had significant positive implications for the international flow of technology to China) to the setting up by 1988 of nearly 10,000 service groups and agencies dedicated to facilitating technology transactions. Third, there is every reason to believe that the authorities will continue to allow these technqology markets and related service organizations to continue to operate once conditions settle down.

I.5.2. THE RISE OF SCIENTIFIC ENTERPRISES AND MINBAN SCIENCE FIRMS

Another set of related developments that occurred in the wake of the S&T reforms relates to the emergence of a large number of new technology-intensive research and production enterprises operating both within the state sector and outside of it. Again, the initial reforms stimulated the emergence of these enterprises in 1984/85 and the State Council formally encouraging their further development in 1987. These new civilian S&T enterprises encompass a variety of actors and operational formats engaging in a range of technology- intensive commercial activities.[15]

14. For further details see R.Conroy, "Reforms to the Science and Technology System at Provincial and Municipal Level, " Mimeo, OECD, Paris, 1989.

15. The actors involved include individuals, collectives, state-run R&D institutes, universities, and state agencies like the CAS and the operational format introduced include individual ownership, share companies, conglomerates, and joint ventures. Their activities range from integrated units carrying out R&D, production and trade in high and medium technology areas, R&D agencies carrying out contract research, university-based groups

The Chinese Academy of Science (CAS) played a leading role in launching some of the more notable scientific enterprises when from 1987 onwards it began to facilitate the creation of enterprises run and staffed by some of the best of its personnel. By 1989 some 400 such companies had been launched with revenues of $241 million and employing well over 10,000 individuals.

More than 15 of these companies are run by the central staff of the Academy and are operating in key areas of strategic importance; some are run by CAS affiliated institutes and, most significantly from our perspective, others are joint ventures formed in co-operation with foreign firms and oriented toward exports of technology-intensive products.[16] CAS has also been setting up services agencies to support this growing network of high tech ventures. It has linked up with U.S. and Hong Kong investors to create a finance company; it has established a consulting agency which acts as a matchmaker to assist CAS companies in linking with foreign or domestic partners; and it has formed a corporation to promote the export of CAS technology. These latter two agencies respond to specific requests for assistance from CAS companies and also facilitate the efforts of foreign firms who approach CAS (or SSTC or MOFERT) to identify potential Chinese partners. Annex 1 gives further details of the major-affiliated companies of the CAS - all of whom either have or are seeking further international collaboration.

Other similar companies have been spun off from universities, from research institutes under industrial ministries and even from S&T associations.[17] All feature some form of concrete link to state institutions, as well as a high tech production and product base, and an emphasis on R&D and innovation.

In parallel with the emergence of these state-linked S&T firms, many scientists decided to separate completely from the state system in order to set up a wide variety of new technology-intensive companies. These *minban* (non-governmental) science firms, numbered between 10,000 and 15,000 in 1988 and employed more than 400,000 staff. Although they represent only a small fraction of total output, some reached prominent positions in certain segments requiring high technology applications and marketing flexibility such as electronics and new materials - though most are not R&D intensive.

Many minban have struggled to overcome financial and political constraints to survive and now exist only on paper. However others were much more successful and a few such as the Stone Corporation known as China's IBM (with sales in 1988 of nearly 900 million yuan

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carrying out teaching, research and production on a contract basis and various kinds of consulting enterprises.

[16]. Hong Kong firms have been the most active (one has joined with the Institute of Zoology to produce pesticides) but others are getting into the act. A Japanese company is involved in a joint venture with CAS to produce infra-red filters, a U.S. firm is co-operating with another CAS enterprise, Kejian, to produce phased array sector medical scanning products involving joint research in Massachucetts and production in the Shekou Special Economic Zone. The quality and cost combination of the product is superior to anything on the market and Japanese have been forced to cut prices to compete; the same CAS company is involved in the production of nuclear magnetic resonators - the U.S firm supplies the electronics, Kejian provides the magnetics, while software and systems engineering is done jointly.

[17]. By 1988, 283 institutions of higher learning had set up 571 S&T complexes encompassing over 1200 enterprises featuring links between production and research. Local S&T associations linked to CAST (the Chinese Association for Science and Technology) have also, since the mid-1980s, been organizing individuals and groups to provide consultancy services to small and medium enterprises. By 1987, local S&T associations had been involved in 53,000 consultancy projects involving 516,000 association members.

($70 million) based on imported and home design computers and printers became quite influential in policy circles prior to Tiananmen Square.

In the Chinese context, these ambitious, scientist-led entrepreneurial initiatives constituted a truly dramatic break from past institutional practice and in terms of the social role of individual scientists. While it was never likely that the whole of the state S&T system would go down this route, minban science firms and scientific enterprises do offer an alternative vision of what can be achieved within the system that is heartening and encouraging both to the science community and to the progressive wing of the leadership.

From our perspective, these enterprises could occupy a key position as a focal point for innovative collaborative projects with the Commission. The evidence available to us suggests that while the survival of these enterprises in their pre-June 1989 form may be in doubt (particularly the minban firms), there will still be room for them to operate once the situation becomes more stable. Certainly, evidence generated by our interviews with senior SSTC officials indicated that the further development and creation of these forms would continue to be encouraged. The options open to the Community regarding possible collaboration with these enterprises are explored in Section 7.

I.6. CHINA'S CENTER-PROPELLED DRIVE TO ESTABLISH NATIONAL HIGH TECHNOLOGY RESEARCH AND PRODUCTION CAPABILITIES

Since the mid 1980s and in the midst of the S&T reforms discussed above, the Chinese leadership has pursued a vigorous and high profile campaign to develop and strengthen China's high technology capabilities via R&D, the launching of new institutional innovations, and the acquisition of knowledge through international collaboration. These programmes have involved a significant expenditure of resources and the drafting in of the leading scientific minds in China on targeted R&D projects. Through these efforts, the government has signalled clearly the importance it attaches to the development of China's high technology capabilities.

This policy thrust is clearly central to our concerns. The activities undertaken have begun to create the right starting conditions for rapid high tech development in China. If these R&D efforts are pursued in the 1990s with the same vigour that they were launched prior to June 1989, they could translate into a broad range of opportunities for R&D collaboration with China. Chinese officials interviewed felt that in the short to medium term, the human and institutional capabilities being created in the course of these high tech programmes could serve as an ideal base for EC collaborative initiatives.

It is, however, quite difficult to disentangle precisely what is happening in the high tech area both because there have been many new initiatives and because there is a deal of overlap in the plans that describe the new programmes and in the institutional set-up for directing and implementing these activities. What we have tried to do for this strategic report is highlight three of these programmes and areas involving state-supported technology development activity in high technology sectors where the prospects for mutually beneficial collaboration between the Community and China seem greatest.[18] In Part 2, we give more detail on the actual institutional set up with regards to the formulation and administration of Chinese S&T policy as well as highlighting specifically Chinese policy towards high tech industries and their technological capabilities.

I.6.1. THE NATIONAL HIGH TECHNOLOGY DEVELOPMENT PLAN FOR RESEARCH, TRAINING AND PRODUCTION

In March 1986, China launched what it considers its prime response to the technological revolution that was transforming the entire basis of production and competition among the advanced industrial economies. Known by a variety of names such as the Baliusan or 863 Programme, it grew out of the efforts of 100 leading scientists and the SSTC to map out high technology development in China until the year 2000.

The plan was described to us as being modelled after Europe's Eureka programme (though the similarities are hard to discern). It incorporates a medium and long term R&D strategy

[18]. We have not considered a number of other important state sponsored technology development programmes such as the SPARK programme because we felt they were somewhat outside the terms of reference for this project. In this context we should mention that some of the officials interviewed felt that the SPARK programme in particular could be an appropriate area for European/Chinese S&T collaboration. See Conroy op. cit. for an analysis.

to close the knowledge and capability gap between China and the advanced industrial countries in 7 priority high technology sectors deemed critical to China's future development - biotechnology, space technology, IT, laser technology, automation technology, energy technology and new materials.

The State Science and Technology Commission (effectively the ministry for science and technology in China) or SSTC is responsible for the 863 programme which features highly focussed R&D and training projects designed to lay the groundwork for an advanced production capability in the post-2000 era.[19] The selectivity element is critical to allow the necessary scale of investment (in term of manpower creation and finance) required to achieve catch-up. The main funding targets of the R&D programme have been the absolute top-rung of China's scientists who were, in some cases, invited to submit bids and tenders that were assessed by committees of experts.

The aim was to involve co-operative groups of researchers in different institutions using existing laboratories and equipment to pursue advanced applied research in key topic areas. Ultimately, the intention is to bring the products developed into commercial production thought the focus on the present term is achieving breakthroughs on applications bottle-necks in the laboratory.

The budget for the 863 programme is not available officially but some estimates given to us were that on the order of 5 billion yuan has already been committed to projected activities through 1995. By the end of 1989, 10,000 scientists were already at work on more than one hundred 863 projects being carried out at over 200 R&D institutes. Preparations are already underway to launch the next phase of the 863 programme in the mid 1990s that will involve taking the products developed into the production stage for domestic as well as export. Plans are also now being laid to bring in international collaboration at the institutional and corporate level on certain 863 priority areas. This is an area where further discussion between the Community and the SSTC should generate some concrete possibilities for collaboration. More details of the priority projects selected for the 863 programme are given in Annex 2.

I.6.2. THE TORCH PROGRAMME FOR THE STIMULATION OF HIGH TECHNOLOGY INDUSTRIES

The greatest weakness of China's S&T system has historically been its inability to effectively transfer research to production. The recently launched "TORCH" programme in 1988 is designed explicitly to exploit China's current capabilities in advanced technology by accelerating their commercialisation both domestically and in export markets. In addition, it also aims to stimulate the development of new high technology enterprises so as to achieve, primarily through exports, a dramatic increase in their share of industrial structure and GNP by the end of the century. The programme is intended to rely on funds from central government as well as on bank loans and foreign borrowing. A wide range of financial instruments designed to encourage establishment of TORCH Programme enterprises are being developed and implemented.

[19]. The Seventh Five Year Plan for S&T Development parallels the 863 plan in terms of its emphasis on high tech development but instead has a short term focus on the rapid development and deployment of specific advanced technologies. This plan is discussed further in Part 2.

The short-medium term targets of the programme are impressive. These include fostering the creation of 1000-2000 new high tech enterprises both independent and attached to R&D institutes and employing 100,000 S&T trained personnel; the development of 2000 new products, 30 percent aimed for the international market; creation of high tech incubators and development zones; the training of 20,000 managers and overseas trade specialists; and expanding the base of specialized venture capital institutions.

Our evidence suggests that in some categories, significant progress has been made in achieving these targets. For example Wuhan, Shenzen, Guangzhou and Shanghai have established Science Parks housing R&D intensive enterprises linked to (and often sponsored by) university departments.[20] The central government has likewise already approved the establishment of 22 technology "incubator" units based on the U.S. AID model and 24 high technology development experimental zones in more than 12 cities.

The most interesting and far advanced of these is the Zhongguancun area in Beijing which though in existence before TORCH serves a model for TORCH type enterprise zones.

It is already home to more than 700 new technology enterprises spread across electronics, biotechnology, space technology, new materials and optoelectronics. It also incorporates China's silicon valley, an agglomeration of more than 150 minban electronics firms employing more than 4000 people. Between 1984 and 1987, the number of people employed in Zhongguancun is 16,000 of which scientists and technicians account for 50 percent. 70 per cent of the firms are scientific enterprises and about 30 firms are joint ventures with foreign enterprises producing for export.

In terms of projects launched under the TORCH programme, the numbers appear equally impressive. Up till May 1990, some 1500 applications for central TORCH funds have been submitted out of which 272 have been selected - on the criteria that they are technologically advanced, suitable for mass production, have good market prospects and can be brought to the market inside of three years. Another 500 applications are now undergoing evaluation.

The problem with qualitative performance data such as that presented above for the 863 and the TORCH programme is that it is often difficult to get a real feel for what substance there is behind the numbers. Nevertheless, it was clear from our interviews not only that progress has been made in the TORCH programme but that the leadership apparently remains committed to the initiative. Moreover, it was stressed to us that the pursuit of the TORCH programme and the continued strengthening of China's high technology industrial capabilities would rely heavily on international R&D collaboration and the development of outward-oriented enterprises and joint ventures with foreign firms.

Annex 3 contains details of some of the key areas where the SSTC is keen to see international collaboration under the TORCH Programme and where the EC might consider focussing its future S&T collaborative efforts. Given that by the end of 1990, the production value of China's high tech industries is expected to top $10 billion, the further planned acceleration of the development of this sector via the TORCH programme (with the maximization of exports and foreign collaboration being given a top priority) is worthy of careful consideration from the point of view of collaborative possibilities.

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[20]. The Wuhan East Lake New Technology Innovation and Service Centre, established only in 1989 has already helped set up 22 small enterprises based on new and high technology.

I.6.3. STRENGTHENING LONG TERM BASIC RESEARCH CAPABILITIES

China's leadership also has long had its eyes firmly placed on the long term challenges of Chinese development. It has therefore, pursued since 1985 (with less fanfare but ultimately more investment than both 863 and TORCH) a policy of developing and strengthening Chinese basic research capabilities at the international frontiers of science. There are many facets to this policy worthy of note but two are particularly relevant to our concerns.

The first involves the establishment of the National Natural Science Foundation (NSFC) in 1986. The purpose of this move was to create an institution responsible for the planning, development and funding of all central government supported basic research activities. As in the new approach to the funding for applied research, the NSFC awards its funds on the basis of competition and peer group and expert committee evaluation. While not all of the NSFC funds are concentrated in high and key technology areas, there is a clear emphasis towards this direction with the share rising from 20 percent in 1988 to 35 percent by 1992.

The significance of the emergence of the NSFC to our concerns is two fold. First, there was a consensus among those interviewed inside and outside of China that the creation of the NSFC, its central control over all basic research activities and the highly competent way in which it is carrying out its duties have strengthened greatly Chinese basic research capabilities in a large number of high technology areas. It is unquestionably the major actor at the national level in basic research with an annual budget of $750 million supporting projects in 1100 institutions.

Second, given this success there were indications that the role of the NSFC was going to be strengthened further overall in the future and it is already viewed by those interviewed as the focal institution responsible for negotiating and arranging international collaboration in basic science. Further details are provided in Part III.

I.6.4. THE NATIONAL KEY LAB PROGRAMME

Since 1986, China has embarked upon a programme of strengthening its basic research capabilities. Major changes are taking place with respect to the organization, creation, funding, staffing and tasking of the country's network of basic research laboratories. There are a variety of efforts under way in this area jointly and individually under the responsibility of the SSTC, the State Education Commission, the Chinese Academy of Sciences and the Ministries of Public Health and Agriculture.

One area where major changes have been put in train relates to establishing a basic research capability in universities - something that never existed before because of the policy of divorcing research from education, as is discussed in Part III. Here the CAS and the State Education Commission are directly involved. Since 1985 forty new research labs and institutes have been opened at universities. Moreover, the State Education Commission has itself established 22 labs, of which 7 have been specially equipped for the visits of foreign scholars. And together the CAS and the universities have established a number of prestigious joint open labs focussing on high technology and meant as sites for international collaboration. [21]

Another major programme of more direct relevance to our concerns involves the creation and funding a network of what are called National Key Research Labs. The aim behind this programme is build centres of excellence in experimental research that will allow Chinese scientists to work with world class facilities on frontier science problems of direct relevance to China's needs.

Of significance to our interest, national key labs have been designated as focal points for international R&D collaboration. So far since 1985, 30 entirely new labs have been constructed and opened under this programme and another 38 are presently in the final stages of completion. The full plan calls for the establishment of some 400 national key lab centres of excellence by the year 2000. Initial funding of $220 million in 1984 (including $120 million from the World Bank) has been augmented by an annual budget of $150 million.

Key lab status is awarded through competition open to existing institutions and new research groupings. In keeping with changes elsewhere in the R&D system, the competition is based on academic merit as is the election of the Director of the labs and the selection of staff. This may sound perfectly normal to outside observers but it is a revolution in the way basic research institutes are staffed and funded in China.

The key labs are mainly organized in relation to problem areas or topics rather than discipline as in the past. Their precise research topics are determined through a combination of self - selection by the Institute and its staff and through competing for central research allocated by the SSTC under the guide-lines of the National Key R&D Plans. A list of National Key Labs provided specially for us by the Chinese authorities is given in Annex 4.

[21]. For example, three of these have been set up jointly by the Academy, Beijing University and Qinghua University in biological membrane engineering, artificial micro-structure physics, and structural chemistry.

I.7. PROPOSALS FOR EXPANDED S&T COLLABORATION WITH CHINA

China places enormous importance on participating in international S&T exchange and co-operation agreements on a bilateral and multilateral basis. These links represent a vital source of experience and knowledge as well as technical and financial assistance and have made a valuable contribution to development in the country.[22] Since June 1989, the government has worked hard to restore the damage done to China's international standing by the tragic events in Tiananmen Square by seeking to re-establish, maintain and expand its international S&T activities and agreements.

The EC (in common with some other countries and agencies) is now moving towards (and may have already formally agreed) to resume its S&T collaboration activities with China after suspending these in the wake of the events of June 4 and afterwards. This would entail the resumption of what was already an extensive programme of technical assistance and collaborative activities in the S&T field.[23]

Not surprisingly however, the government officials we spoke with (primarily from the SSTC and affiliated agencies), expressed considerable interest and enthusiasm during our interviews for an even greater level of involvement with the EC in S&T collaboration than had existed in the past. While they were not in a position to make overly specific proposals for collaboration they made clear that China would be favourably disposed towards carrying the discussions further.[24]

One of the critical questions the EC now faces is whether it should move beyond the resumption of normal relations and begin to explore the possibility of a greater degree of S&T collaborative activity with China. This is a political judgement best left to the Commission. However, based on our research and interviews, we can put forward a number of observations and proposals that relate to this question and to the other issues of central concern to the SAST project.

We would like to start with a few general observations linked to the points made above about China's strong desire to foster greater international S&T ties before moving on to more specific proposals. We should make clear that our entry point into this discussion is that further collaboration could certainly be justified on the basis of the mutual benefit that would arise in the short and the medium term.

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[22]. There is a more extensive discussion of Chinese strategies towards international S&T collaboration in Part 2. See also Bibiane Han-Etty, "China's Science Policy, International Co-operation and its Prospects", China Information, Volume III, Summer 1988 for a fairly comprehensive listing of existing international agreements. In addition, Wu Yikang, Director-General of the Department of International Co-operation, SSTC prepared a document for this project entitled "China's Policy and Experience in International Scientific and Technical Co-Operation" that could be made available if desired.

[23]. See the document, "La Co-operation Entre La Communaute Europeenne et la Republique Populaire de Chine: Note de Background, Brussels 28th February 1989 for further details.

[24]. We should make clear here that SRA had the opportunity of discussing our preliminary conclusions with senior Chinese S&T officials in Beijing in February 1991. Overall, these were well received and the advisability and possibility of expanded S&T collaboration with the Community and the Commission was universally endorsed. During this occasion, we also pressed for specific recommendations and observations on the types of S&T collaboration proposed by SRA in its first draft. Some recommendations were made by these officials (and these have been incorporated in the this final report) but by and large they felt that the best way forward was for more detailed discussions to be undertaken by the Commission and China at an official level.

I.7.1. CONSIDERABLY INCREASED BARGAINING POWER FOR EUROPE AND THE COMMISSION

During the 1980s, China had become a favoured recipient of international S&T assistance from multilateral and bilateral agencies, often coming top or near the top of the list in terms of the allocation of resources.[26] The size of the country, the extent of its needs, the enormous potential of its domestic market and most importantly its rapidly growing political and economic significance on the world stage acted as powerful magnet in attracting this attention. In the course of developing these linkages, China accrued a formidable reputation as a tough and expert negotiator very adept at exploiting the enthusiasm of competing agencies in order to garner the best possible deal. It had much the same reputation in the realm of industrial negotiations with foreign firms over the terms of equipment purchases, technology transfer contracts and investment arrangements.

The events of June 1989 and their aftermath has significantly weakened the bargaining power of China in the international arena. We have already pointed out some of the concessions it has been forced to make in its intellectual property and foreign investment regime in order to attract new investment. This fact, and the continued importance being laid by the leadership on maintaining forward progress in the area of S&T development, have created favourable conditions for expanding S&T collaboration with China.

Another trend running in Europe's favour is growing Chinese disenchantment with the aggressive nature of Japan's efforts to dominate trade with China while being reluctant to effectively transfer technology. We were advised that this problem is receiving particular attention among senior policymakers and that considerable trade advantages could develop for European firms willing to transfer technology to China. It was acknowledged in our interviews that the Community could advance this process considerably.

Taking advantage of the favourable co-incidence of these different trends to strengthen Europe's S&T and industrial links with China will require a clear set of objectives and detailed knowledge of the economic and political pressures operating on China at the moment, the institutional set-up as well as Chinese S&T and industrial priorities and related strengths and weaknesses. This report goes some way toward providing this detail - though inevitably more information may be required to support detailed strategy design and subsequent negotiations.

I.7.2. THERE ARE LEGITIMATE GROUNDS FOR PRESSING CHINA TO GO FORWARD WITH REFORMS RELATED TO S&T

While the Chinese authorities have proved very resistant to what they perceive as unwarranted interference in internal affairs, they are most likely to listen if such pressure is applied to reform areas where they need expanded international contact. Investment by international firms and international flows of S&T are two such areas. Thus the EC can play a positive role by emphasizing, in the appropriate context, the value to China of a more

[26]. It was for instance the foremost recipient of UNDP funds (totalling $256.5 million between 1979-1991) as well as being the largest recipient of U.S. S&T assistance.

general spirit of openness and the need to maintain its forward movement on reform activities related to foreign enterprises and the S&T system. The message needs to be gotten through that ultimately greater openness will probably be of much greater benefit to the China.

I.7.3. THE CHINESE DESIRE TO PURSUE PARTICIPATION IN THE EUROPEAN FRAMEWORK PROGRAMME

An issue that came up repeatedly in our interviews was a strong desire on the part of the Chinese S&T establishment that China be allowed to participate in the Framework programme. We indicated that this was not permitted under the current terms of the Framework programme nor was it likely that there would be any changes in this position. However, the issue came up so often in our interviews that we feel obliged to flag this as an issue which the Chinese will undoubtedly continue to pursue in any future official discussions with the Commission.

I.7.4. CONFUSION OVER THE MEANING OF MUTUALLY BENEFICIAL S&T COLLABORATION

Some of the officials we interviewed had difficulty understanding the Commission's interest in developing collaborative S&T projects where the mutual benefits to both sides were concrete and demonstrable. Their difficulties with this position arose partly because they insisted on looking at S&T collaboration with the Community from the aid-related perspective on which EC funded S&T projects had been undertaken in the past. They also were of the rather traditional opinion that all international S&T exchange was mutually beneficial in principle and did not have to be proven in specific terms. The gulf in perception of the meaning of mutual benefit was much greater in the case of China than with any other of the countries studied for the SAST project.

This difference in perception might conceivably be a stumbling block in further discussions regarding collaboration along SAST lines if it is not addressed head on. However, it should be possible to clear up any misperceptions by careful discussion of the Commission's precise meaning of mutual benefit in this case. It is essential that this discussion takes place. The EC should be aware that great problems have arisen in the realm of international S&T exchange between China and the advanced countries in the past as a result of differing perceptions on issues that seemed straightforward at the outset.[26]

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[26]. These problems have cropped up in many sectors. See for example the case of the off-shore oil sector discussed in G.Oldham et al, "Technology Transfer to the Chinese Offshore Oil Industry," SPRU Occasional Paper No. 27., University of Sussex, 1988.

INDUSTRY-RELATED INITIATIVES

I.7.5. OPPORTUNITIES FOR FOREIGN ENTERPRISES

As noted above, despite some problems, the general thrust of the "open door" policy will remain in the open direction established earlier. Indeed, it is clear the government is increasingly anxious to attract more foreign investment and production activities by offering better terms and conditions than at any time during the 1980s. More specifically, there was acknowledgement in our interviews that Chinese reliance on Japan and the US as their main sources of industrial technology had to be moderated. Japanese reluctance to transfer technology was a particular source of irritation and it was pointed out that there were considerable trade advantages for European firms who were prepared to effectively transfer technology.

We believe this situation presents genuine opportunities that could be exploited by foreign enterprises who understand how to do business with the Chinese. The prospects, as noted earlier are particularly bright for firms operating in high technology sectors, for those able to put together technology-intensive projects in mainstream manufacturing sectors and for those able to guarantee that a majority of output will be exported.[27]

There is by now a great wealth of well documented and easily accessible experiences by foreign firms on the particular problems and rewards of operating in China on which these companies can draw in formulating their strategy.[28] There could be a specific role for the Community to play in promoting further investment projects by European firms. The officials we interviewed were not however in a position to offer much insight on what this role should be - other than to point out that the bilateral agencies of some European countries had previously been the main vehicles through which European governments had advanced the interests of their industrialists in China. Thus the Community will need to develop support programmes and initiatives that complement the efforts of bilateral agencies.

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[27]. A number of specific recommendations were made with regard to areas for industrial collaboration with Europe where the Commission might be able to play a facilitating role. The aircraft industry, motor vehicles, iron and steel and machine tools were singled out as mature industries where further collaboration would be welcomed.

[28]. There are many references but see especially the articles in The China Business Review for practical detail based on direct empirical research but see also for example B.B.Schlegelmilch et al "The China Syndrome: An Empirical Investigation of Danish Companies' Experiences in the People's Republic of China," Department of Business Studies, University of Edinburgh, Working Paper No 88/21 for an academic survey; Jim Mann, Beijing Jeep: The Short, Unhappy Romance of American Business in China, New York:Simon and Schuster, 1989 for in depth journalistic reporting; and Alan M.Webber, "The Case of the China Diary", Harvard Business Review, November-December 1989 for a management perspective.

I.7.6. TWO POSSIBILITIES FOR PURSUING INNOVATIVE FORMS OF COLLABORATION

There are two areas of possible collaboration where it may prove fruitful to have exploratory discussions with SSTC as well as with other elements of the government apparatus such as MOFERT, the agency concerned with foreign investment and trade or the Chinese Venture Investment Corporation (CVIC). The first relates to possible EC support for the fledgling but still operating venture capital agencies in China who are now being promoted by the TORCH programme. Such support could be tied to the participation of European firms or laboratories with Chinese firms in joint projects to develop new products or processes for domestic production and export. However, this is probably best considered as a medium term initiative since a number of obstacles still exist to the creation of a genuine venture capital market in China - such as tremendous distortions in the pricing system, the lack of a bankruptcy law and the very primitive nature of existing stock markets.

The second follows on from the earlier discussion of the emergence and development of scientific enterprises and minban firms in the civilian S&T sector. The S&T reform process in China, with its emphasis on the market and rewarding individual merit, freed a significant portion of the Chinese science community from the institutional and personal shackles under which they had been constrained since 1949. In this new environment, Chinese scientists and technicians demonstrated a willingness to experiment with organizational change and take quite exceptional entrepreneurial and career risks while at the same time producing good science that was often of international significance. Certainly, the activities of these scientists created many nodal points where the EC could develop innovative and beneficial collaborative projects.

While there is some evidence that minban firms are temporarily out of favour among more conservative middle ranking bureaucrats, we found a general endorsement among the officials we consulted for expanding European contacts with these firms. It is also clear that the government also attachs considerable importance to strengthening other aspects of the civilian S&T sector - including encouraging their linking up with foreign enterprises. In light of this, the EC could propose a programme of joint research and/or production ventures between scientific enterprises and European firms. This should be targeted both at the less favoured private sector minban firms and at those enterprises retaining state links. Such a programme would also obviously need to be well-defined by product, topic or problem area.

Such links would strengthen considerably the domestic position of minban firms. And depending on the project, European firms could conceivably benefit in a number of ways - through the lower unit R&D costs; through efficient product development work aimed at the local market; through access to product or process technology developed by the minbans themselves; and most importantly through the creation of a high tech base for the expansion of its operations in China. The Chinese officials consulted felt that collaboration with minban firms offered real possibilities for extending EC/Chir.a S&T collaboration into new areas. We offer this possibility as a topic for further discussion by the relevant Commission services.

I.7.7. THE PROVISION OF SUPPORT TO EUROPEAN HIGH TECH FIRMS INTERESTED IN INVESTING IN CHINA

Given the Chinese government's desire to attract, high tech and export oriented investment, there are other roles the Community could play in support of these firms.

One would be for the EC to facilitate the provision of information support to these firms in the way of intelligence reports on what the competition is doing and how the government operates, a digest of potential investment opportunities, informed discussions of the particular problems of doing high tech business in China, etc. Such an initiative would clearly need to be well designed, targeted and should complement or build on any ongoing Community projects in this area.

Another more complicated and costly initiative would be to propose EC sponsorship or support for a high tech zone or science park solely for use by European firms involved in high tech export activities.

COLLABORATIVE PROJECTS LINKED TO BASIC RESEARCH

I.7.8. JOINT RESEARCH WITH NATIONAL KEY LABS

China would appear to offer a wider range of possibilities for mutually beneficial collaboration in basic research than other advanced developing countries. Their capabilities are acknowledged as being world class in fields as diverse as short term pulses, quantum well structures, crystal growth, superconductors and analytical methods in materials research. Chinese officials interviewed were eager to encourage EC sponsorship of joint research and would be prepared to nominate a number of areas where such collaborations would be welcomed and receive favourable treatment.

The appropriate locations for such joint research would be in any of the 68 national key labs (30 established and 38 under construction) that have been specifically designated as national centres of excellence in basic research and as suitable for joint project with foreign scientists. As noted above, a listing of those national key labs where international collaboration is being actively promoted is given in Annex 4.

APPLIED SCIENCE-RELATED INITIATIVES

I.7.9. ESTABLISHMENT OF EC SUPPORTED APPLIED RESEARCH INSTITUTE TO SUPPORT JOINT RESEARCH INTO ENVIRONMENTAL AND AGRICULTURAL PROBLEMS

One aspect of co-operation the Chinese were keen to promote was the establishment of joint research centres staffed by European and Chinese researchers to undertake joint projects on topics of mutual interest in the environment and agriculture. Some of these have already been set up under the auspices of bilateral aid programmes but we were told this was an area that might be of interest to the EC. Among those already established are U.S. and Japanese programmes on seismic research, a French programme on plate tectonics, Canadian support for seafood research and Swedish support for dairy research.

As with the efforts of these other countries, the rationale for the EC further pursuing joint research projects of this kind derives both from the objective of mutual benefit (collaboration with world-class Chinese scientists would be of benefit to European scientists) and from more development aid oriented objectives.

I.7.10. DEMONSTRATION PROJECTS ORIENTED TOWARDS SYSTEMIC SOLUTIONS OF THE SURVIVAL PROBLEMS OF CLOSED OR ISOLATED COMMUNITIES

The Chinese stressed the success of an EC funded project that constructed an energy demonstration base on Daichen island. Various alternative energy systems have been built, tested and successfully demonstrated with the aim of supporting the community's economic development and diversification previously constrained by an energy shortage. Now both sides are undertaking a joint venture to explore commercialisation and production of these systems for sale in China and export. The officials we spoke to emphasized they would value similar projects tackling similar integrated problems affecting isolated communities.

NEAR-MARKET COLLABORATIVE ACTIVITIES

I.7.11. JOINT R&D PROJECTS LEADING TO COMMERCIALISATION AND PRODUCTION

China's most recent successful innovation in international S&T collaboration has involved activities that come very close to what we call near-market or pre-competitive research. One of these has been with Japan with whom Chinese researchers developed a new technology process for extracting niobium from molten iron. This has now been patented and has entered an experimental phase where mass production will be undertaken on a joint venture basis. They have done the same with France in relation to the development of a catalytic cracking agent for residual oil and are negotiating similar sorts of co-operative projects in relation to space and satellite technology with Germany and Brazil.

Given the pressure on China's R&D institutes to generate outside funding, and the undoubted technical capabilities of some of these in areas of interest to Europe, there would appear to be similar prospects for other near market joint research projects that could be sponsored by the EC. Among those fields put forward by the Chinese as offering opportunities for near market joint research are space related projects, telecommunications networks based on ISDN, optoelectronics and optical fibres in the 2 to 5 micro meter range.

We should make one further general point here that emerged from our interviews and should be kept in mind. In the more industrialized countries, a typical ratio of investment in research:development:production is 1:10:100. We were advised that in China, this ratio is closer to 1:0.5:several hundred. This imbalance is due to the Chinese government's past bias towards providing relatively generous support at the expense of investing in prototype and development activities as well as technology transfer. This means that there are probably lots of research achievements sitting "on the shelf" in China that have not been commercialized. European/Chinese collaborative efforts which focus on exploiting this dimension of Chinese S&T strengths would be well received and would have a high potential for generating mutual benefits.

I.7.12. JOINT VENTURE TRAINING INSTITUTES

Another collaborative model the Chinese are keen for the EC to explore relates to joint training institutes. Again in proposing this option to us the Chinese clearly had in mind a number of such institutes that have already been set up involving foreign governments and a mixture of aid financing and private industry support. For example, there is a Sino-U.S. Scientific and Technological Management Training Centre, a Sino-Japanese Business Management Training Centre and a Sino-Japanese Post and Telecommuni- cation Training Centre. All three of these institutes have clearly been supported by the Japanese and the U.S. government with an eye towards future business prospects.

Interestingly the EC also supports 8 such training centres. However these differ from the others in that the commercial connections are very remote since they deal primarily with energy related training matters. Clearly there is room for the EC to explore the possibilities of supporting additional training centres where the benefits to Europe might be more easily realizable.

I.7.13. EXPLOITING THE OPPORTUNITIES FOR COLLABORATION OFFERED BY THE 863 AND TORCH PROGRAMMES

The TORCH programme, designed to speed the commercialisation of new and existing high technology products and innovations within China and on an export basis is still in its early stages. Nevertheless, the officials we interviewed made clear that they would soon be looking to invite in foreign participation in different TORCH supported projects. Indeed, this may already be occurring and the relevant Commission services may have already been approached. This was emphasized repeatedly as the one of the key programmes where the EC should look to for collaborative possibilities.

The way be open for the Community to pre-empt such approaches (which are almost certainly going to be engineered by the Chinese side to attain maximum benefit at least cost) by proposing a major collaborative project linked into TORCH. Its conceivable that in the face of this approach, the Chinese authorities might be prepared to grant special access and privileges to participating European firms. As noted earlier, a list of TORCH programmes where such collaboration would be welcome is given in Annex 3.

PART II : DECISION BASE

II.1. - THE MAIN ELEMENTS OF REFORM AND ITS ECONOMIC CONSEQUENCES

II.2. - FAVOURABLE ECONOMIC IMPACTS OF THE REFORM PROCESS

II.3. - OVERALL EXCELLENT TRADE PERFORMANCE

II.4. - FOREIGN INVESTMENT PROSPECTS - BUILDING CONFIDENCE AMONG THE INTERNATIONAL BUSINESS COMMUNITY

II.5. - STALLED REFORMS AND INCREASING ECONOMIC DIFFICULTIES LEAD TO ECONOMIC RETRENCHMENT AND POLITICAL TURMOIL

II.6. - KEY POLICY INSTITUTIONS IN CHINA'S S&T SYSTEM

II.7. - SIZE AND STRUCTURE OF THE S&T LABOUR FORCE

II.8. - THE SCALE AND SCOPE OF CHINA'S R&D SYSTEM

II.9. - GROWING EXPENDITURE ON S&T

II.10. - CHINA'S INTERNATIONAL RELATIONS IN S&T : AN AREA OF STRATEGIC IMPORTANCE

II.11. - THE DEVELOPMENT OF CHINA'S HIGH TECH CAPABILITIES

II.1. THE MAIN ELEMENTS OF REFORM AND ITS ECONOMIC CONSEQUENCES

Under the leadership of Deng Xiaoping, China embarked on a process of far-reaching economic and institutional reform in 1978 whose aim was the pervasive modernization of the Chinese economy at all levels. The leadership embarked on the reform process for two reasons. First, living standards in the late 1970s had hardly risen above those of the late 1950s. In 1977 the average wage of employees in the state industrial sector was 8.4 per cent lower than it had been in 1957. As a result the population was growing restive and increasingly reluctant to accept continual hardship and belt-tightening in exchange for a promised brighter future.

Second, the leadership under Deng was forced to recognize that the early successes of the pursuit of Soviet-style industrial development had given way to stagnation and severe economic problems that were largely structurally determined. The critical nature of the problems faced was obvious not only from severe domestic difficulties but from growing awareness that the gap between China's economic achievements and those of the developed economies had grown massively - in 1960, China's GNP was nearly the same as Japan's but in 1979 it was less than one-fifth. The problems of economic and industrial development confronting China since the departure of the Soviets had not been relieved by either the Great Leap Forward or by the initial post-Mao economic strategy of the 1960s that laid great stress on ideological and moral incentives to stimulate expansion of the economy.

In short, the leadership and the Communist party faced both a crisis of political legitimacy in the eyes of the population and an internal collapse of confidence in the ability of previous strategies to produce economic development. The net outcome of this situation was that by 1979, the government was forced to make a public commitment to a strategy of "modernization" designed to improve living standards for the mass of the people in the short run. Bold projections were made that this bright future would come about through the pursuit of rapid economic growth in three phases - doubling 1980 gross agricultural and industrial output by 1990; doubling these output levels again by the year 2000; and finally reaching per capita income levels of moderately developed economies by the middle of the next century.

II.1.1. THE MAIN ELEMENTS OF REFORM

After a protracted period of debate and experiment that is extensively documented in the literature, a major programme of economic and institutional reform was instituted in order to allow the Chinese economy to meet these ambitious growth objectives. The reforms involved the phased introduction of fundamental changes on previous practice in four interlinked areas affecting every facet of Chinese economic activity.

Through the introduction of the "responsibility system" in the productive sectors, workers, managers and enterprises were given greater autonomy and offered incentives to increase output, improve quality and lower costs. These reforms were first introduced into the agricultural sector where they proved very successful and were extended, beginning in 1984 to the urban industrial sector.

Second, attempts were made to reform the price and wage system in order to give the market a greater (though not an entirely free) role in determining the prices of commodities, products and wages in both the agricultural and industrial sectors. Ultimately, this proved the most difficult element of the reform programme to implement both because of structural rigidities and the entrenched opposition of political conservatives.

The third, and most publicized component of the reform programme was the widely heralded "Open Door" policy which involved an unprecedented opening of the economy to foreign investment and international trade. This policy constituted the central element of the government's ambitious modernization strategy which, it was felt, could only succeed by bringing into the economy large inputs of foreign technology and capital. The objective of the Open Door policy was to re-equip China's antiquated industrial production base while also creating an internationally competitive industrial sector capable of generating the export earnings necessary to finance further development.

Finally, the fourth area of reform, closely linked to the other three areas involved a fundamental restructuring of the country's science and technology system. This was deemed necessary because in the leadership's view, the long term success of the modernization programme and particularly the attainment of the growth objectives was critically dependent upon China's ability to generate and diffuse science and technology that met directly the challenges of economic development. Thus the S&T system became closely identified as the main mechanism for improving economic performance and maintaining economic growth. Because of this, reform of the S&T system became a top priority for the leadership - and has remained so to the present.

II.1.2. THE COASTAL DEVELOPMENT STRATEGY

It is worth noting separately at this stage that a significant element underlying the Open Door policy in particular was a strategy to rapidly advance the development of China's southern coastal zone. Beginning with the establishment of the four special economic zones in 1979 (in Shenzen, Zhuhai, Shantou and Xiamen), and strengthened by moves taken under the Open Door policy and the S&T reform programmes, Chinese planners pursued throughout the 1980s in the midst of the overall reform process a coastal development strategy focussing on south China. This strategy was further advanced in 1984 by the further opening up of another fourteen coastal cities and three coastal areas and finally given a formal launching in the spring of 1988 with publication of a coastal economic development strategy and the establishment of Hainan Province as a special economic zone. By that time, this coastal zone covered some 320,000 square miles, populated by some 200 million people producing about 1,000 billion yuan of output.

The aim of this strategy was to develop within this massive coastal area an export-oriented economy characterized by both labour-intensive processing industries and high technology industries based heavily on foreign investment and imported technology. The intention was that the rapid expansion of the coastal zone would thus generate export earnings, act as a magnet for foreign investment and technology and give an impetus to the economic development of the inland areas through a process of take-off and inter-industry and inter-regional demand and supply.

This parallel policy (to the reform process) of using the selective opening of the Chinese economy to maximize access to Western and Japanese technology through foreign equity participation in designated areas not surprisingly was the aspect of Chinese policy that attracted very considerable commercial attention from foreign firms and governments.

II.2. FAVOURABLE ECONOMIC IMPACTS OF THE REFORM PROCESS

During the 1980s, the implementation of China's revolutionary reform programme and pursuit of its ambitious economic objectives garnered much international attention. Not surprisingly, the interest of western and Japanese governments and firms was attracted by the glittering commercial prospects created by the Open Door policy and the stirring of China's potentially enormous domestic market. However, many other observers were simply struck by the enormity of the task that faced the authorities in trying to fundamentally transform the Chinese economy into a dynamic engine of growth. The problems in doing so seemed to be almost insuperable at the outset. Yet looking back over the years since reform in 1978, it is clear that, despite the many problems encountered, this has been a period of momentous and remarkable change in China. The scale and scope of the change is most evident in the overall performance of the economy.

II.2.1. GENERAL PERFORMANCE OF THE ECONOMY

As shown by Table 1, during 1981-1988, real GNP achieved an annual growth rate of 9.8 per cent (11.1 per cent if measured between 1982 and 1988) and had reached $329.75 billion by 1988. This growth was underpinned by annual increases in real gross industrial and agricultural output averaging 12.8 per cent and 7.2 per cent respectively, and a 9.5 per cent annual growth in real national income. The growth rate achieved in all four areas during these years exceeded that achieved over the entire 1953-86 period. Moreover, during the 1980s, absolute levels in all these categories more than doubled over that period easily exceeding the first stage economic targets.

TABLE 1 : Economic growth in China, 1978-1988 (1980 prices)

	1978 (billion yuan)	1980 (billion yuan)	1985	1988	1981-87 (annual growth rate)
GIAOV	563.3	706.6	1333.3	2371.8	11.4
GIOV	423.6	514.3	971.7	1810.1	12.8
GAOV	139.7	192.3	362.1	561.8	7.2
NI	301.1	368.8	703.1	1153.3	9.5
GNP			833.1	1385.3	9.8

GIAOV - Gross industrial & agricultural output
GIOV - Gross industrial output value
GAOV - Gross agricultural output value
NI - National income
Source : A statistical survey of China (1988); Almanac of China's economy (1987)

A number of aspects of this aggregate performance are worth noting.

- China remains a poor country, with GDP per head at $340 in 1988 current prices, although in terms of life expectancy, nutritional standards and primary education availability its accomplishments particularly in the last ten years place it on equal footing with many middle income countries.

- Though the bulk of employment (60.1 per cent in 1988) is still in agriculture, industry is increasingly dominant. This is shown by the unusually large share of industry in total output (59.8 per cent in 1987). The urban economy dominates here with 60 per cent of industrial output coming from state-run enterprises.

- Most of the existing state-firms have experienced some change in their operating environment due to the reform programme. The most significant S&T related changes that have occurred were a) the rapid growth of a large number of medium and high technology consumer goods and industrial sectors (as shown by Table 2) which for example saw sectors such as consumer electrical products experience a 57 per cent expansion of volume between 1987 and 1988; and b) the emergence of technology markets as a source of innovations for existing firms and the growth of so-called scientific enterprises linked to the R&D system.

- The reform programme also created scope for the emergence of the private firms in the urban economy (at least through mid-1989) with the numbers of enterprises increasing from virtually zero in 1978 to nearly 225,000 by 1988 employing an estimated 3.6 million people with an average firm size of 16. Among this blossoming of the private sector, the most notable development from our perspective has been the growth of (a relatively small number of) entrepreneurial S&T firms along with the entry of more than 1 million scientists and engineers into part-time private consulting activities.

- Finally, and probably most significantly from a macroeconomic perspective, rural reform gave an enormous boost to the creation of private and collective rural light industrial enterprises engaged in industry, construction, transport, commerce and catering. Many of these are quite small producing consumer and industrial goods using agricultural inputs but a surprisingly large number are sizeable firms, well managed and able to compete directly with state-owned enterprises. By 1988 there were allegedly some 19 million of these rural or township enterprises employing more than 48 million people. Between 1982 and 1986 their output grew by a staggering 43 per cent annually (compared to 4.2 per cent for agricultural crops) so that by 1987 the value of their output exceeded that of agriculture itself. In 1988, their output growth was 38.4 per cent or three times as fast as the state sector, raising their share of national industrial output to 21 per cent and accounting for a remarkable $8.02 billion (16.2 per cent) of China's total exports (mainly in textiles, clothing and handicrafts). These industries constituted the most dynamic force for expansion in the economy creating new wealth and employment for millions of former peasants. However, as we shall see below, there is a widespread view that the rate and manner of this expansion caused enormous macroeconomic difficulties for which role these industries now face serious problems.

TABLE 2 : Output of consumer products industries, 1983-1987 (million units)

	1983	1984	1985	1986	1987
Refrigerators	.300	.400	.620	1.100	4.100
BW TV sets	6.820	10.000	16.150	14.500	19.750
Colour TV sets	.550	1.100	4.650	4.550	6.250
Cameras	.730	.625	.800	1.350	1.400
Washing machines	3.010	6.100	8.350	8.340	10.000
Sewing machines	11.000	9.650	9.900	9.800	9.800

Source : Compiled from data provided by State Statistical Bureau

II.3. OVERALL EXCELLENT TRADE PERFORMANCE

As noted above, a central focus of the reform effort was on foreign investment and trade expansion. There can be little question that reforms and policies directed at this area of the economic activity had a profound impact. Taking the area of trade performance first we can see that from the perspective of export-oriented economies such as South Korea or Thailand, China has historically exhibited a relatively low dependence on trade. However, during the decade of reform, international trade came to play an absolutely central role in modernizing the economy and sustaining growth and investment. As Table 3 shows, the rate of expansion in total trade has been notable starting from $28.2 billion in 1978 to $113.9 billion in 1989. This is roughly equivalent to an impressive 28 per cent of GNP, up markedly from the 15-18 per cent average of earlier decades.

TABLE 3 : China's merchandise trade, 1979-1989 ($ billions)

	Exports	Imports	Total
1979	13.2	15.0	28.2
1981	20.1	21.3	41.3
1983	21.0	20.0	41.0
1985	28.0	40.2	68.2
1987	39.1	40.7	79.8
1989	51.9	62.0	113.9

Source : Chinese customs statistics, various years

Table 3 also records the growing strength of China's export capabilities and shows the accompanying scale of import growth that had attracted so much interest on the part of foreign equipment suppliers. Between 1982 and 1989, exports grew at an impressive annual rate of 16.8 per cent over this period from $9.8 billion to $39.4 billion and placing China 16th among world exporters - up from 32nd in 1979. This performance demonstrates the success of Chinese policies to encourage exports via the provision of support to both domestic export-oriented firms and foreign enterprises - who for example saw their export earnings double between 1986 and 1987 to $1 billion.

On the import side, there was a fourfold increase in imports from $10.9 billion to $43.2 billion over the 1982-1989 period. This was equivalent to a 14 per cent annual rate of growth (17.6 per cent between 1978 and 1988). The continually rising trade deficit through this period reflects the country's commitment to massive imports of capital equipment as well as the effects of the relaxation on consumer imports in 1984-85. The widening trade gap followed by a sharp slow-down in import growth, particularly in 1985/86 and 1989/90 also reflects the government's ability to abruptly reign in imports when macroeconomic conditions worsen.

Tables 4 through 6 show different dimensions of China's commodity trade performance. Table 4 shows the changing commodity composition of exports and demonstrates the growing share of manufactured goods in overall exports between 1975 and 1986 - and which had grown to an estimated 72 per cent by 1989. Tables 5 and 6 show the principal elements of China's imports and exports over the 1982-86 period as well as a more detailed breakdown for the latest year on which comprehensive statistics are available, 1988. These tables demonstrate that China is still at an early stage of industrialization, with a high concentration on traditional manufactured exports such as textiles and clothing and heavy continued dependence on imported industrial equipment.

Table 7 captures the importance of China as a market for Western and Japanese capital goods imports in the mid 1980s when imports into the rest of the developing world were declining rapidly. Table 8 gives more details on this aspect of China's imports and shows the extremely rapid growth in imports of engineering and related services between 1982 and 1986 broken down by type of contract.

TABLE 4 : Commodity composition of exports, 1975 to 1986

Year	Primary products (% of total exports)	Manufactured goods (% of total exports)
1975	56.4	43.6
1978	53.5	46.5
1981	49.6	50.4
1983	43.3	56.7
1986	36.3	63.7

Source : Almanac of China's foreign economic relations and trade (1987)

TABLE 5 : Composition of exports and imports by commodity categories, 1982-1986 (% of total)

Export item	1982	1983	1984	1985	1986
I. Primary goods	44.97	43.28	45.66	50.58	36.43
- Food	13.01	12.84	12.37	13.89	14.38
- Beverages & tobacco	0.43	0.47	0.42	0.39	0.38
- Non-food raw materials	7.40	8.51	9.26	9.70	9.40
- Mineral fuels	23.78	20.99	23.06	26.11	11.90
- Animal&vegetable oils, etc	0.35	0.47	0.55	0.49	0.37
II. Manufactured goods	55.03	56.72	54.34	49.42	63.57
- Chemicals	5.35	5.63	5.22	4.96	5.60
- Textile & light industry, minerals & rubber products	19.25	19.64	19.33	16.42	19.02
- Machinery & transport equipment	5.65	5.49	5.71	2.82	3.54
- of which power machinery & electrical appliance	0.73	0.74	0.70	0.43	0.60
- special machinery	2.09	1.31	1.22	0.74	0.77
- telecommunication & consumer electronics	0.52	0.92	1.29	0.34	0.79
- other transport	1.36	1.64	1.76	0.77	0.47
- Miscellaneous	16.57	17.12	17.97	12.74	15.99
- of which clothing	8.70	9.27	10.15	7.49	9.41
- camera & watches	0.55	0.77	0.74	0.23	0.36
- other	4.79	4.64	4.72	3.17	4.03
III. Other products	8.21	8.84	6.11	12.48	19.42
Import item	1982	1983	1984	1985	1986
I. Primary goods	39.56	27.15	19.00	12.52	13.17
- Food	21.78	14.59	8.51	3.67	3.79
- Beverages & tobacco	0.67	0.22	0.42	0.49	0.40
- Non-food raw materials	15.61	11.50	9.27	7.66	7.33
- Mineral fuels	0.95	0.52	0.51	0.41	1.17
- Animal & vegetable oils, etc	0.55	0.32	0.29	0.29	0.48
- Metal ores & scraps	1.02	1.13	1.15	1.30	1.56
II. Manufactured goods	60.44	72.85	81.00	87.48	86.83
- Chemicals	15.22	14.88	15.46	19.58	8.79
Textile & light industry, minerals & rubber products	20.25	29.41	26.70	28.16	26.09
- Machinery & transport equipment	16.61	18.64	26.43	38.43	39.11
- of which power machinery & electrical appliance	0.66	1.09	2.15	3.13	2.74
- offices machines & data processing eqpt.	0.85	1.27	3.01	2.46	1.30
- telecommunication & consumer electronics	2.05	1.64	4.13	5.97	3.24
- other transport					
- Miscellaneous	16.57	17.12	17.97	12.74	15.99
- of which scientific instruments	1.45	2.84	2.39	2.08	2.53
- cameras & watches	0.45	0.48	0.68	0.94	0.76
- other	0.52	0.72	1.06	1.25	0.86
III. Other products	5.84	6.26	8.10	5.81	8.41

Source : Trade and price statistics in 1987, State Statistical Bureau

TABLE 6 : Major traded commodities, 1988

Exports	% of total	Imports	% of total
Textile yarn & fabrics	13.6	Industrial machinery	16.6
Clothing	7.9	Iron & steel	8.4
Petroleum & products	7.1	Electrical machinery	4.2
Textile fibres	3.5	Fertilisers	4.2
Vegetables & fruit	3.4	Cereals	3.4
Fish	2.0	Telecommunications & recording equipment	3.3
Animal feed-stuffs	1.8	Road vehicles	2.7
Oilseeds	1.4	Other transport equipment	2.1
Cereals	1.4		
Coal & coke	1.2		

Source : Econ. information and consultancy Co., China's Customs Statistics, 1988

TABLE 7 : Imports of capital goods in China and developing countries, 1981-1986

	Developing countries	China
1981	127	3.2
1982	120	2.4
1983	104	3.1
1984	101	4.8
1985	95	10.2
1986	98	11.3

Source : UNCTAD Trade and Development report, 1987

TABLE 8 : Engineering and related sales contracts to China, 1982-1986 ($ million)

Complete plant	157.0	250.5	581.2	2234.3	3651.8
Technical licenses	37.8	110.5	182.4	219.8	419.4
Technical services	39.9	183.3	128.5	12.9	235.8
Consultants	.8	8.0	6.6	8.9	12.1
Cooperative production	4.7	10.4	51.2	485.4	36.4

Source : R.E.Gillespie, "Foreign Engineering opportunities in China", China Business Review, sept-october 1988

II.3.1. MAJOR PROBLEMS LIE AHEAD

While the above data gives the impression of a perennially expanding import market in fact the prospects for even a medium term continuation of this trend are not as strong as suggested by the recent sustained slackening in overall import growth. Total imports were down an estimated 20 percent in 1989 and in the first four months of 1990 had slumped an additional 17.8 per cent over the 1989 figures with Japan suffering the sharpest decline in orders down 37.5 per cent followed by the EC and the Soviet Union both with an 13.2 per cent while the U.S., Hong Kong and Canada all registered increases.[29]

Obviously a good deal of this decline is due to import cutbacks imposed by the authorities in response to recent economic problems but we believe it unlikely that imports will soon return to their former levels. The latest Chinese forecasts call for a much reduced rate of import growth at around 5.5-7.5 per cent through the 1995. At approximately $69-$75 billion, this would still be $25-$30 billion greater than in 1989 and indicates China will remain a significant export market. It does, however, represent a dramatic decline from import growth rates of 14 per cent and more in the 1980s.

II.3.2. EXPORTS REPRESENT A BRIGHT FUTURE

The story with relation to exports is a very different one. Prior to Tiananmen Square, manufactured exports had not only been booming but China had begun to successfully diversify its export base beyond traditional products such as textiles and handicrafts. Partly this was lead by export-oriented foreign firms. First Hong Kong manufacturers of toys, luggage and low-end consumer electronics products (such as cassette recorders, phonographs and TVs) began to set up shop in the mid 1980s in the SEZs and other "open" cities and areas followed by Japanese, Korean and North American electronics and telecommunications firms. One piece of evidence that captures this effect is given in Table 9 which shows the scale and growth in SEZ exports between 1986 and 1989.

TABLE 9 : Exports from special economic zones, 1986-1989 ($ million)

1986	400.84
1987	607.30
1988	987.50
1989	952.87

Source : Elizabeth Cheng, "Down but Not Out", Far Eastern Economic Review, 8th February 1990, p.38

Domestic firms played a major role in exporting more technology intensive products as well. For example, they are significant players in the machinery and electrical products sectors which registered $8.3 billion worth of exports in 1989 - an increase of 35 per cent over 1988. Of this total, $1.21 billion was earned from metal products, $2.58 billion by processing and assembling imported materials, and most significantly $4.32 billion from

[29]. On the import side, steel imports were down by 50 per cent, consumer durables by 62 per cent (of which colour TVs down by 87 per cent) and cars down by 18 per cent - all areas where Japan is a dominant supplier.

machinery and electrical equipment, instruments and meters (up by 40.7 per cent) and making this the dominant product category in the group and including 19 products whose export value exceeded $100 million.[30]

The contribution of more technology-intensive products in the export mix has thus improved considerably, rising form approximately 4 per cent in the early 1980s to about 20 per cent by the end of the decade. In addition to this, China has enjoyed a modest but significant rise in exports of technology via licensing. These rose from less than $20 in the five period up to 1984 to approximately $112 million by the end of 1988.[31]

It is now clear (from a vantage point at the end of 1990) that despite a sharp downturn in mid 1989, China's trade performance has resumed its upward trend, registering a surplus of $1.31 billion in the first four months of 1990 compared to a deficit of nearly $4 billion a year earlier. Based on a combination of tighter import controls, growing international competitiveness, and continued government support for exports, this trend should continue through the 1990s.

II.3.3. TRADE PATTERNS BY COUNTRY

As shown in Table 10, in 1988, Hong Kong was China's major trading partner, followed by Japan, the EC, and the U.S. This ranking has been consistent over the last few years. Of more interest are Tables 11 and 12 which break down the commodity composition of Chinese trade with these countries between 1982 and 1986, and give a more detailed comparison between the U.S. and Japan for 1988. There are many aspects of the country/regional pattern of Chinese trading relations worthy of comment. Among the more important from our perspective are:

- the expected pre-eminent role of Hong Kong historically rests on re-exports, trade in services, the extensive and early involvement of Hong Kong firms in setting up production for export of low value added goods; more recently it depends on the growing synergy between the Chinese and Hong Kong economies. Interestingly, the Chinese connection has also been responsible for the growing strength of Singapore as a trading partner. Its total trade in 1988 of $2.5 billion brings it into sixth place exceeded among European countries only by Germany.

- the increasingly strong European export performance allowing Europe to retain a trade surplus with China throughout the period of reform; the marked shift in the composition of EC exports to China away from manufactured goods towards higher value-added machinery and equipment with manufactures and machinery accounting for 54 per cent and 20.2 per cent respectively in 1978 and 24.8 per cent and 57.0 per cent respectively in 1986; and China's continued dependence on labour intensive manufactures (such as textiles - 28 per cent of exports in 1984 and 1986) as its main export to the EC.

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30. At a more aggregate level, sectors averaging an export volume in excess of $1 billion were petrochemicals, textiles, farm and related products, machinery and electronic products.

31. See for example Eric Baark, "China's Technology Exports," The China Business Review, August 1988.

- the sharp differences in U.S.-China and Japan-China trade. From 1984-88 Japan exported more than three times as much to China as did the U.S. ($57 billion compared $18.5 billion) with Japan maintaining a multibillion dollar surplus over that period ($26.4 billion net) while the U.S. increased in deficit over those years from $400 million in 1984 to $4.2 billion in 1988.[32]

- this unevenness in trade performance between the U.S. and Japan is further compounded by extreme differences in the composition of trade. As Table 12 shows, Japan tends to export a high percentage of high value-added manufactured products and imports a large share of raw material and inputs, the U.S. tends to export raw materials and commodities and imports finished manufacturing products.

TABLE 10 : China's leading trading partners, 1988

Exports to	% of total	Imports from	% of total
Hong Kong	39.4	Hong Kong	21.9
Japan	16.7	Japan	20.0
EC	9.9	EC	14.7
Socialist bloc	7.6	- of which Germany	6.2
USA	7.1	USA	12.0
Middle East	4.8	Socialist bloc	8.0
ASEAN	5.9	ASEAN	5.5
- of which Singapore	3.1	Canada	3.4
		Australia	2.0

Source : Economic Information and Consultancy Co., China's Customs Statistics, 1989

[32]. Underlying this deficit is the spectacular growth in Chinese exports to the U.S. growing from $324 million in 1978 by tenfold to $3.38 billion in 1984 and then taking a quantum leap to $9.27 billion in 1988.

TABLE 11 : Chinese commodity trade with leading trading partners, ($ 100 million)

	Hong Kong		Japan		U.S.		EEC	
Export trade	1981	1986	1981	1986	1981	1986	1981	1986
Total exports	56.7	101	48.6	61.1	15.4	26.3	25.3	39.9
I. Primary products	21.8	23.2	38.2	48.3	6.2	6.6	11.3	10.9
II. Manufactured goods	34.9	77.8	10.5	14.6	9.2	19.7	13.9	29.1
Chemicals	2.1	3.5	2.1	2.6	1.0	1.6	3.6	4.3
Textile, menerals & rubber products	16.6	24.9	4.8	5.5	3.1	5.3	4.7	6.1
Machinery & transport equipment of which :	3.1	4.2	0.1	0.2	.49	.77	.18	.51
- power machinery	0.1	0.2	-	-	.02	.04	.02	.02
- special machinery	0.3	0.2	0.1	0.1	.14	.02	-	.02
- telecommunication & consumer electronics	0.8	1.9	.01	.05	.02	.04	-	.03
- electrical machinery	0.8	0.9	.03	.08	.03	.07	.03	.03
- other transport	0.1	0.1	3.5	5.6	4.5	11.2	5.4	7.5
Miscellaneous								
- of which clothing	5.2	4.6	2.2	4.0	3.6	8.6	2.6	4.3
- footwear	0.6	0.9	0.2	0.3	.19	.36	.42	.60
- cameras & watches	0.8	0.8	-	-	.02	.01	.08	.07
- other	5.4	5.1	0.8	1.1	.54	1.7	7.9	2.2
II. Other products	0.1	32.1	.03	.72	.01	.80	-	10.5
Import Trade	1981	1986	1981	1986	1981	1986	1981	1986
Total imports	12.7	56.9	62.8	124	47.6	47.2	27.7	76.6
I. Primary products	0.6	1.8	2.6	3.06	32.5	6.7	3.8	3.8
II. Manufactured goods	12.1	55.1	60.2	147*	15.1	40.5	23.9	72.8
Chemicals	0.2	1.3	5.9	8.4	5.3	6.9	7.8	9.3
Textile, minerals & rubber products	1.9	8.9	16.3	45.5	5.9	2.9	3.5	16.3
Machinery & transport equip. of which :	2.4	8.5	35.1	85.5*	2.6	25.6	11.4	43.6
- special machinery	.44	3.2	26.7	19.7	1.3	9.2	9.9	27.5
- offices machines & data processing eqpt	.17	.41	0.42	4.85*	.37	3.11	.22	.23
- telecommunication & consumer electronics	1.3	2.1	2.88	19.3*	.14	.67	.05	1.98
- other transport	.07	.23	0.98	3.6*	.39	11.9	.46	5.19
Miscellaneous	3.0	1.85	6.2	1.1	1.1	4.5	.88	3.4
- of which scientific instruments	.04	.26	0.91	3.53	.73	3.5	.61	2.7
- cameras & watches	.33	.70	0.57	1.44	.12	.61	.06	0.3
- other	.26	1.6	0.34	1.02	.11	.34	.19	.38
III. Other products	6.8	33.3	0.97	1.20	.31	.49	.23	.18

* : estimates

Source : Compiled from China Trade and Price Statistics, 1987, State Statistical Bureau

TABLE 12 : Japanese and U.S. China trade by commodity, 1988 (% of total)

Exports to China	Japan	U.S.
Vehicles	8.2	-
Industrial machinery, parts	10.0	-
Telecommunication and sound recording eqpt	11.1	-
Specialized machinery	14.0	11.5
Electrical machinery	16.6	-
Iron & steel	39.7	-
Organic chemicals	-	10.5
Fertilizers	-	14.6
Cork-wood	-	14.6
Cereals/cereal preparations	-	19.8
Artificial resins/plastics	-	25.5
Imports from China	**Japan**	**U.S.**
Iron & steel	8.3	-
Vegetables/fruit/fish	9.3	8.0
Textile fibres	10.3	-
Textile yarn/fabrics	15.8	22.3
Clothing	17.6	37.7
Petroleum/products	38.8	16.1

Source : Adapted from T. Thurwatcher, "Japan in China", The China Business Review, January-February 1990.

II.4. FOREIGN INVESTMENT PROSPECTS - BUILDING CONFIDENCE AMONG THE INTERNATIONAL BUSINESS COMMUNITY

As attested to by the prominence given to the Open Door policy throughout the 1980s, the leadership has consistently placed great emphasis upon attracting foreign investment to China as a means of gaining access to both foreign capital and foreign technology. Not surprisingly, foreign firms had initially a very enthusiastic response to the opening up of the Chinese economy and there was considerable euphoria in the early years over the prospects afforded by China's massive domestic market. Table 13 shows the slow start and then a massive jump in the number of investment agreements of different kinds signed in the 1980 - 1987 period as well as giving available details of the amounts invested across different types of agreement. Tables 14 and 15 show the distribution of agreements across sectors with manufacturing dominating and across countries where the dominance of Hong Kong entrepreneurs is clear right from the start.

TABLE 13 : Annual foreign investment in China, 1980-1987 (number of investments; $ million)

Type								
Equity joint ventures								
- Number of investment	20	28	29	107	741	1300	892	1399
- Value of investment	63	28	29	188	1060	2027	1375	1920
Co-operative ventures								
- Number of agreements	320	70	402	331	1089	1500	582	786
- Value of investment	500	1300	926	504	970	2189	1358	1286
Wholly foreign-owned ventures								
- Number of agreements			33	15	26	46	18	45
- Value of investment				4	99	32	20	470
Joint oil development								
- Number of agreements	4	0	1	18	0	4	6	3
- Value of investment	1112	0	170	1031	0	143	80	4

Source : Chen, Nai-Ruenn, Foreign investment in China : current trends, 1989; various Chinese sources

In 1986 there was a sharp contraction in foreign investment activity. The contraction occurred partly because of growing disillusionment by foreign investors with the difficulties of actually doing business in China and partly in response to the economic difficulties of the 1984-85 period. Three things happened to change this picture. First, after a short period of restraint in 85/86, reform driven economic activity picked up again making domestic prospects brighter.

TABLE 14 : International equity ventures in China by country, 1980-1987 (% of total)

	1980	1981	1982	1983	1984	1985	1986	1987
Hong Kong	55	57	72	73	82	71	69	67
U.S.	10	18	10	9	6	7	9	10
Japan	15	7	-	5	6	11	14	16
EC	10	7	14	9	2	4	7	5
Other	10	11	4	4	4	7	1	2

Source : Chen, Nai-Ruenn, Foreign investment in China : current trends, 1989; various Chinese sources

TABLE 15 : International equity ventures in China by sector, 1980-1987 (% of total)

	1980	1981	1982	1983	1984	1985	1986	1987
Agriculture	5	11	-	1	6	4	5	2
Manufacturing	65	57	66	57	61	68	68	67
Services								
- Oil related	-	14	3	10	2	4	8	6
- Engineering	2	4	14	7	3	9	9	10
- Tourism	20	4	7	8	10	6	4	5
- Other	8	10	10	17	18	9	6	10

Source : Chen, Nai-Ruenn, Foreign investment in China : current trends, 1989; various Chinese sources

Second, the Chinese government also responded to the growing unhappiness of foreign investors by implementing the October 1986 "Provision to Encourage Foreign Investment". This law made concrete improvements in the overall investment climate as well as decentralizing responsibility for foreign investment negotiation and export administration. Other adjustments were made to the treatment of intellectual property and technology, investment and joint venture contracts that also improved the investment climate.[33]

Third, more significant than legislation and institutional change was the cumulative effects of the protracted "learning process" that foreign firms and the Chinese authorities had gone through since the Open Door policy was launched. These new conditions began to become manifest in 1987 and by 1988-89, though all the problems had by no means been eliminated, both sides had learned how to negotiate with each other, to have realistic expectations about what was possible and to live within certain limitations imposed by the

[33]. There is an extensive literature on this subject. See for example the comprehensive review of the treatment of intellectual property in 1986 in Jamie P.Horsley, "Protecting International Property", The China Business Review, November-December 1986; and David B.Kay, "Trademark Update", The China Business Review, July-August 1988 as well as the articles by Gao Hang and Chris Oechsli in the same volume.

wider Chinese context. Most importantly, foreign business people felt they were dealing with a stable economy and government and with an open and manageable system.

Consequently, it is true to say that before Tiananmen, even in the face of increasing domestic difficulties and the 1988-89 austerity programme, there had been a boom in foreign investment. Between January 1987 and June 1989 the number of contracts signed grew by 400 per cent and their unit value by 67 per cent over the totals accumulated from 1979-86. In the first half of 1989, foreign investment was up by nearly 50 per cent. This included an estimated 410 contracts for wholly-owned enterprises signed in 1988 for a value of $480 million (up from 45 and less than $400 million in 1987) and 423 allegedly signed in the firs six months of 1989.

Importantly, an increasing share of this investment had begun to flow into capital and technology intensive projects rather than into the hotel and labour intensive assembly sectors. By 1988, the amounts actually invested by foreign firms had risen to above $2 billion annually ($2.4 billion in 1988) from only a few millions in the 1970s.

A very important dimension of foreign investment activity in China is that since the beginning of the Open Door Policy, foreign investment commitments have consistently exceeded actual investments. Thus for the 1980-88 period, real new investment from all sources totalled between $15 to $18 billion while investment commitments totalled some $32 billion. A good rule of thumb is that until June 1989, only 40 per cent of investments commitments were actually fulfilled - since then the gap has risen by an unknown factor.

As noted above, foreign investment activity is spread across a variety of forms. According to official Chinese statistics, there are now some 12,000 joint equity ventures, 8000 joint production operations and 1500 wholly foreign owned subsidiaries. However, again, these numbers have to be interpreted carefully since many of those counted by the authorities have no real substance.

Table 16 gives the geographical distribution of foreign investment in China between 1979-1987. Only two of the counties listed, Hunan and Shaanxi, are not on China's south/eastern coast thus indicating the success of the coastal development strategy and underlining the government's ability to direct foreign investment in the areas it desires. This implies the need for foreign investors to take seriously the new Shanghai/Pudong development strategy mentioned earlier.

Table 17 gives the top 10 foreign investors in China over the 1979-1988 period. The leading role of Hong Kong is clear as are the strong positions of the U.S. and Japan relative to European investors. Hong Kong is China's leading investment partner accounting for 70.8 per cent ($17.9 bn) of all approved projects involving foreign partners between 1978 and 1988. This ranking is mainly on the strength of investments in hotels and light assembly industries.[34] Hong Kong is followed in second place by the U.S. with 8.5 per cent ($2.4 bn), Japan third with 4.7 per cent ($1.3 bn) of the total and the EC with 3.9 per cent ($987 mn). Japan while taking third place in terms value is second in terms of numbers of projects.

[34]. This aspect also explains Singapore's surprising showing in fourth place - 70 per cent of its investments are in hotels and real estate with the rest in services and light manufacturing.

TABLE 16 : Geographic distribution of foreign investment in China, 1979-1987

Country	% of total	Country	% of total
Guangdong	61.0	Liaoning	2.2
Fujian	10.0	Jiangsu	2.0
Shanghai	3.0	Zhejiang	1.5
Guangxi	2.9	Shandong	1.4
Beijing	2.6	Shaanxi	1.1
Trianjin	2.4	Hunan	1.0

Source : China statistics monthly, November 1988

TABLE 17 : Leading foreign investors in China, 1979-1988

Country	Number of projects	Total value ($ million)	Percent of total foreign investment
Hong Kong	13,421	17,874	70.8
U.S.A.	647	2,398	8.5
Japan	647	1,313	4.7
EEC	-	987	3.9
Singapore	239	530	1.9
Germany	55	333	1.1
Spain	2	191	0.7
Canada	55	162	0.6
U.K.	54	160	0.6
Holland	14	156	0.6
France	50	147	0.5

Source : Data supplied by MOFERT

Japanese manufacturing investments tend to be concentrated in electronics, electrical appliances and electrical machinery and are a logical extension of the avalanche of consumer electronics products that poured into China in the mid-1980s from Japan; U.S. manufacturing investment involves a much larger variety of activities ranging from highly visible high tech projects across sectors such as motor vehicles, electronics, computers and advanced control equipment through a much larger presence in low tech sectors such as food processing, and apparel/shoe assembly. European investments tend more strongly to the medium-low technology end with some high tech exceptions in motor vehicles, electronics, flat glass, etc.

II.4.1. TECHNOLOGY TRANSFER

Accompanying the inward flow of foreign investment funds was an equally sizeable inflow of imported technology both embodied as part of the foreign investment and as arms length purchases of technology. This scale of this inflow dwarfed all previous importations of technology. For example, between 1970 and 1978, China signed nearly 300 contracts for imported technology valued at $9.9 billion - but very many of these were never completed and never paid for. In contrast, over the 1980-89 period, the government claims a real level of expenditure for imported technology in the region of $27 billion spread across more than 27,000 contracts.

Of this expenditure, the government claims that it spent some $15 billion on imports of high technology involved in 7000 contracts. We believe this to be a rather overinflated figure and estimate (based on information from interviewees) that in fact only about 30 - 35 per cent of total technology import expenditure was allocated to imports of more advanced technology from the western economies and Japan. Though details on recent import patterns are hard to come by, Table 18 documents Chinese high technology imports by country between 1980 and 1986. These show a consistent rise in expenditure in keeping with Chinese policy commitments and a not surprising third place showing for European high technology exports behind Japan and the U.S.

TABLE 18 : Know Chinese imports of high technology equipment, 1980-1986 ($ millions)

Total	930	674	581	1103	1422	3336	3561
Belgium	2	2	3	1	6	28	73
Denmark	6	5	6	11	16	17	20
France	44	34	40	32	41	238	192
Hong Kong	11	11	17	33	114	199	108
Ireland	0	0	0	0	0	1	3
Italy	11	11	6	10	23	70	121
Japan	204	310	176	279	467	887	1040
Netherlands	10	10	4	4	7	13	24
Spain	0	0	0	0	1	5	5
U.K.	129	70	55	53	76	113	139
U.S.	257	105	145	514	471	1332	1085
Germany	175	43	36	79	96	214	438
Other	81	73	93	87	104	219	313

Source : U.S. Central Intelligence Agency, "China : Economic Performance in 1987 and Outlook for 1988", Washington, D.C., 1988

II.5. ECONOMIC RETRENCHMENT AND POLITICAL TURMOIL

Despite the relative success of the reform programme, some very serious problems emerged during their implementation, particularly in the post-1985 period, that eventually led to the present economic and political crisis. Simply put, the reform process foundered on the inability (and often unwillingness) of the economy, bureaucracy, enterprises and individuals to cope with the enormous pressures for radical change that were placed upon them by the leadership.

These problems became visible at both the macro and micro level. At the macro level, the most serious was undoubtedly the emergence of an unprecedentedly high rate of inflation that went from virtually zero in 1978 to an average of 10.3 per cent by 1985 and growing sharply to more than 20 per cent in 1988 and close to 30 per cent in 1989 before the imposition of draconian credit restrictions which should at least halve it by the end of 1990.

The unbridled demand for consumption goods and decentralization of control over imports stemming from the reforms resulted in a ballooning of the country's foreign trade deficit to $14.19 billion in 1985 though this stabilized by 1987 to a lower but still uncomfortable level of $10-11 billion. In parallel, China's out- standing debt tripled between 1984 and 1987 to nearly $32 billion rising to $40-45 billion in 1989.[35]

At the micro level, economic reform in the rural and urban sectors fairly quickly ran into some very severe problems. In the rural areas, after the initial rush of success, the pace of reform was deemed to be too slow and partial particularly in relation to agricultural production per se - while the uncontrolled growth of household and collective enterprises placed enormous strain on the economy. In the urban areas, apart from some successes linked to the establishment of high tech industries, it proved far more difficult than expected to institute even the most basic reforms among the vast majority of state-run productive enterprises.

Inevitably, reform of the price and incentive structure was most problematic. So much so that by 1988 the prices of most industrial products were still not reflecting their true scarcity value and many state-run industries remained hopelessly inefficient and unproductive. As a result, serious shortages of raw material developed, major transport bottle-necks emerged and huge stockpiles of unsaleable, poor quality goods piled up through the latter half of 1987 and all through 1988. As noted above difficulties also plagued the efforts to attract foreign investment with rates of new investment sharply off in 1985-86 over earlier years though a number of these problems were addressed and overcome by new regulations regarding foreign investment issued in October 1986.

[35]. As a result of this situation, China faces a worrying period in the early 1990s when its annual debt repayments will be approaching $10 billion and its ability to refinance or rollover this debt will depend on the acquiescence of the international finance community - an uneasy prospect given the current political situation.

II.5.1. ECONOMIC AUSTERITY

Despite this success on the foreign investment front, China's other economic problems were not so susceptible to amelioration via state fiat. By mid 1988, it was clear that the reform process was at a critical juncture and the leadership was faced with a painful set of choices over the next steps to take. Despite earlier attempts at correction, the problems faced by the Chinese economy were widespread and fundamental.

In response to this situation, a strict austerity drive was instituted in early 1989 involving severe credit restraints, an abrupt slow-down in capital investment, a sharp cutback on imports and a reallocation of raw materials in favour of the state sector. This austerity programme had some impact on the economic front (and for instance led to a sharp reduction in inflation and a dramatic improvement in trade balances as imports were slashed) but it only exacerbated the political tensions referred to above. This unsustainable situation was ultimately resolved by the government's use of force in June 1989.

Since then the economy has continued to struggle both with the restraining effects of the austerity programme, the continued imbalances caused by the earlier reforms and deep-rooted structural weakness and the debilitating effects of political uncertainty and decisions to slow and in some cases reverse the process of reform as discussed in Part 1. Among the main features of the economic difficulties facing China are the following:

- GNP grew by only 4 per cent in 1989, the slowest rate since 1976 and less than half of the rate of growth over the last five years. Underlying this was a contraction in industrial output growth from 20.7 per cent in 1988 to 8.3 per cent in 1989 - with industrial growth in the last quarter of 1989 up by only 0.7 per cent; retail sales were down by 8.3 per cent in 1989; one government response to this slow-down has been to inject 25 billion yuan into the economy primarily to prop up inefficient state enterprises - this is two times what was needed in first nine months of 1989.

- in the wake of this, it is estimated that 20 per cent of all state owned factories are now standing idle (virtually all such factories ceased producing for part of 1989) while productive activity in some specific sectors such as consumer durables, which had experienced some of the highest rates of growth in the mid-1980s, had contracted by between 10 (bicycles and refrigerators) to 30 per cent (washing machines) while the computer industry is running at only 20-30 per cent of capacity;

- the stock of rural township enterprises, who were directly targeted in the credit squeeze because of the their alleged contribution to overheating the economy has been sharply reduced by the bankruptcy of nearly 4 million enterprises in 1989/90.

- credit restrictions and a downturn in demand led state and collective enterprises to slash their investment expenditures by 11 per cent in 1989 compared to a rise of 18 per cent in 1988;

- productivity in the state-owned enterprises in 1989 suffered a severe drop as well ranging between a 5 per cent decline Liaoning, an 8 per cent average decline in Peking and Tianjin and a 10.2 per cent decline in Jilin

- the slump has continued in 1990 with a further 2.2 per cent fall nationally recorded for the first quarter of 1990.

- the employment capacity of the economy has also been greatly weakened. Between 1980-1988 the Chinese economy generated an estimated 80 million new jobs - equivalent to four fifths of the entire non-agricultural labour force in the EC! The contraction in economic activity over the last 18 months has sharply reversed this pattern. Some 8-9 million people have been thrown out of work by the collapse of millions of township enterprises since the beginning of 1989; the urban state enterprise and collective sector are also shedding labour - for example employment in these sectors was reported down by 700,000 in the months of January 1990 alone.[38] The scale of these lay offs and the likely continuance of the crisis for some time yet, means the ability of the economy to absorb the continual stream of new entrants to the urban labour force is now under serious pressure.

- on the international scene, severe import restrictions contributed to the positive trade performance reported earlier. However, the authorities were nevertheless forced to introduce a 21 per cent devaluation in December 1989 - the first such devaluation since 1986 - and only 11 months later were forced to enact an additional 15 per cent devaluation in November 1990; both of these measures are designed to ease a burgeoning balance of payments problem that will be teetering on the brink of crisis for some years to come;

- finally, and of particular significance to our interests, a direct result of Tiananmen Square has been a reduction in foreign investor confidence that has lead, temporarily at least, to a downturn in new investment projects and proposals. Planned foreign investments were down by 25 per cent in the 4th quarter of 1989 and, allegedly, by another 20 per cent in the 1st quarter of 1990. It is reported that in the first six months of 1990, the foreign exchange value of negotiated foreign investments had in fact dropped by nearly 32 per cent.

[38]. Workers also suffered the additional blow of having their bonuses cut and of being compelled to participate in a forced saving plan by having to purchase government bonds worth one month wages.

II.6. KEY POLICY INSTITUTIONS IN CHINA'S S&T SYSTEM

Responsibility for civilian S&T matters in China is shared by a number of organizations. The State Science and Technology Commission (SSTC) is now effectively the Ministry for S&T and reports to the State Council, the highest in the land. SSTC's position within the government system vis a vis S&T has recently been strengthened by the planned dissolution of the Leading Group for Science and Technology in 1988 - as noted the chief architect of the S&T reforms introduced in 1985. SSTC is the focus for S&T planning and implementation at a national level and acts as the central co-ordinating body for S&T activities in China. Consequently, it is directly or indirectly involved in most aspects of S&T development.

On the planning side, SSTC co-operates closely with the State Economic Council (SEC) and the State Planning Commission (SPC) in identifying priority S&T projects necessary to fulfil the economic objectives of the National Plan. Similarly it works with line and socio-economic ministries to identify projects for inclusion in the National Development Plan and in the various national S&T plans that it produces. (See Table 19) Typically, each ministry has a department of science and technology responsible for S&T related activities and projects linked to the national plan.

Similarly, each province has its own science and technology commission, as do some counties and cities with whom the national SSTC consults at the planning stage and then co-operates with at the execution stage. The power and competence of these local S&T commissions varies widely, with those in the southern regions and cities such as Guandong and Shanghai being the most powerful.[37]

At the risk of oversimplifying the Chinese system for organizing and administering S&T activities we would characterize SSTC as involved principally with the formal S&T/R&D network and with the generation of new knowledge and S&T solutions while the SPC and more predominantly the SEC now have a fair measure of responsibility for the diffusion and introduction of technology in the productive sector.

The SPC is responsible for preparing the 1 and 5 year economic plans that govern the development of the Chinese economy and for ensuring the necessary human, financial and physical resources are available to execute the plan. This function involves the SPC in planning and implementing large scale (usually in excess of $5 million) strategic projects requiring technology importation and transfer.

The SEC has traditionally implemented the plan and has taken a leading role in economic reform. It comes into direct contact with technology issues through its responsibility for overseeing the technological transformation of the established Chinese enterprise - efforts which inevitably involve importing technology.[38] During the just concluded Seventh

[37]. See for example the discussion in Saitch, op.cit.

[38]. Another important ministry whose activities have a high S&T component is MOFERT, whose responsibility is to plan and administer foreign trade. This brings it into direct contact with technology issues through its provision of advice to domestic and foreign enterprises seeking to import technology on the needs, domestic availability and international sources of technology and through its involvement in approving technology transfer contracts.

Five-Year Plan (1986-1990) it had responsibility for 3000 transformation projects as well as for some 14,000 technology import projects.

TABLE 19 : Main Chinese science and technology plans and programmes

Long-Term Plans	
1956-1967	Ist S&T Development Programme
1963-1972	2nd S&T Development Programme
1978-1985	3rd S&T Development Programme
1986-2000	15 Year Programme for S&T Development Programme (incorporating the 863 Programme)
Five Year Plans	
1980-1985	Sixth Five-Year Plans for Key R&D Projects
1986-1990	Seventh Five-Year Plans for Key R&D Projects
1991-1995	Eighth Five-Year Plans for Key R&D Projects
State Priority S&T Project Plan (Launched 1975)	
State Priority Basic Research Project Plan (Launched 1985)	
State Priority Industrial Experimental Project Plan (Launched 1984)	
State Priority Technological Import & Digestion Project Plan (Launched 1987)	

Source : Compiled from a variety of published and unpublished sources

In addition to these established institutional S&T actors, the development of Chinese S&T is also often pursued through the establishment of special ad hoc groups set up to plan and then oversee S&T activities at the national, sectoral or topic level. This strategy is pursued both to focus national expertise on a problem area as well as to overcome the problems of bureaucratic malaise and cross-institutional rivalry that often bedevil the workings of the Chinese system for organizing S&T. Thus they are likely to include fairly heavyweight political players as well as top flight S&T expertise. The establishment of the Leading Group for Science and Technology is the best known case of this approach but there are others.

One of the more successful and powerful of the sectoral leading groups is the one formed in 1983 with responsibility for the development of the computer and electronics industry as discussed below. Ad hoc expert groups have also been convened to assist in developing technology plans for specific areas - since 1983, they have been responsible for drawing up and overseeing implementation of technology policies in 14 fields such as energy, transport, communication, agriculture, machinery, raw materials, urban construc- tion, IT and biotechnology.

II.6.1. OTHER KEY ACTIVITIES OF THE SSTC

In addition to its national planning activities, the SSTC, along with the SPC and SEC, is also directly involved in the design, management and implementation of a large variety of special S&T related projects and programmes outlined either in the national plan or specified in specific S&T plans. The main thrust of SSTC's activities in this area can be seen as one of "science and technology push." and it currently operates five major programmes to stimulate S&T development that are described in more detail below in Section.

The SSTC also operates a variety of smaller programmes to promote S&T modernization and has a direct role in implementing various aspects of the S&T reform process (described in Part 1) particularly those dealing directly with the management of R&D institutes. It also has responsibility for international S&T collaboration and currently oversees more than 50 agreements with countries, regional governments and bilateral and multilateral organizations. These are discussed below. Annex 5 identifies the major departments of the SSTC and gives a further idea of the scope of the work of the SSTC

There are three other major national S&T organizations that in theory come under the aegis of the SSTC but in reality act in very independent fashion. These are the Chinese Academy of Sciences, the National Natural Science Foundation and the Chinese Association for Science and Technology. Of these, the Chinese Academy and the National Natural Science Foundation are of particular interest and are described in more detail below.[39]

II.6.2. THE CHINESE ACADEMY OF SCIENCES (CAS)

The CAS is the premier government scientific institution in China and was established in 1949. It has gone through a variety of changes and was deeply affected by the S&T reforms described in Part 1. The CAS now has three main functions. The first and most traditional is to act as an assembly of leading Chinese scientists, similar to the Royal Society, involving 352 academicians organized across five divisions (earth science, biology, maths and physics, chemistry, and engineering. Membership of the Academy is aspired to by most young scientists as it is the most prestigious scientific honour awarded in China.

The second and most innovative function of the CAS was discussed in detail in Part 1 and relates to its role as a catalyst in the creation of a network of new scientific enterprises whose aim is to develop high-tech products; and to its direct involvement in applied co-operative research projects with universities, the defense sector, industrial ministries and local government. These activities have come about as a direct result of the reform process

The third and predominant function is to act as a comprehensive nationwide research unit geared towards harnessing thee country's S&T capabilities to the tasks of national development. Its work is mainly devoted to natural science and basic research and it is the premier institution in both of these areas. This work is carried out through support of the research and related activities of a network of over 150 institutions comprised of 12 regional branches, 123 research institutes, a number of scientific instrument factories, independent libraries and the Chinese National Science and Technology University. In addition to its direct responsibilities for this R&D network, the CAS often serves in a review and advisory capacity towards the S&T system and other government agencies not only

[39]. CAST serves as an umbrella organization for 150 national science associations and over 120,000 local and provincial S&T associations. CAST is principally concerned with the popularization of science (identified as an area for possible collaboration), the organization of international academic exchanges and continuing education. CAST organizes about 1500 S&T seminars a year of which 40-50 are of international status.

getting involved in planning activities but also assisting to evaluate the research activities and scientific capabilities of non-CAS research activities.

CAS employs a total staff of 82,326. The composition of this workforce across CAS institutions and by area of activity is given in Tables 20. CAS approves the research budgets for these institutions and has some administrative control through this function, 3-5 year independent reviews and its ability to appoint institute directors. Typically however, the research institutes themselves are very independent particularly in the wake of the S&T management and financing reforms described in Part 1 which lessened the ability of CAS to exercise control.

TABLE 20 : Staff composition of the Chinese Academy of Sciences

Category	Number
A. Total staff	82,326
B. Employed in 123 research units	6,855
of which scientists & engineers	37,006
other S&T personnel	10,124
C. Staff engaged in S&T activities	53,727
of which scientists & engineers	34,987
other S&T personnel	8,276
1. In R&D tasks	
of which scientists & engineers	28,219
other S&T personnel	7,618
2. In S&T services	
of which scientists & engineers	4,330
other S&T personnel	9,193
3. In S&T management	
of which scientists & engineers	2,438
other S&T personnel	1,929

Source : SSTC, Guidelines to China's science and technology system, 1988, Beijing, S&T documents press, July 1989

CAS institutes are also of very uneven quality with some capable of world class R&D and others relatively far behind the frontiers of knowledge. Nevertheless, the CAS and its institutes taken together represents both the wellspring of the country's S&T capabilities (including much of the country's basic research and high tech R&D capabilities) and the one of the key mechanisms through the which the government pursues its S&T policy.

For example, during the Sixth Five-Year Plan period, (1980-85) the Academy was a leading actor in the nation's key S&T projects. 27 civilian projects incorporating 441 subjects were undertaken involving 85 institutions and some 5600 S&T personnel while more than 50 institutes undertook 200 military R&D projects. Under the auspices for the Seventh Five Year Plan, in addition to its central and continuing role in the National Key Labs Programme (described below), the Academy participated in 47 projects, 140 subjects and 529 topics involving 109 Academy institutes and 7000 scientific staff.

The CAS is also a major training Centre for young scientists with 118 institutions offering master's degrees and 83 institutions conferring doctoral degrees. Since 1978, 3500 graduate students have received CAS Master's Degrees and 820 Ph.D degrees. Between

1978 and 1987, the Academy sent 5.888 persons to study abroad of which one-third were postgraduate students. CAS is a also a major focal point for international scientific exchange and it has signed co-operation agreements with 50 foreign counterparts and universities which have in turn facilitated more than 5000 two way exchange visits per year with foreign scientists - five times the number in 1978.

II.6.3. THE NATIONAL NATURAL SCIENCE FOUNDATION OF CHINA

After 4 years of experiment, the State Council set up in 1986 the National Natural Science Foundation of China (NSFC) as part of its strategy to strengthen China's basic and applied basic research capabilities - as was discussed in Part 1. Though guided by the SSTC, the NSFC is independent from other administrative bodies and receives its funds directly from central government. Its objectives are to guide, co-ordinate and support basic research through the administration of a central fund provided by the central government.

Before the establishment of the NSFC, unallocated state funding for basic research (i.e. not tied to state specified projects) stood at less than 50 million yuan annually ($) (out of a total spend on basic R&D of 800 million yuan in 1987). However the NSFC budget has grown steadily in the past three years to approximately three times that much in 1989 or around 150 million yuan. NSFC grants are used only for direct expenditure on research projects, not for wages and other expenses - if these were included, the amount of funds involved would be over 300 million yuan. Interestingly, the NSFC is allowed to clawback 15 per cent of any profits arising from the exploitation of research it has funded.

The NSFC is widely reckoned to have been one of the more successful S&T institutional innovations in China in recent years. The stability of the institution, the visible degree of political commitment to it by central government and related to this, its growing financial resources (expected to double in the first few years of the Eighth Five Year Plan) has attracted and given stability to the careers of many thousands of scientists engaged in basic research in China. This has immeasurably strengthened the core structure of China's basic research capabilities The growing importance accorded to NSFC is also indicative of the significance attached by central government to the strengthening of the country's basic research capabilities.

Some measures of the NSFC performance are that more than 50,000 researchers operating in about 1000 institutions have received NSFC funds over the last three years via over 10,000 projects; some 10,000 researchers have been trained and 27,000 post-graduate students supported through taking part in NSFC funded projects; some 32,000 papers and books of high academic merit have been published based on NSFC projects - one fifth of these by foreign publishers and journals; and finally NSFC has established 162 collaborative international projects under 51 agreements while hosting 57 international conferences in China in 1987, 96 in 1988 and over 100 planned for 1989.

Equally important is the fact that the NSFC has taken the lead in breaking down the tradition of administrative departments making decisions regarding research projects - thus removing politics from this critical area of S&T development (at least until the events of June 1989) The majority of NSFC funding is allocated via an open competition to so-called "free application" projects. Any scientist can apply for an NSFC grant in any field. Evaluation of projects submitted for funding is carried out via a peer review mechanism involving 15,000 experts and a set of scientist staffed evaluation panels.

Projects are only supported if there is a guarantee by the scientist's institution that it will cover all necessary wage and related overhead expenses. However, the institutions cannot interfere in the projects; scientists are responsible to the NSFC only and only the scientists may decide how to use the grants provided and how to implement the projects. This is a truly revolutionary departure from the previous system of support for basic research which was riven by petty politics, allocation was made on the basis of non-scientific criteria while administrators were able to interfere with the conduct of the research and allocation of the grant.

The NSFC supports three types of projects - free applications projects, key projects and major projects. The average support for free application projects over the 1986-1989 period was approximately $30,000 and 8690 projects were supported over that period. 80 key projects (selected from the above) received larger amounts (an average of $79,200 because they were deemed to be of particular academic significance and have clear application possibilities. Major projects representing frontier R&D and oriented towards solving ley national problems received 30 per cent of total funds. Up to 1989, 56 major projects involving 400 topics had been approved at an average rate of $390,000 per project. The allocation of funds across disciplines for the 1986-88 period is given in Table 21.

TABLE 21 : Disciplinary breakdown of NSFC grants, 1986-1988 (% of total)

Discipline	Share of total grant funds
Mathematical & physical sciences (including astronomy & physics)	12.0 %
Chemistry and chemical engineering	17.9 %
Life sciences (including biology, medicine, agriculture & aquaculture)	26.3 %
Earth sciences	13.6 %
Materials & engineering sciences	16.6 %
Information & management sciences	13.6 %

Source : Li Guang Lin : "The National Natural Science Foundation of China", Science and Public Policy, vol 17, N°.4, August 1990

Interestingly, though 1000 institutions in all were supported through NSFC grants and China has more than 1000 institutions of higher education and some 5800 R&D institutions, 70 per cent of the grants given by the NSFC were allocated to 131 CAS R&D institutions and 31 key universities directly under the State Education Commission In addition the 56 major project grants mentioned above were concentrated in 40 key state laboratories and 7 open laboratories. This indicates clearly that China's national capabilities in basic research are concentrated in a small number of institutions and that the NSFC is playing a key role in further developing these. Table 22 gives details of the NSFC grants (approximately $18 million) in 1987 that were directed towards high technology R&D projects in the CAS, "key" and "open" laboratories. We were informed during our interviews that NSFC would be pleased to discuss its priority areas for R&D co-operation with the EC.

TABLE 22 : Allocation of NSFC funds to high technology R&D projects, 1987 ($ million)

Field	No. of projects	Amount
Biotechnology	36	4.14
Space technology	24	2.19
Information technology	42	3.08
Laser technology	12	1.08
Automation technology	35	2.52
New energy technology	35	1.54
New materials technology	44	3.31
Totals	228	17.86

Source : Li Guang Lin : "The National Natural Science Foundation of China", Science and Public Policy, Vol 17, N°.4, August 1990

II.7. SIZE AND STRUCTURE OF THE S&T LABOUR FORCE

Statistics governing the size and composition of China's S&T manpower are incomplete, contradictory and often confusing. The most reliable data set relates to what are called natural scientific and technical personnel in state owned R&D units. These consist of science and technical graduates (in science, engineering, agriculture and medicine) of universities, colleges and secondary technical schools who have technical or scientific posts (including R&D), workers and peasants who have been promoted to do research or are engaged in education of production techniques, and people with the same qualifications who are doing administrative work related to S&T in state-owned organizations, enterprises and institutions.

By the end of 1988, China had a manpower stock of 9.66 million people in these categories, up from 7.35 million in 1984. Of these 800.000 are scientists and engineers directly engaged in scientific research and technology development. Between 1978 and 1988 there was an 8.4 per cent annual increase in the stock of trained S&T personnel.

II.7.1. STRUCTURAL PROBLEMS IN THE DISTRIBUTION OF S&T MANPOWER

Both Chinese and foreign analysts have identified a number of severe problems relating to the internal structure of the S&T labour force which have been addressed during the reform period but which continue to plaque to system. Four of these are worthy of brief mention. First, there is a fairly massive shortfall of S&T personnel at all levels relative to the country's needs. This is particularly acute in high technology sectors but also affects other areas such as public health and agriculture. Second, the quality of existing S&T personnel, particularly engineers and related technical personnel, and their absorptive capacity is low. This is partly because of poor training but more because they have been kept away from exposure to modern methods and techniques for so long.

Third there are serious distortions and imbalances between the nature and distribution of existing S&T personnel and the needs of the economy. One dimension of this is that there are not enough senior people in the system with technical expertise and management experience. Another is that the ratio between skilled and unskilled groups, between administrators, scientific and technical personnel and "scientific" workers with no formal training, and between high, middle and low skilled workers. This is largely a legacy of the interruption in training caused by the Cultural Revolution and of the way in which skilled personnel were given job assignments in the past.

Finally, it is alleged that there is a serious problem of inappropriate allocation of people - particularly with respect to the S&T capabilities of different sectors. In short, there are too many people working in the wrong fields and the wrong locations. The previous emphasis on the military and heavy industry meant that these sectors received a large share of qualified personnel while light industry and agriculture were and are seriously deprived of access to technical personnel. Another dimension of this problem is a highly uneven geographical distribution of S&T personnel characterized by very high concentrations in Beijing, Shanghai, Tianjin and the industrial North-East. In Beijing and Shanghai, the ratio of engineers in state-owned units to the total municipal population in 1987 was 1:55 and 1:71 respectively while in Anhui it was 1:649 and in Tibet 1:1037.

II.7.2. ADDRESSING THE PROBLEM OF LABOUR MOBILITY

A key element of the S&T reform programme addressed directly this problem of S&T labour mobility. Under the old system, there was no job mobility. Once a scientist had been assigned to a job, it was to all intents and purposes, theirs for life. Further compounding the problem was the practice of many training institutions of identifying bright and promising students and then seeking to retain their services while letting go of the less able students.

Such practices seriously constrained the diffusion of knowledge and resulted in the distributional distortions referred to above. The aim of S&T reform in these areas was to devise a set of mechanisms whereby talented S&T personnel could move to those places where their skills and expertise were valued highly and would be put to good use. Various measures were introduced including renewable contracts, the granting of freedom to S&T personnel to engage in consulting work, and so. Prior to June 1989, it was clear that these measures were beginning to enjoy considerable success. Leaving aside the issue of those S&T personnel who have left the state-supported R&D sector entirely, by the end of 1988 some 485,000 S&T personnel has left their home institutions and taken up jobs in other organizations.

II.7.3. THE HIGHER EDUCATION SYSTEM

China has come a long way in the development of its higher education system particularly given the disruptions caused by the Cultural Revolution. By the end of 1987, there were 1063 full-time institutions of higher education up from less than 200 in the 1950s.. Among these were 602 universities and colleges, 339 two or three year colleges and 122 short-term professional colleges.

There were 1.959 million students enroled in this sector and 385,000 tutors. Of these there were 106,185 graduate students, including 7319 Ph.D students, 92,215 M.A. students and 6,615 enroled in graduate courses. These numbers compare very favourably with only 300,000 full-time students in 1983, 37,000 graduate students, 18,000 masters students and only 29 doctoral candidates. The rapid growth recorded in the early-mid 1980s is expected to continue. By the end of 1990, there are expected to be 2.6 million graduates from regular university course and 200,000 from postgraduate courses.[40]

Table 23 presents data on the distribution of S&T postgraduates across fields of study for 1988 and shows the extremely high degree of concentration in engineering and natural sciences.

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[40]. Though large, the higher education sector is dwarfed by the primary and secondary education system. There are some 220 million pupils in China, with 10 million new entrants every year taught by some 10 million teachers of whom 8 million work in primary and secondary schools.

TABLE 23 : S&T postgraduates by field of study, 1988

Field	
Natural sciences	24.5 %
Engineering & technology	40.3 %
Medical sciences	10.8 %
Agricultural sciences	7.6 %
Humanities and social sciences	16.8 %

Source : compiled from data provided by SSTC

As with the higher education system in most developing countries, there are many problems. Perhaps the most relevant to our concerns is that despite the emphasis placed on developing China's high technology capabilities, educational opportunities in these areas are still relatively limited. For example, far too many students are still taking traditional mechanical engineering and agricultural courses as opposed to being able to specialized early on in electronics, computer science, biotechnology, materials science and information technology. Improvements are occurring coming but these are slow in coming.

One notable exception is that, at least until June, 1989, there seemed to be an insatiable supply of students wishing to train abroad. During the second half of the 1960s and most of the 1970s only 1217 students had gone abroad for training. Between 1979 and 1985 some 47,500 government sponsored students were trained abroad. Between 1985 and 1988 this number had nearly doubled again. Two points should be noted. Despite the attraction of foreign countries, most students in fact return to China after their overseas training - or did until the Tiananmen Square massacre. Certainly a far higher percentage that compared with India. Second, 80 per cent of these were engaged in the study of science or engineering. Third, well over 70 per cent of overseas students go to the U.S.

II.8. THE SCALE AND SCOPE OF CHINA'S R&D SYSTEM

China's state supported research and development system is composed of five major elements (once described as the "five front armies") - the Chinese Academy of Science and its affiliated institutes; the institutes associated with the higher education system under the direction of the Ministry of Higher Education; the institutes under the control of various ministries and state commissions; the national defense research sector and institutes under the direction of the local government system.

Unfortunately, comparable, comprehensive and up to date data on the Chinese R&D system is not available beyond 1986. At that time the number of all R&D institutions affiliated with government departments at different levels stood at 8640, of which 5,394 were above the county level (up from 4006 in 1979). By 1988, the number of R&D institutes above county level had risen slightly to 5,671. These figures excludes those within the education system, institutes which are at or below the county level and thus under the control of local government, and those controlled by industrial enterprises. Table 24 gives further data.

TABLE 24 : China's R&D institutions and distribution of personnel, 1988

	Total institutions	Scientists & staff	Other S&T engineers	Personnel
Total	5671	1043991	410456	210244
R&D institutions above county level	5275	1017674	397245	203313
Affiliation natural sciences & technology	4933	996342	383538	198936
Social sciences & humanities	342	21332	13707	4377
Information institutions	396	26317	13211	6931

Source : Calculated from data supplied by SSTC

Tables 25 and 26 summarize various aspects and characteristics of the state-supported R&D system above and below the county level. Among the interesting points to note are the numerical importance of R&D institutes at or below the county level and the predominance among these of relatively small institutes; compared to the numerically smaller institutes directly under central government or the CAS and their larger average size; the heavy bias towards agricultural R&D (accounted for by the activities of institutes at or below county level which are virtually all concerned with agriculture or rural industry).

An element of interest not shown by the data is the sharp increase in the number of institutions under central government control between 1985 and 1986 (from 622 to 1044). This increase is the result of the S&T reform process launched in 1985 and represents the shift of a number of military R&D institutes to control of the civilian sector.

TABLE 25 : R&D institutions and their personnel in natural sciences and technology, 1988

	Total institutions	Scientists staff	Other S&T & engineers	Personnel
Total	4933	996342	383538	198936
Agriculture, etc.	1524	161322	46649	28895
Manufacturing	1904	504448	185379	94535
Geological	81	20711	11129	3822
Communication & transport	127	26452	11777	5509
Environmental	647	181886	89373	35318
Other	650	101523	39231	30857

Source : Compiled from data supplied by SSTC

TABLE 26 : R&D institutions at or below the county level, 1985

	Number of institutions	Number of staff
Total	3267	77435
Agriculture, forestry, fishery	2524	67782
Industry	469	6268
Geological	3	15
Construction	12	280
Communication & transport	4	60
Other	255	3030

Source : Statistical data on science and technology of 1985, Beijing, SSTC

II.8.1. CHINA'S CORE R&D CAPABILITIES

We have already highlighted the three main dimensions of what we consider to be the core of China's high tech and leading edge R&D and S&T capabilities. These are to be found in the CAS institutes reviewed above; in the network of national key labs and open labs that fall directly under the jurisdiction of the State Council as discussed in Part 1; and as also discussed in Part 1, in the emergence of the non-government R&D/S&T production sector with its orientation towards high tech research and production. Below we review the other four main elements of China's R&D system.

II.8.2. R&D CAPACITIES IN THE HIGHER EDUCATION SECTOR

The research institutes associated with the higher education sector are the weakest element in the Chinese R&D system. This derives from the historical separation between research and education that was adopted as a policy in the 1950s and not fully abandoned until the middle of the 1980s. At the end of 1987, there were 1076 full-time institutions of higher education in China which included fully-fledged universities offering the full range of disciplines, polytechnic universities specializing in science and engineering, and specialized institutes for particular areas of technology. The total budget for the higher education system in China, including R&D came to approximately $6.6 billion in 1988.

However, the historical lack of attention to research in higher education and the lack of adequate financing for education as a whole let alone the limited provision of funds for advanced research in this sector has meant that the promotion of research in these institutions has encountered considerable difficulties. Neverthe- less, an estimated 976 higher education institutions were engaged in some form of scientific research in 1989. This was carried out among 1514 R&D organizations of which 641 were research institutes and 831 research laboratories. The State Education Commission funds 36 of these universities directly, including the key and superkey universities, another 200 are funded by government departments and the remainder by the provincial or county governments.

A number of measures have been taken to strengthen research capabilities in the higher education sector. Direct subsidies for the support of R&D provided by the central government have been added to the educational budget since 1979. Beginning in the early 1980s, the government adopted a practice, abandoned during the Cultural Revolution, of supporting a select group of "key" and "superkey" universities as centres of scientific excellence. By the mid 1980s, approximately 90 universities had been accorded the status of key universities and another 7 identified as superkey universities and selected as sites for government funded laboratories. Among those superkey universities were those of Tsinghua in Beijing and Xian Jiaotong in Shanghai.

Key and superkey universities are marked out for the reception of extra funds and are regularly involved in national key research projects. For example, a World Bank loan of $200 million in 1981 was used to purchase instruments and computers for training and research in 26 key universities. This pattern of strengthening select universities through specific resource allocations tied to research has been expanded considerably through the national key labs programme described earlier. In this context it is important to note that in the aftermath of the reform process, the strengthening of key universities via provision of additional funding and the award of research contracts is done on the basis of the track record of the university and the quality of the staff.

However, it is not only the key universities that are receiving greater support. State funds allocated to R&D in higher education as a whole have gone up significantly in the last few years from $202 million in 1986, to $257 million in 1987 and up again to $325 million in 1988. The SEC provides less than 4 per cent of these monies with the rest coming from the SPC and the SSTC.

In addition to this greater help from the state, a number of universities have strengthened their capabilities on their own initiative by responding aggressively to the governments urging to all R&D institutes to establish greater links with the local community and the productive sector. As early as February 1984, some 25 major universities and colleges had signed over 50 long-term contracts with government and industry and had set up 30 scientific enterprises (as described in Part 1) to combine research with production. Some of the technically more competent universities have gone on to develop a wide variety of projects and contracts with the industrial sector.

II.8.3. RESEARCH INSTITUTES UNDER MINISTRIES

Research institutes that operate under the control of the ministries are primarily engaged in applied and developmental research. As a rule they do relatively little basic research though this is sometimes undertaken. Typically, they are administered either by ministry headquarters from Beijing or by its local or municipal bureau. At the end of 1987, there were some 922 research institutions under the direction of the ministries and the state councils with a total staff of roughly 450,000 of whom slightly less than half were classified as S&T personnel.

The Ministry of Agriculture, Animal Husbandry and Fisheries and the Ministry of Public Health have their own academies that administer fairly large numbers of research institutes - the Chinese Academy of Agricultural Sciences and the Chinese Academies of Medical Sciences and Traditional Medicine. In addition to these major academies, there are other smaller academies under ministerial control such as the Academies of Forestry, Geological Sciences, Railway Research, Petroleum Exploration and Development, and Space Technology.

Most industrial production ministries (26 in total) have their own research and training institutions as do the State Council Bureaus (15 in total) concerned with industry. Among the most notable research institutes attached to these ministries are the Research Institutes of Coal-Mining, Aeronautics and Petrochemical Engineering.

Some of these ministry based S&T networks are characterized by a large and well-defined research structure composed of engineering and design institutes, colleges and technical schools. For example, in the case of the Ministry of Chemical Industry, the network includes 180 chemical research institutes of which 23 are run by ministry headquarters in Beijing, 8 by state-owned complexes and the rest by local ministry offices and provincial authorities.

II.8.4. RESEARCH INSTITUTES UNDER PROVINCIAL CONTROL

As noted above, there are a large number of research institutes that fall under the administrative control of the provincial or county governments. Indeed they constitute the second largest group of institutes in the country and are meant to act as the local conduit for the translation of national S&T policy as it relates to agricultural and rural development into technical solutions suitable to local conditions.

As of 1986, there were approximately 3260 such institutes. Of these, some 1300 institutes were specifically concerned with agriculture, fishery, forestry, animal husbandry and agricultural mechanization at prefectural level and above, employing 133,000 people of whom 42,500 are S&T personnel. Below prefecture level, there are just 500 county level institutes plus 110,000 dissemination stations and 700,000 workers.

This may seem a large number but in fact the ratios are very modest - in 1989 there were only 6.6 agricultural S&T personnel per 10,000 agricultural population, one technologist per 7000m of cultivated land, while two thirds of all villages have no resident agricultural technician. Moreover, the local S&T system has been plagued by many problems not least of which is lack of resources. As noted above, these R&D institutions tend to be much smaller than the institutes in either the Academy or State Council sectors and in 1987, 25 per cent of them had less than 20 personnel engaged in S&T activities - the absolute minimum necessary to do any good. Moreover, many of the S&T personnel, particularly those working in institutes below provincial level, are poorly trained. Consequently, the effectiveness of many of these R&D institutes and the local S&T commissions who direct their activities has long been severely constrained.

Nevertheless, In terms of the structure of the Chinese economy, the key role played by the agricultural sector and the emphasis given to the sector in the country's overall development strategy, these R&D institutes are of central importance to China's development efforts and their activities have been the focus of considerable S&T reform efforts since the mid 1980s.

However, given their largely agricultural and rural focus and the applied nature of their work and their overwhelming orientation towards domestic technology generation and application, they are of limited interest to our concerns - though the government has mounted a major programme called SPARKS which is designed to transform the rural sector through the rapid development and diffusion of appropriate technology and the mobilization of largely local human and financial resources.[41]

II.8.5. RESEARCH CAPACITIES IN THE DEFENSE SECTOR

Despite the openness of recent years, Western analysts still know relatively little about the actual size and capabilities of the defense R&D establishment. However compared to the civilian R&D sector, the defense R&D sector is reputed to have more and higher quality scientists and technical personnel; more and better equipment and instrumentation; and it has enjoyed greater financial and political support that has contributed to its successes in nuclear weapons and space technology. Thus we are certainly talking about a defense R&D sector that involves numerous large and well equipped R&D institutes and thousands of top flight scientists. There appears to be considerable technological competence in the fields of atomic energy, radio-isotope, remote sensing, space technology, telecommunications, laser, automatic control and precision mechanical engineering, new materials and a variety of analytical and testing technologies.

The counterpart of SSTC on the defense side is the National Defense Science, Technology and Industry Commission established in 1982 as part of the reform process. A key aim of these reforms was to reorient military R&D to better support the civilian R&D and production effort. This is being accomplished both by fiat and directives and by the introduction of the contract system. Though there has been considerable opposition to these changes, information available to us indicates that significant strides have been made in this direction.

[41]. See Conroy, 1989 op.cit for a discussion.

There are numerous reports in the press of military institutes that have either transferred technology to the civilian sector or have reoriented a significant share of their output in that direction. One recent report is that over the last 8 years some 30,000 items of arms technology have been transferred to the civilian sector realizing a gross output value of 11 billion yuan ($); while the proportion of civil products produced by the national defense S&T industry has increased to 66 per cent in 1989 from 8.1 per cent in 1979 at annual rate of improvement of 20 per cent.[42]

One argument made to us is that as a result of being drawn into closer contact with the civilian "market", the defense R&D establishments as a whole are now more competitive than the CAS institutes. Certainly there appears to be no slackening off in the pressure being applied to this sector to improve both its capabilities and its orientation to the productive sector. For example over the last 12 months, the Commission for National Defence has set up 19 "field groups" to oversee key projects in photoelectronics, new materials, computers, etc. involving new expenditure of hundreds of millions of yuan. Experts involved in these groups are drawn from more than 50 R&D institutes, many of them from the CAS and higher education R&D network.

II.8.6. INTERNATIONALLY RECOGNIZED SCIENTIFIC CAPABILITIES OF LIMITED PRACTICAL USE

The scientific prowess of the Chinese R&D system is well recognized. In terms of achievements to date these are many and widespread ranging from the country's notable accomplishments in space and nuclear technology in the 1960s and 1970s, its perennial excellence in theoretical physics and mathematics, world leadership in many areas of the geological sciences and its more recent internationally recognized breakthroughs in superconductivity, laser technology and quantum well structures. The very large number of international scientific exchanges and collaborations that have been established with leading universities and scientists throughout the world are indicative of the quality of Chinese science.[43]

At the institutional level, scientific excellence is still concentrated in a relatively few number of favoured institutions - though with the establishment of the national key and open lab programmes, the rota of world class scientific institutes in China can be expected to expand considerably. Typical of the institutions recognized internationally for the excellence of its science, staff and facilities in the Institute of High Energy Physics of the

[42]. One particularly important group of ministries whose R&D and production engineering capabilities constitute a critical S&T resource for China grew out of the relatively recent reorganization of the once dominant Ministry of Machine Building and its combination with the Ministry of the Ordnance Industry. A new State Commission of the Machine Industry was formed along with five separate ministries all with specialized machine building and technology development responsibilities that are implemented through their captive network of research institutes - the Ministries of the Nuclear Industry, Aeronautics Industry, Electronics Industry, Astronautics Industry and the China State Shippbuilding Corporation. The State Commission has been given responsibility for implementing a major new policy for the technological development of the machine building industry.

[43]. Citation analysis conducted specifically for this project indicated that out of 11,738 scientific papers published by international journals between 1981 and 1986 with Chinese authorship, 24 per cent involved collaboration with overseas scientists - the highest figure for any developing country. The U.S. was the largest single collaborator with a nearly 50 per cent share, Community countries colleectively accounted for 21 per cent and Japan for 10 per cent.

CAS in Beijing is a good example. The Institute employs 2000 people of whom 1000 are scientists and engineers. It is the site of a newly established electron-positron collider supporting world class synchotron radiation research and nuclear physics.

Another example is the Xian Institute of Optics and Precision Mechanics employing more than 1000 people. Devices developed at the Institute include an opto-mechanical high speed camera, image converter, streak camera and image intensifier for medical uses. The streak camera for example has a resolution of 300 femtosecond in single shot and 1.1 picosecond for synchroscan operation - equivalent to or better than anything else available in the world. It has also developed a femtosecond ring dye laser pumped by a Beijing made YAG laser - an impressive technical accomplishment - though as with so many scientific developments in China, the developer still was not clear on what its precise uses would be.

This in a nutshell captures China's main S&T problem - and one that the whole of the S&T reform process described in Part 1 was aimed at changing. The list of China's scientific accomplishments and the pool of recognized technical excellence in China is inordinately large by developing country standards. We could fill dozens of pages with this information - the listing of projects and leading institutions given in the appendices where the authorities would like to see greater EC related collaboration only scratches the surface.

It is of course, also the case that these resources stand out from amongst a much larger sea of mediocre individual and institutional S&T capabilities. Nevertheless, recognized Chinese R&D capabilities are relatively easily identifiable and provide ample basis for straightforward R&D collaboration. However as discussed in part 1, the crucial area where China is weakest and where S&T co-operation would be most beneficial from the Chinese perspective is at the interface between R&D and production where existing links are notoriously weak. In one sense, the precise fields of such collaboration matter much less than does the development of projects which can bring together European and Chinese capabilities in a successful link between R&D, production and the markets.

II.9. GROWING EXPENDITURE ON S&T

Getting any sort of concrete estimate of China's expenditure on S&T is notoriously difficult. Good quality, disaggregated, interna- tionally comparable statistics are difficult to come by and rarely published. Nevertheless the available data does indicate that China's expenditure on S&T activities, though gyrating fairly widely, did rise as a percentage of GNP between 1949 and 1979 from less than .1 per cent to around .5 per cent.

However it is only in the last twelve years that the government has begun to allocate a significant share of state resources to S&T. Our best estimate is that the state budget allocated to civilian science (incorporating both R&D and capital construction projects) has risen by at least 15 per cent annually since 1979, more than doubling by 1985 and on course to double again by the end of 1990;.

In 1988, the last year for which there are comprehensive figures available, total national expenditure on S&T activities amounted to 14.45 billion yuan ($3.2bn) just over 1 per cent of GNP of 1401.5 billion yuan and up from .76 percent in 1982. Of this 7.4 billion yuan ($1.61bn) can be counted as direct state investment in R&D through the state supported R&D institutions. The rest of the investment would have been allocated to various capital construction as well as monies channelled to S&T activities via regional science administrative agencies.

While this figure is low compared to other advanced developing countries such as South Korea, it is nonetheless a significant amount because of its rapid expansion since the 1960s when S&T expenditure was just under .3 percent of GNP. This greater expenditure on S&T is directly related to the leadership's firm commitment to strengthening S&T as part of its modernization drive. Tables 27 and 28 provide details of the government's S&T allocations for 1988 - the latest date for which this data is available.

TABLE 27 : Government R&D allocation by institute and field of study ($ millions)

Total	1,992.76
R&D institutions above county level	1,926.26
Natural sciences & technology	1,876.45
Social sciences and humanity	49.72
Information institutions	66.59

Source : Compiled from data supplied by the SSTC

One concrete indication of the government's willingness to channel an ever greater proportion of funds to S&T is to be found in the threefold rise in expenditure on targeted R&D programmes between the Sixth Five Year Plan for Key R&D Project to which 1.5 billion yuan was allocated and the Seventh Five Year Plan for Key R&D Projects to which 5 billion yuan has been allocated. Some 76 key S&T tasks were identified under this plan and about 30 per cent of the funding earmarked for civilian S&T will be directed towards these projects.

Another indication is the growing commitment to the support of basic R&D via the funding provided by the NSFC - as discussed above. A final sign is that despite the current

TABLE 28 : Government R&D allocation by types of research - Basic, applied and experimental development ($ millions)

	Total fund input	Basic research	Applied development	Experi-mental
Total	575.03	50.66	234.14	290.23
R&D institution above county level	90.00	1.82	19.02	69.15
Institutes directly under control of State Council	485.03	48.84	215.12	221.08
- of which Chinese Academy of Sciences	99.56	30.04	47.93	21.57

Source : Compiled from data supplied by the SSTC

economic difficulties faced by the country, our interviewees were adamant that there would be no cutback in the planned S&T allocation over the next few years. Indeed the leadership apparently remains committed to increasing the funds available for S&T activities at a faster rate than the growth in general expenditure throughout the period of the Eighth Five Year Plan.

II.9.1. FINANCIAL SYSTEM REFORMS

It is probably worth noting briefly here that one of the broadest and most ambitious areas of reform involved the question of financing S&T activities in general and R&D activities in particular. Though many individual steps were taken, the basic thrust of S&T funding reform dealt with the relative contribution of central government. The government is seeking to reduce substantially the past practice that 99 per cent of all required funds would be provided by central government. Consequently it is seeking to reduce each year (since 1986) the amount of funds provided to R&D institutes for operating expenses. R&D institutes are in turn expected to gradually increase the share of operating costs that they raise from other sources by the active seeking of research contracts and consultancy arrangements among enterprises and in the marketplace..

Directly related to this the government is seeking to do away with past practices of allocation of resources where no attention was given to merit or quality. From 1987 onwards, an ever increasing share of resource allocation via government sponsored projects was to be done on the basis competitive tendering and bids. Moreover, basic and applied research institutes , particularly those linked to the CAS and key universities typically too far removed from the market to raise large amounts of money from contract research are being required to adhere to a contractual system providing certain guarantees of delivery and performance.

Given the extent and longevity of past government support, these changes represent a fundamental break with the past. This is particularly the case in relation to applied R&D institutes operating close to the final market or working directly for sectoral enterprises, ministries or state commissions. While some level of central funding will remain, there appears to be a firm intention to reduce the level of government support of these institutes as much as possible.

II.10. CHINA'S INTERNATIONAL RELATIONS IN S&T: AN AREA OF STRATEGIC IMPORTANCE

As should be clear by now from earlier remarks, international co-operation in S&T is extremely important to China. The leadership sees China's forward progress in its modernization drive as critically dependent upon continued access to international flows of S&T. This comes through in the importance attached to commercial technology transfer through foreign investment and the massive expenditures during the 1980s on arms length technology transactions documented earlier.

The same level of significance is attached to formal S&T co-operation. Since 1978, China has expended considerable diplomatic effort on securing and expanding bilateral and multilateral co-operation in S&T. For its part, China has grown increasingly generous in offering reasonably wide access to Chinese S&T and areas of particular interest to foreign scientists. However, at the same time China has also garnered a formidable reputation for its relentless pursuit of S&T co-operation agreements that serve its own clearly defined purposes in terms of knowledge acquisition in areas of priority importance to Chinese strategic development objectives. In this sense, the Chinese differ dramatically from the Indians who attach little strategic significance to international co-operation.

Given this background, it is not surprising that China has now compiled an impressive catalogue of international S&T co-operation agreements. Since 1978, China has engaged in bilateral and multilateral S&T co-operation and exchange with 108 countries and has formally concluded inter-governmental S&T agreements with 56 countries. Under these umbrella agreements, China has established literally hundreds of protocols between counterpart ministries and agencies. For instance there are 27 protocols with the U.S.; 28 with Germany; 35 with France 17 with the U.K, 35 with the Soviet Union and 5 separate agreements with different DGs of the Commission. Moreover, the Chinese Academy of Sciences has signed 50 agreements of co-operation with academies of science and research organizations in 26 countries; while China has joined over 280 international academic organizations including those under the auspices of the U.N. and ICSU.

Over the years, the level and forms of international co-operation have gradually expanded in many directions In 1988, China registered a total of 14,300 ongoing scientific and technical projects of co-operation with other countries. China has given increasing emphasis to academic exchanges between senior scientists and these have grown rapidly during the 1980s. In 1989, it registered a total of 47,800 exchanges split 50/50 between Chinese scientists going abroad and visits to China by foreign scientists. Given this level of activity, it is difficult if not impossible to generate any balanced assessment of the relative costs and benefits of S&T collaboration to China and her collaborators. Clearly, China's own development efforts have been aided significantly and many examples can be given including those arising from EC funded projects. Similarly there has been considerable improvement in the effectiveness of the operation of the institutions and systems in place in China to facilitate co-operation.

And as China's own S&T capabilities have developed, so too has the importance to foreign countries of S&T co-operation with China. Not surprisingly, the Chinese officials interviewed were also keen to see expanded co-operation with the EC develop as a result of the SAST initiative. This willingness on the part of the Chinese to explore further S&T co-operation with the Community is certainly to be welcome. However, in the wake of the events of June 1989, such offers need to be evaluated carefully by the EC from a strategic perspective that incorporates political as well as scientific factors.

II.11. THE DEVELOPMENT OF CHINA'S HIGH TECH CAPABILITIES

China began development of its high tech capabilities during the late 1950s as part of its strategy for building national defense capabilities. These efforts continued through the 1960s and 1970s and allowed China to lay down a basic production infrastructure and achieve a degree of R&D proficiency.[44] However beginning in the late 1970s, the leadership has devoted an increasing degree of policy and planning effort on the further development of high tech industries. These industries are now accorded a critical role in China's industrialization process over the medium to long term.

The development of these industries has been pursued through a wide variety of policies, programmes and institutional initiatives. These include some general efforts already mentioned such as the 863 plan, the TORCH programme, the Seventh Five Year Plan for S&T Development, the national key labs programme, and the stimulation of the scientific enterprise sector, as well as others which are more sector specific such the creation of the Leading Group on the Electronics Industry, the VLSI Plan, the creation of a mechatronics (a la Japan) ministry in 1988 (the Ministry of Machine Building and Electronics Industry, and the launching of sectoral strategies for high tech industries such as electronic components, bioengineering, telecommunications and computers.

The government has been increasingly willing to back up these plans with growing investments in R&D and production. The cumulative total investment in all aspects of the development of high tech sectors during the 1980s (including production and R&D) has been recently estimated as exceeding 100 billion yuan - or approximately 6.3 per cent was these sector, with the bulk of this coming in the last five years or so. So far these estimates have not translated into a major increase in production - estimated output of high technology products in 1989 was less than 5 per cent of total industrial output with exports only a fraction of this. Nevertheless, there is great hope that the groundwork has now been laid, and that high tech industries will come to play a dominant role in the future. Official expectations are that by the year 2000, the output of high tech industries will reach about $20 billion in value.

China's high tech potential cannot be denied. The surfeit of plans and policies shows a great deal of effort is being invested in charting future progress. And there is undoubtedly an impressive accumulation of scientific expertise and capabilities locked up in the many R&D labs where high tech work is going on. However, when considering the actual status, production capacity and competitiveness of these industries, it is clear that China has a very long way to go yet before it can even begin to fulfil its ambitious plans.

The bias towards R&D capabilities but a limited production base is painfully obvious in biotechnology where it conducts world class research in a number of leading edge areas such as plant cell and tissue culture, control of plant viruses and X-ray crystallography but where it is ten years behind in the development and implementation of production

[44] Its capabilities in defense-related technologies such as space (where it has had 25 successful launches), satellite communication, lasers, optical fibres (it no longer lays coaxial cable) and nuclear technology are well known and highly regarded.

technologies.[45] Because of the low level of Chinese capabilities, direct foreign investment is likely to be very welcome in the area of production or production equipment where there is still as yet remarkably little foreign involvement.

China's state electronics industry is considerably further advanced but still faces many problems. Though the focus of a sustained planning effort and backed by substantial political will, the industry is still falling far short of the technology and production targets that have been set as well as being well behind international standards. Output has undoubtedly increased fairly rapidly. The total value in 1988 was about $13.43 billion, up from $11.51 billion in 1987 and a six fold increase since 1978 and suggesting an annual average rate of growth of about 31 per cent. These figures include low technology consumer electronics products which have been China's biggest success story so far.

The total size of state-supported civilian electronics sector numbers about 3000 factories, 130 research institutes, and 6 dedicated universities focused on electronics. Some of the computer enterprises are among the largest firms in the electronics sector. The Great Wall Computer Group for example consists of 58 production units, 4 R&D institutes and 5 university departments. Though there are several hundred state-owned computer producers, 75 per cent of computer and software production is accounted for by the top ten firms. There is a small but significant foreign presence in computers and automation technology that was established during the mid-1980s and is primarily oriented towards the domestic market.[46] During 1990, six large joint ventures involving some of the biggest international computer firms were formed. Some of the major co-operative ventures are listed in Table 29 and some of the newer more export-oriented foreign ventures are discussed below.[47]

Exports are small but growing from around $180 million in 1987 to a planned $800 million in 1990, of which slightly less than half will be software exports and most of the remainder low tech consumer electronics products. Imports grew rapidly from 1980 to 1985 and were then sharply curtailed in 1985 and again in 1987 as China's planners decided that the country should aim for greater self-sufficiency in electronics as well as saving badly need foreign exchange. Approximately $2.5 billion was spent on all forms of imported IT

[45]. Biotechnology development is undoubtedly a priority despite these problems. There has been a ten fold increase in its allocation of R&D resources between the Sixth, Seventh and Eighth Five Year Plans. The focus of this work is on three areas - development of new high yielding and disease resistant varieties of animals and plants to greatly increase meat, fish, grain and dairy production; development of new medicines, vaccines and gene treatments; and protein engineering. See Dean H. Hamer and Shain-dow Kung, "Biotechnology in China: Summary of a Report", China Exchange News, December 1989.

[46]. One interesting recent development is the rapid increase in the degree of co-operation between German and Chinese universities in computer R&D. Computer scientists from Munich Technical University, Berlin University, Hamburg University, the University of Bremen and Bochum University have all recently become involved in China-related computer R&D projects. A German language journal on China and computing has also been established.

[47]. See also L.Curry, "Computer makers go in search of Chinese goodwill", p.8, Financial Times, February 20, 1991 for a more recent review of the activities of foreign computer companies in China.

TABLE 29 : China's major computer manufacturing joint ventures

Partners	Value/split	Products
Allen-Bradley(US)/ Construction & Development Corp of Xiamen	NA 50/50	Automation control products
Foxboro Co.(UK)/Shanghai Meters&Instruments Co.	$ 15 million 49/51	Process control instruments
Hewlett-Packard (US)/ Beijing Computer Corp	$ 5 million 50/50	HP 3000 superminis
IBM (US)/Ministry of Electronics	NA	IBM 5550 PC
Wang Labs (US)/Shanghai Computer Industry	$ 6 million 60/40	Wanbg minis & Chinese workstation
Japan Int'l sortware Corp/China computer Systems Engineering	NA	Computer software & hardware
Proficient Enterprise Co (HK)/Huagan Development Co.	$ 580,000	PCs, electrical & electronic products
Rail Air Ltd (UK)/NA	$ 50 million	Microcomputer systems LSI design; assembly & testing of IC devices
Semi-Tech Microelectronics Corp (Canada)/Shenzen Electronics Group	$ 270 million	Microcomputers
Yun Hoi Trading Co (HK)/ Linfen Electronics Factory	NA	Microcomputers, electronic horns, TV signal eqpt
Zhaohua Electronics Co (HK)/ Fushun Hualian Computer Corp	$ 323,000	Microcomputers

Source : adapted from Kelly Ho Shea, "Computer Investments", China Business Review, March-April 1988

products during the Sixth Five Year Plan and less than half of that during the Seventh plan period. In computers, imports rose from less than $100 million to $815 million in 1985 and collapsed to $525 million in 1986 and below $400 million in 1987.[48]

It is however at the level of sectoral performance where the problems are revealed most sharply. If we consider the integrated circuit sector, it is clear that there are well laid plans and that the sector has been the focus of consistent efforts to develop technology and increase production.[49] Mainly through the importation of production lines output was

[48]. The surge in computer imports through 1985 did not bring widespread computerization to the economy. By the end of 1987, fewer than half of the country's 140,000 installed microcomputers were in use and another 20,000 had not even been moved out of the warehouse. Lack of peripherals, software and particularly programmers was responsible. One recent estimate is that 100,000 programmers and 500,000 operators will be needed in the 1990s. See A.Bhalla, "Modernizing China", Science and Public Policy, August 1990.

[49]. For example, a VLSI plan was published in 1984 that set out a three phase programme for the development of VLSI capabilities: Stage 1 from 1986-90 involved mastering 3 inch chip and 3.5 micron technology and achieve mass production of 16 bit microprocessors and 4k CMMOS RAMs; Stage 2 from 1991-95 will require mastering 4 inch chip and 2 micron production technology; achieving mass production of 64k MOS RAM and 32-bit

increased from 24 million units in 1983 to an estimated 100 million units in 1989. Yet domestic demand for semi-conductors was estimated at 600 million in 1990 far outstripping local capacity - which is anyway severely skewed towards the supply of relatively low technology components.

For example, China currently produces about 680 types of ICs in 30 different categories but it is mostly using technology from the late 1960 or early 1970s based or outmoded U.S. and Japanese designs. Only 6-7 per cent of the ICs produced in 1989 were medium and large scale circuits. Moreover Chinese ICs are five to ten times the cost of imported components and of poor quality - though there have been recent improvements reported and Chinese computer research scientists have achieved a number of notable milestones.[50] Thus despite a still enforced government policy of restricting imports in order to improve performance, Chinese electronics industries are not only deprived of sufficient components but also have to pay high costs for the poor quality that is available.

The computer sector feels the effects of these component supply problems more than most sectors and these are compounded by the demand dampening effects of economic retrenchment. Though there are conflicting estimates available it is clear that the industry has fallen far short of its output targets in the last few years. Last year only 1300 minicomputers and 60,000 home designed microcomputers were produced. This is despite an annual capacity in micros of 300,000 units and an annual demand for 100,000.

Similar problems of affect the minicomputer industry. Government sources estimate the industry overall is operating at less than 30 per cent capacity. Despite having experienced 30 per cent annual growth rates for most of the decade, output grew by only 17 per cent in 1989 and has actually fallen by close to 10 per cent in 1990. This sort of performance will inevitably negatively effect the wider computerization of the Chinese economy.

In response, the Ministry of Machinery and Electronics Industry has announced yet another set of plans to revamp the industry, increase capacity and achieve greater integration and concentration. New investments will be steered towards the largest of state-enterprises to allow the attainment of scale economies and to improve product quality. Private sector firms (minbans) will not benefit at all. The new plan calls for geographical concentration of the production of computers and components - computers in the Yangtze River delta and Shandong Province and components and software in southern China, particularly in Guangdong province, the Shenzen and Xiamen special economic zones and the Zhongshan high technology zone.

To meet the unsatisfied demand for semi-conductors, the Ministry plans to set up 12 semiconductor enterprises and six microchip plants in Peking and Jiangsu province, These will be complemented by a number of new joint venture projects reflecting the belief that expansion of the industry depends critically on imported technology and foreign investment. Wuxi Huajing Corp., the largest microchip producer, is importing technology from both Siemen and Toshiba to increase output from 40 million to 100 million units. NEC of Japan are involved in negotiations to set up a $200 million plant to produce 50 million high-end

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microprocessors; and focusing R&D on 5 inch and 1 micron technology; Stage 3 from 1996-2000 will see a move into VLSI production including mass production of 512k MOS RAM and 32-bit microprocessor.

[50]. See the discussion in Denis Fred Simon, "Integrating the Electronics Industry", The China Business Review, July-August 1988.

circuits by 1994. This represents a major technological leap for the industry. Other microchip joint ventures will involve Phillips, AT&T and Motorola.

Given the size of the potential market, the undoubted scientific and technological prowess that exists in the research labs of the electronics sector, and the growing intensity of the government's committment, the prospects of the industry seem bright.[51] But then this has been the case for the last ten years. It remains to be seen whether the new plans will reverse the trends of the past and actually result in a substantive improvement in China's electronics capabilities.

[51]. On example of this prowess as well as illustrating the time lag in China's home grown computer technology is its 1988 version of the U.S. Cray-1 supercomputer was faster and more reliable than that older model. Applications software is another area where technical virtuosity and time lags are characteristic. Such is the price China is prepared to pay for technological independence. See Cornelis J. Kuiken, "Chinese Data-Processing and the Chinese Computer Industry", China Information, Vol.III, No.3 Winter - 1988/89

ANNEXES

ANNEX 1: MAJOR AFFILIATED COMPANIES OF THE CHINESE ACADEMY OF SCIENCES

Beijing Ke Hai Corporation - development, production and marketing of new products and technology in the electronics, light industry, machinery and bio-engineering fields.

Beijing Software Experimental Factory - design of software engineering technology.

Blast Engineering Company - demolition engineering and development services offered on contract or consulting basis.

China Sign-Optics Electronics Ltd - development, production and marketing of photoelectronic technology; technical consulting.

Corporation for Scientific Instruments on Sensing Techniques - production of electrical equipment; remote sensor R&D; technical consulting; establishment of high tech joint ventures.

Da Heng Company - contract R&D on optics and fine mechanics.

Da Tong Company - development and production of computers and communications technologies.

Hope (H) Computer Company - development of computer hardware and software; technical consulting; office automation equipment sales and purchases.

Kejian Corporation Ltd. - manufacture of components and complete sets of NMR imaging and scanning equipment for medical use.

Keli High Technology Corporation - contract product development and manufacture of microcomputers and systems using digital techniques.

Keshen Corporation for Scientific and Technological Consultancy and Development - new product consultancy.

San Huan New Material Research and Development Inc. - development and production of rare-earth magnetic materials.

Science, Education and Technology Development Corporation - contract R&D relating to optical, mechanical and electronic technologies.

Shenzen Science and Industry Park Corporation - contract development and production of high technology products.

ANNEX 2 : PRIORITY RESEARCH AREAS AND PROJECTS FOR CHINA'S 863 HIGH TECHNOLOGY DEVELOPMENT PROGRAMME

Below we present further information on the seven fields that have been identified as focal points for the 863 High Technology Development Programme which is under the leadership of Professor Ma Junru, Director-General, Department of Fundamental Research & High Technology, SSTC. Under each field the SSTC has identified a select number of major research topics (approximately 15) that will provide an umbrella for the development of other related disciplines and research branches. A select list of these major research topics has been given under each priority field according to the fields that have been identified by the SSTC as priority areas for international collaboration. We also give more details on the Automation Technology R&D component of the 863 programme in order to illustrate how the programme operates.

BIOTECHNOLOGY

1. Development of high yield, high quality and adversity proof animals and plants.[52]
2. New medicines, vaccines and genic therapy
3. Protein engineering

SPACE TECHNOLOGY

1. Develop advanced launch vehicles with enhanced capacity for commercial services.

INFORMATION TECHNOLOGY

1. Intelligent Computer Systems
2. Optoelectronics devices and microelectronic optoelectronics systems integration technology.
3. Information Acquisition and Processing Technology

LASER TECHNOLOGY

1. Apply laboratory achievements to the development of applications for material processing, plasma technology, pulse power technology and high resolution spectroscopy.

[52]. Under which programme there are more specific objectives such as to:
- develop hybrids of rice sub-species to average one ton per mu in double cropping;
- develop new strains of high protein wheat, disease-insect resistant high protein vegetable varieties and high-protein, draught salinity tolerant herbage strains;
- develop maize, soybean and vegetables strain with nitrogen fixation capabilities; and
- develop new breeds of fast growing lean meat hogs, disease resistant livestock and poultry, and disease-cold resistant fishes.

ENERGY TECHNOLOGY

1. Coal-fired MHD power generation technology to fully utilize medium-grade and high-sulfur coals.
2. Advanced nuclear reactor technology development.

ADVANCED MATERIALS

1. Photoelectronic materials.
2. High performance structural materials with corrosion resistance and light weight.
3. Special functional material
4. High temperature-wear resistance and high strength composite materials.
5. Development of special testing and measuring techniques.

AUTOMATION TECHNOLOGY

Under the automation technology programme, two main subject areas for work have been identified - computer-integrated manufacturing systems (CIMS) and intelligent robots (IR). A Directorate of Automation Technology has been set up (under the leadership of Zhang Yuzhen SSTC) reporting to the Department of Fundamental & High Technology of the SSTC. Under the Directorate there is one overall Expert Committee and two Expert Groups for each topic. To facilitate attainment of the objectives, two national research centres and 13 national laboratories will be established by 1992.

The CIMS project (Cui Deguang, Director, CIMS Office, Tsinghua University) has an Engineering Research Centre now under construction at the Tsinghua University while the IR project's chief engineering centre is located at the Shenyang Institute of Automation Control (Zhang Xiufang, Director). Among other institutions involved are - the Department of Aeronautics and Astronautics at Beijing University, Shanghia Jiao Tong University, Xian Jiao Tong University (Xian), the Beijing Research Institute on Machine Tools, South East University (Nanjing), Harbin Institute of Technology, (Harbin), The Institute of Automation (CAS-Beijing), the Hefei Institute of Intelligent Machine Research (CAS-Hefei) and Nankai University (Tianjin).

Work is currently underway under 9 main project areas under the CIMS programme - open system architecture; development and diffusion strategy for CIMS in China; engineering analysis for product design, manufacturing and systems integration; flexible manufacturing engineering; CIMS quality control systems; management and decision-making system; CIMS database development; and CIMS systems technology. The intention is to have all key technologies necessary for demonstration of CIMS production line ready by 1995 and to have a CIMS demonstration product under operation by 2000.

Work on the IR programme is going forward under 7 main subject areas - system architecture of IR; manipulator and driving mechanisms for IR; robot controllers and system integration; robot vision; force and torque sensor development; artificial intelligence; and new structural materials, energy sources and communication. Second generation robot prototypes will be developed between 1989 and 1992 and the intelligent robot system will be developed between 1992 and 2000.

ANNEX 3 : PROJECTS IDENTIFIED AS SUITABLE FOR INTERNATIONAL COLLABORATION UNDER THE TORCH PROGRAMME

The directorate of the TORCH programme (based within the TORCH High Technology Industry Development Center, SSTC) has singled out 5 technical fields under which projects can be considered as TORCH projects. The five technical fields are - new materials, biology, electronics and informatics, mechatronics and new energy resources.

For consideration as a TORCH project, the projects must either be based on mature research results or already patented technology ready for commercialization. Between 1988 and 1989, more than 270 projects were classified and approved as national level TORCH projects and more than 1000 as local TORCH Programme projects. From this set, 127 projects have been identified as suitable for international collaboration with reference to both further developmental research and commercialization. For reasons of space, we provide below only a sample listing. Further details and a full listing can be provided if desired but direct contact should also be made with the TORCH Directorate at SSTC if serious explorations are under consideration. We understand that SSTC has already approached the Community about possible collaboration under TORCH on HDTV technology so further contact could be pursued through these channels.

New Materials

PBT wool imitation stable fibre
Highly errosion-resistant Zn-Al coating materials
DZR components
Dual-axes directed polyimide membrane
Microcrastatal glass
High precision mirror copper tubes for refrigerator freezer and condenser
Sensitive Agent for PS Printing Plate

Biology

CHIMEHERB - artificial skin
Monascus pigment
Factory-scale production of Thuringiensis
Non-cariogenic palatinose
Instant ELISA kits for Hepatitis

Electronics and Informatics

Raster digital display systems
PSC-128 programmable subscriber line concentrator
Thick fil hybrid and surface mount tech
PTC thermal sensors
LaB6 cathode
TL-2 graphic measuring and calculating system
GC-3 micro measurement system

Mechatronic

Gold dopin plasma coating machine
ZF2-3D55 three dimensional auto-profile milling machines
Acoustic oil displacement system and acoustic extracting vehicle

New Energy Resources and Energy Saving Technologies

Submerged electrical oil pump
A new type of powder metallurgic titanium ball valve
Scroll compressor for air conditioner

Other Unclassified TORCH Projects

New liquid jet mixing device
HUAXIA integral drill rods
Granular activated carbon regeneration furnace by forced discharged

ANNEX 4 : NATIONAL KEY LABORATORIES

The following is the most up to date list available of the network of world class laboratories being developed under the National Key Laboratory Programme which the SSTC have singled out as being focal points for international R&D collaboration.

SPONSORING INSTITUTION	LABORATORY SPECIALITY	DIRECTOR	LOCATION
Beijing Medical University	Natural and bionic medicines*	Wang Ling	Beijing
Beijing University	Artificial micro-structure physics	-	"
"	Audi-visual informatics*	Shi Qingyun	"
"	Protein engineering and plant genetics*	Gu Chunccheng	"
CAAS Inst of Plant Protection	Plant disease biology		"
CAMS Inst of Blood Research	Blood immunity		"
CAMS Inst of Capillary Circulation	Capillary circulation	Xiu Rijuan	"
CAMS Institute of Tumours	Molecular tumours*	Wu Min	"
CAS Inst of Atmospheric Physics	Geo-fluid dynamics		"
CAS Inst of Chemistry	Dynamic spectrum & stable structures	Tang Youqi	"
CAS Inst of Metallurgy	Sensor sciences*	Wang Weiqing	Shanghai
CAS Inst of Physics	Super-conductivity		"
CAS Inst of Hydro-Biology	Freshwater ecology*	Liu Jiankang	Wuhan
CAS Inst of Acoustics	IT for acoustics*	Guan Dinghua	Beijing
CAS Inst of Automation	Model recognition*	Feng Songde	"
CAS Inst of Bio Physics	Bio-macromoleculars	Zou Chenglu	"
CAS Inst of Biochemistry	Molecular biology*	Z.Youshang	Shanghai
CAS Inst of Chemical Physics	Catalytic chemistry	Wu Youxian	Dalian
CAS Inst of Geochemistry	Organic geo-chemistry		Guiyang
CAS Inst of Metals Research	Metal fracture & material deactivation	Wang Zhongguang	Shenyang

CAS Inst of Optics & Fine Mechanics	Applied optics	Mu Guiguang	Chang-chun
CAS Inst of Glaciology Cryopdelogy	Permafrost engineering	-	
CAS Inst of Organic Chemistry	Natural & bio-organic chemistry		Shanghai
CAS Inst of Physics	Environment information systems*	Chen Shupeng	Beijing
CAS Inst of Physics	Atomic physics*	Yie Chaohui	Wuhan
CAS Inst of Physics	Surface physics*	Wang Sheng	Beijing
CAS Inst of Plant Physiology	Plant molecular genetics*	Xu Zhihong	Shanghai
CAS Inst of Semi-Conductors	IC superlattice Chromium-Cr	Zheng Houzhi	Beijing
CAS Inst of Technical Physics	Infrared physics		Shanghai
CAS Inst of Zoology	Bio-membrane engineering	Liu Shusen	Beijing
CAS Sci&tech Univ	Information security		Beijing
Central China Univ of Sci&Tech	Laser technology*	Sun Xueyi	Wuhan
Chang Jiang Aquatic Institute	Biotech for oil-bearing crops*		
Chengdu University	High speed hydraulic power		Chengdu
Chongching Univ	Mechanical transmission		Chong-ching
Dalian Univ of S&T	River bank engineering	Qiu Dahong	Dalian
Fudan University	Applied surface physics	Chen Ping	Shanghai
Fudan University	Genetic engineering*	Zheng Zhaoxin	"
Fudan University	Surface optimization	Li Fuming	"
Human Medical University	Medical genetics		Changsha
Institute of Veterinary Medicine	Biotech for veterinary medicine*	Lu Jingliang	Harbin
Jiaotong University	Marine engineering	Sheng Zhen	Shanghai
Jiatong University	Metal composites	Wu Renjie	"
Jiatong University	Structural strength*	Shen Yapeng	Xian
Jilin University	Enzyme engineering*	Chen Yuhua	Chang-chun
Jiaotong University	Dynamics engineering		Xian
Lanzhou University	Applied organic chemistry*	Liu Youcheng	Lan-zhou
Nanjing University	Computer software	Xu Jaifu	Nanjing
Nanjing University	Co-ordination chemistry	You Xiaozeng	"

Nanjing University	Solic micro-structure physics*	Feng Rui	"
Nankai University	Organic chemistry*	Li Zhengming	Tianjin
Institute of Virus	Virus genetic	Hou Yunde	
Institute of Virus	Virus genetic engineering*	Hou Yunde	
Qinghua University	Friction research*	Wen Shizhu	Beijing
Qinghua University	AI systems*	Zhou Yuanqing	"
Qinghua University	Chemical engineering		
Qinghua University	Optical electronics		"
Shadong University	Crystal materials*	Jiang Minhu	Jinan
Shanghai Inst of Birth Planning	Medical tools for birth control		Shanghai
Shanghai Tumour Inst	Cancer genetics*	Gu Jianren	"
South China Inst of Tropical Crops	Biotech for tropical crops		
Trianjin University	Engines*	Shi Shaixi	Tianjin
Tongji University	Civil engineering	Zhu Beilong	Shaighai
Wuhan Technical University	Synthetic materials		Wuhan
Wuhan University	Software*	He Xianqing	"
Xiaman University	Solid surface chemistry	Ian Shaowu	Xiaman
Zhejiang University	CAD	Liang Youdong	Hangzho
Zhejiang University	Hyperpure silica&silane*	Yao Hongnian	Hangzho
Zhongshan University	Spectroscopics for super speed lasers*	Yu Zhenxin	Guangzhou

CAS - Chinese Academy of Sciences
CAAS - Chinese Academy of Agricultural Sciences
CAMS - Chinese Academy of Medical Sciences
* - denotes key labs already established and operating

ANNEX 5 : SSTC MAJOR DEPARTMENTS AND FUNCTIONAL OFFICES

1. The Science and Technology Department - concerned with with devising policy and drafting relevant S&T regulations.

2. The Forecasting Department - concerned with the analysis of data for the projection of future developments.

3. The Planning Department - a joint department with the State Planning Commission promotes co-ordination of the work of the two commissions with respect to linking S&T policy to the needs of the economy and society.

4. The Works Management Department - co-ordinates the work of all the industrial ministries as well as the work of CAS relating to specific state S&T projects. This department is also concerned with the key R&D projects identified in the five year plans.

5. The Department of New Technologies - now encompasses the various directorates that have been set up to oversee the 863 and TORCH programmes, as well programmes supporting basic research and the programme of key and open laboratories.

6. The Science and Technology Management Department - is responsible for developing and implementing the institutional organizational reform aspects of the S&T reform programme.

7. The Financial Facilities Department - responsible for financial affairs, particularly with respect to capital construction.

8. The Scientific and Technical Cadres Department - responsible for organizing the nation's S&T cadres, particularly with regard to the labour policy reform aspects of the S&T reform programme.

9. The Information and Data Department - responsible for data collection and analysis.

10. The Department of International Scientific and Technical Co-operation - responsible for deciding on joint projects and research programmes with foreign countries as well as formal S&T exchange programmes.

LIST OF TABLES
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