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IMPLEMENTING CHINA'S S&T MODERNIZATION PROGRAM

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I. Introduction

Studies of policy implementation in both the industrialized and developing nations indicate that "successful" implementation is the product of organizational adaptation and evolution.[1] As such, implementation is best viewed as a process rather than just a discrete event. Analysis of this process must concern itself with the interplay between organizational strategy and political-economic context, as well as with the formal structures and procedures designated for carrying out policies formulated by national-level decision-makers. Attempts at policy implementation usually pass through several stages, each one conditioning the process and affecting the outcome. The strategy for implementing a certain policy may undergo considerable change during the course of implementation both unintentionally or in response to the influence of contextual factors beyond the immediate control of the planner or policy administrator. These changes should not necessarily be viewed as an indication of shifting goals or a policy failure, but rather may be seen as part of a building process designed to enhance the attractiveness of and facilitate greater receptivity to a new policy.

Within socialist systems, the problems of developing and adapting a strategy for policy implementation are often compounded by the issue of centralized versus decentralized control. Within such policy arenas as science and technology, for example, the typical concerns of policy implementors tend to be focused on the imperatives of system-ordering. In other words, political leaders in socialist states are concerned about maintaining their ability to control and coordinate, and if need be, to orchestrate events at lower levels within the bureaucracy and economic system.[2] Yet, for science and technology to prosper and advance, there must be room for innovation.[3] Berliner, in his study of industrial innovation in the Soviet Union, has shown that the so-called "imperatives of centralized administrative coordination" within a socialist system must at some point in time give way to the forces of the marketplace since competition rather than administrative decree frequently is needed to promote greater effectiveness and efficiency within both the R&D unit and the production enterprise.[4] And, as Weiss and others have suggested, it is the prevailing environment--the domestic institutional, economic, social, and ecological setting as well as the international conext--that has as much influence on the evolution of technology and its application as the activities of the formal technological institutions.[5]

This paper will discuss some of the methods adopted by the Chinese to improve the "implementation environment" for science and technology policy. It offers two basic themes: First, as

China's leaders have come to realize, progress in science and technology is not merely dependent upon increased investment in R&D or specific policies adopted to rectify deficiencies within the research sector,. Rather, rehabilitation and modernization of the S&T sector depends, to a great extent, on policies adopted in the area of economic policy. Without adequate demand for new and more advanced products and production processes, China's R&D organizations and personnel will lack the needed incentives to respond to the nation's economic needs.

Second, implementation of China's national science and technology policy is, in many ways, the function of a mixed strategy in which key leaders are seeking a balance between use of central control and some market mechanisms. The major objective of S&T policy, which is also the prime implementation issue in the context of this paper, is to make science and technology serve the economy, i.e. to get more applied, production-related research. As such, S&T policy has a strong programatic element to it. [6] The term "programatic" is used not in the narrow sense of a set of projects, but in an inclusive sense so that it connotes a set of policies that embody a strategy for achieving a particular set of objectives. This strategy, which continues to undergo substantial fine-tuning, is characterized overall by the movement away from the Soviet-style, centrally-led form of administration and management that dominated Chinese S&T prior to the Cultural Revolution in the mid-1960s. [7] Instead of being "pushed" from the center, the development of S&T is to be accomplished, for the most part, by what Sigurdson has termed a "demand-pull" approach.[8]

This paper will discuss implementation from a facilitative perspective. Policy implementation is viewed as a series of shifting strategies and dynamic processes occurring simultaneously, each designed to alter not only the environment in which science and technology decisions are made, but also the calculus of decision-making among persons responsible for establishing research priorities and accomplishing economic objectives. These shifts come about through the incessant pulling and tugging over control and resources that takes place between local and central authorities. Within such a framework, centralized versus decentralized approaches need not necessarily be viewed as movements along one implementation continuim, but rather as part of the same, multifacted "mixed" strategy where the role, function and responsibilities of various central and local units are constantly re-defined to achieve greater responsiveness to the central goal of making science and technology serve production.

II. The Role of S&T in the Four Modernizations

A. The Dilemma of Policy Implementation

In an effort to promote a more rapid and sustainable pattern of economic development, China's leaders have taken some rather bold policy initiatives, many of which would have been considered politically taboo during the heyday of Chairman Mao's rule. These initiatives have covered the spectrum from expanded use of profit incentives in industry to a partial dismantling of the commune system in the rural areas. Of all these recent experiments and policy innovations, Beijing's actions within the realm of science and technology have been the most dramatic and far--reaching. Along with the efforts to improve the operation of the domestic research system, the Dengist leadership has taken the somewhat unprecedented step of opening China's doors to large quantities of foreign technology imports and widespread participation of foreign experts. Because of the broad range of institutional and attitudinal changes that have been and will continue to be required to make these efforts yield desired outcomes, the modernization of science and technology represents, in this author's view, the most difficult challenge facing China for the rest of the century. In many ways, the task confronting Beijing involves more than just the mere reformulation of existing policies for science and technology. More critically, progress in science and technology requires nothing less than a major transformation of the economic and political environment in which research is conducted and technology-related decisions are made.

Implementation of a national program to modernize science and technology has not been an easy task for the Chinese leadership. Faced with a domestic science, technology, and education infrastructure decimated by the political turmoil of the Cultural Revolution, Chinese leaders have been faced with the monumental challenge of rebuilding, almost from scratch, an institutional structure and pool of competent scientists and technicians to move the country forward in the years ahead. As a result of the Cultural Revolution, China's research system stagnated, leaving the Chinese 10-20 years behind the West and Japan in most critical science and technology fields. The task of stimulating scientific and technological advance is an arduous one and will hold important political implications for the nature of Chinese society in the years ahead. Moreover, without appreciable progress and expanded application of modern technology, China's pattern of economic growth will continue to be erratic and uneven at best. [9]

The key factors that have influenced the implementation process related to science and technology can be grouped under three main headings: political, structural, and external. The political factor derives from and continues to be fueled by the legacy of the Cultural Revolution and the political reversals of the past thirty years. [10] In several respects, the political factor is a double-edged sword. Party cadres in positions of authority, many of whom earned their credentials and attained their positions as a result of their activism during previous political campaigns, such as the anti-science aspects of the Cultural Revolution, remain reluctant to accept a new system of government administration based on technical rather than ideological criteria. Yet, this does not mean that all of China's policy problems, implementation-related and otherwise, would be resolved if scientists and engineers were given a free rein. Within an environment where financial, manpower, and equipment resources are in scarce supply, the costs of granting the scientific community extensive authority in policy circles could be quite severe if the practical needs of the country were to be subordinated to the scientific quest for knowledge.

Many Chinese scientists, particularly those affiliated with the Academy of Sciences, refuse to surrender their commitment to basic science and "dirty their hands" in the movement to give greater emphasis to applied research. [11] Even though younger scientists have begun to appear on the scene, the core of China's scientific community is well advanced in age. [12] A large percentage of these have been trained in the West or Japan, and their "role models" for research project selection and development tend to be the advanced nations. Many apparently believe that the current "pro-science" climate may be their last opportunity to achieve a nationally or internationally recognized scientific accomplishment. This "ivory tower" mentality, which is precisely what got the scientific community in political trouble during the Cultural Revolution, is compounded, in some respects, by continued apprehension and fear about the longevity of the present policies. Though strongly committed to the spirit and direction of the Dengist policies, a large percentage of Chinese scientists remain uneasy about the future.

The second factor, i.e. the structural variable, is associated with the faults in the basic design and organization of Chinese research system. In spite of the perception of many students of the development process, Chinese science and technology has not been applications oriented. According to one author, only 10% of all research can be translated into production; even in the highest caliber research institutes the rate is only 30-40%.[13] The R&D system has tended to be highly compartmentalized, particularly between the civilian and defense sectors. Connections and communications among researchers and between researchers and endusers have tended to be erratic.[14] Research institutes have had very little incentive to serve the needs of the enterprise. And, the factory manager, concerned mainly with attaining output quotas, has had little incentive to adopt new product or process innovations, especially since marketing and quality considerations have not been driving forces behind economic behavior at the level of the firm.

> The current state of affairs in our country is that management is more backward than technology. Some of our technological facilities are not at all inferior to other people's, but the products are very backward in both numbers and quality. The reason is primarily bad management.[15]

A related manifestation of the Chinese system has been the problem of labor allocation and mobility.[16] Because of the highly centralized nature of the system for determining job assignments and the scarcity of scientific and technical personnel, many individuals have been forced to remain in jobs for which they do not have the proper skills or for which their skills are obviously redundant. For example, in the industrial sector almost 2/3 of the engineers and technical personnel are concentrated in the machine-building and metallurgy sectors while the number of similar personnel in light industry is less than 15% of the total.[17] In some geographic areas there are too many chemical engineers, while in others there are not enough. One cause of this imbalance has been the poor communications among components of the research sector. A more important factor, however, has been the operating "culture" among institute managers. Given the difficulty and uncertainty in securing replacement personnel, particularly in outlying areas, institutes have tended to restrict the movement of their personnel and to retain individuals even though jobs transfers might be of benefit to both the researcher and the receiving institute.

The last, but perhaps most critical of the three factors that have defined and influenced the context of policy implementation in science and technology has been the external one. This has been alluded to above concerning the proclivity of some scientists to look abroad as a point of reference in selecting research priorities and goals. Its most serious manifestation has been in the tendency of the scientific community to "pay no heed to the national condition, blindly catching up and over-taking, and actually engaging in "world science."[18] These tendencies are reinforced by China's expanded participation in bilateral science and technology cooperation programs with the US, Japan, and Western Europe. In almost all cases, large numbers of Chinese scientists are sent overseas to visit or work in comparatively more modern, well-equipped research facilities on expensive projects that would fit into the category of "basic" rather than "applied" research. This has served to exacerbate the gap between what many Chinese scientists feel they want to do and what economic leaders believe should be done.

The importance of the international context is also discussed below in terms of the strong influence that overseas Chinese scientists have had on the structuring of research programs and objectives.[19] Moreover, China's selection of technologies and equipment has been influenced by the external envoronment as well. Here again, many Chinese have been inclined to purchase foreign-made "state-of-the-art items when more so-called "appropriate" technologies or domestically-produced equivalents would have sufficed.[20]

In short, without changes in economic incentives and alteration in the links between researchers and producers, without changes in institutional personnel policies, and without better management of external forces, effectively implementing any new S&T policy will be frustrated. The context must be changed before policy and institutional behavior will begin to change--a task more easily said than done.

B. The Big-Push of 1978

The pivotal role to be played by science and technology was most clearly articulated at the time of the March 1978 National Science Conference when China's highest political and scientific leaders noted that "the crux of the four modernizations rests with science and technology development."[21] The holding of a national science conference in March 1978 signified the importance that the regime attached to improvements in both research and education.[22] The comprehensive program announced at the March meeting had been the product of many months of intensive political discussion and negotiation that had begun as early as late 1976. China's stated goal was to "catch up" with the advanced nations in science and technology by the year 2000.

A set of eight priority areas were spelled out for immediate attention.[23] It becomes apparent after looking at the list of priorities that their selection reflected not one homogeneous viewpoint, but the varying interests of the different institutional groups concerned with science and technology modernization. In some cases, as in the selection of energy and materials science, the primary objective was clearly economic. In other cases, as in high-energy physics and genetics, the choices reflected the desire of many leading Chinese scientists, a large percentage who were foreign-trained, to jump back into the world scientific community, and perhaps, even achieve a Nobel Prize. A third group of topics-- space, computers and electronics, and lasers--were given attention because of their obvious military, as well as economic applications. This is not to deny that within fields such as genetics, there were practical applications that were possible--but in many instances translation of these priorities into specific research projects often individual organizational goals rather than practical problem-solving. [24]

The heavy emphasis placed on the development of high-energy physics has long been a critical point of discussion among both Chinese and Western scientists. Citing the strong interest exhibited by Chairman Mao Zedong in this field, both Deng Xiaoping and Fang Yi argued that substantial resources and personnel should be devoted to promoting Chinese advancements in the field. Investment of time and effort in this area was supported and pushed by a coterie of Chinese-American scientists--many of whom were physicists and felt that advanced research in high-energy physics was a good vehicle for boosting China's scientific capabilities and for Chinese scientists to gain international notoriety. This desire for international recognition cannot be underestimated since the Chinese scientific community had been shut off from world research for over a decade. Accordingly, a large-scale cooperative program to build a 50 GeV proton synchrotron was begun as part of the Sino-US S&T cooperation program. [25]

The remarkable aspect of this entire process during the first year after the national science conference was that basic research was allowed to command such significant amounts of financial and personnel resources--both of which had been in short supply. This is not to suggest that applied research was totally ignored. However, it did signal the strong influence of the Chinese Academy of Sciences in the formulation and implementation of science and technology policy. [26] And, it also raised the more fundamenal issue of whether various Chinese leaders actually understood for policy purposes the differences in function and orientation between "science" and "technology." Lacking a sophisticated appreciation for the distinctions between the two, it was not very surprising to see high-level support given to any work that had a "scientific" quality to it--even when it lacked a practical application.

This tendency for Chinese "science" to leap ahead and technology development to still lag behind brought to the surface the continued disinterest and, in some cases, reluctance of the industrial sector to seize upon the new opportunities for product and process improvement that were being made available as a result of the new emphasis being given to S&T. In retrospect, it suggested that the key to expanded interest in applied research and a more responsive research establishment would not necessarily come from the center itself in the form of new science and technology policy. Rather, the catalyst for bringing about S&T modernization was to be found elsewhere in the system.

Another important dimension of the 1978 national science plan was the lack of attention paid to reform of the basic structure and design of the domestic S&T system itself. After the downfall of the "Gang of Four," the approach adopted by Chinese leaders was to rehabilitate the system as it existed prior to the Cultural Revolution rather than to consider fundamental structural change. From an overall perspective, China's research system had been modelled after the basic structure of the Soviet system--having a three pronged structure characterized by the sharp division between basic and applied research and the lack of a strong research capability within the university sector.[27] The system was managed by one overarching organization, the State Science and Technology Commission(SSTC). During the height of the Cultural Revolution, the SSTC had been disbanded and replaced by a revolutionary committee charged with overseeing science and technology affairs.

In 1977, re-establishment of the SSTC was one of the first steps taken by the Deng-led regime as it attempted to revitalize the country's traumatized research sector. Moreover, very little was done to alter the situation in the university sector regarding the harnessing of scientific personnel for research purposes. In the view of many Chinese administrators and scientists, some of whom had received extensive training in the Soviet Union, the Soviet-style system had produced a nuclear weapon and other desired scientific/technological advances, and was therefore not viewed necessarily as a possible obstacle in the implementation process.

The initial response to the new stress placed on science and technology modernization was mixed, resulting in wide variations in the ways in which policies formulated in Beijing were interpreted throughout the country and within each research institute. In some localities, local cadre within various institutes and enterprises basically ignored or paid lip service to the call to modernize science and technology. As pointed out at a December 1979 national forum on progress in science and technology, "quite a few leading cadres were still accustomed to giving guidance to scientific and technological work by adopting the method of promoting political movements."[28] Moreover, unwilling to relinquish their political positions, they obstructed the call for placing persons with technical credentials in positions of authority. Their behavior was primarily motivated by three factors: their lack of technical training, self-interest and an apprehension that the political winds might once again shift and that a high profile "pro-science" position might turn out to be politically dangerous.

> At present there are still many cadres within the party, including some who are in charge of economic, government, and party leadership, who are insufficiently aware of the importance of science and technology or who do not sufficiently support science and technology work. Many party committees and administrative leadership organs have still failed to put scientific and technical work on their agendas, or pay lip service to its importance but actually relegate it to second place, so that it loses out when the pressure of work increases. Some comrades even consider that science and technology stand in the same relationship to production and the economy as the cock that crows at dawn, i.e. that "dawn comes whether the cock crows or not," and that it makes no difference whether science and technology are pursued or not.[29]

In spite of the fact that the majority of scientific and technical personnel received China's renewed emphasis on science and technology in a positive way, a large percentage remained skeptical about the staying power of the new leadership and its policies. Some scientists, fearful of once again being singled out for pursuing their intellectual activities or engaging in a research "failure," viewed the statements coming out of Beijing with some trepidation.[30] This type of response proved to be antithetical to the research process which involves an inherent element of risk taking in order to move ahead. In many instances, this led to widespread duplication of research, particularly regarding "successful" projects that had been completed in the West or other parts of China. It was politically safer to undertake and repeat a proven research experiment than to assume responsibility for a more speculative scientific venture.

In other instances, the response to Beijing's emphasis on science and technology resembled something of a bandwagon effect. Many local officials, some sincere in their efforts to dispel the disdain for science and technology that had been engendered by the Cultural Revolution and others anxious to court Beijing's favor, went to extremes in popularizing the value of S&T to peasants and workers. The movement to popularize science and technology led to a massive outflow of rather simplistic "scientific and technical publications" and to a proliferation of relatively worthless research institutes.[31] In one province, the number of so-called "institutes" increased by 153% in one year. Many of these institutes came to be called the three no centers--having no projects, no equipment, and no personnel. In others areas, as noted above, the stress on "popularizing and engaging in" science and technology led to extensive attempts to replicate foreign research, much having little practical or immediate value to China's needs. The tendency to pursue S&T activities in such a fashion was reinforced by the rapidity with which China was expanding its S&T contacts with the outside world. In many cases, the development of these contacts forced China to give the appearance of engaging in world class research. It also forced the Chinese to create "counterpart" S&T organizations in order to offer up an acceptable partner for cooperative purposes.

The difficulties encountered within the realm of the research system itself were compounded by Chinese behavior regarding the acquisition of foreign technology and equipment.[32] Here again, the general response to the announcement of the "four modernizations" was to proceed on the basis of the past, with primary emphasis given to the purchase of whole plants and equipment rather than actual technology and know-how. Articles appearing in the Chinese press have suggested that less than 10% of the funds expended for so-called "technology imports" actually went for technology.[33] Numerous delegations and buying missions were sent abroad to survey the state-of-the-art in various fields. Many of these missions proceeded to sign contracts for advanced items which China could not possibly use.

The situation concerning computer imports was particularly serious.[34] Many medium and large, high-speed computers acquired from abroad were severely underutilized or poorly maintained.[35] And, in some instances, the computers were never unpacked from their original shipping crates. Stress was placed on the level of sophistication rather than on the appropriateness of the technology. [36] Contracts were signed by over-enthusiastic technical delegations when in fact they had little authority to commit scarce Chinese foreign exchange for these purchases. In addition, in most cases, feasibility studies and project assessments were not conducted beforehand, resulting in inefficient use of both imported items and domestic resources. For example, most of the ancillary equipment and infrastructure to make the whole plant and equipment purchases worthwhile were lacking. The results, such as in the case of the Baoshan steel mill, turned out to be disastrous with very little actual technology transfer taking place. [37]

Although many of these problems had begun to surface by the time of the Third Plenum in December 1978, it was not until early 1981 when they assumed a leading position on the working agenda of the top leadership. During the ensuing period after the Third Plenum, many of the expectations that earlier had been placed on the efficacy of science and technology for eradicating China's development problems disappeared. A program of economic readjustment was announced at the Third Plenum in response to the appearance of a series of domestic budgetary and trade deficits--the largest in the history of the Communist regime. The basic provisions of the program were embodied in the so-called eight-character slogan of "readjustment, restructuring, consolidation and improvement." The program, which constituted a major retrenchment, consummed the full attention of both economic and political leaders. At the 2nd and 3rd Sessions of the Fifth NPC(June 1979 and September 1980 respectively), several large scientific projects were cutback and scientists were encouraged to assist with the economic modernization program. High-energy physics, for example, was a prime target for these cutbacks. From an overall perspective, however, the critical shortcomings of the research system were addressed only implicitly. The readjustment program would have important implications for science and technology, particularly with respect to the relationship between research and the economy.[38] Yet, not until the signals underlying economic behavior were rectified could Beijing expect attitudes towards the development and use of science and technology to change.[39]

III. Economic Readjustment and Readjustment of S&T

A. Rethinking S&T Modernization

Although the details are scarce, a national science and technology meeting to review the problems and revise the strategy for S&T modernization was held in December 1980.[40] The meeting set the stage for an outpouring of Xinhua (New China) news broadcasts and several articles in both People's Daily and Guangming Daily regarding the appropriate role of science and technology. These articles indicate that a major revision of the approach for stimulating S&T advance was underway in early 1981, as reflected in the *Xinhua* admonition that "in performing science and technology work, we should make the promotion of economic development our primary task."[41]

The full thrust of the new approach was described in two interviews, one with Yang Jike, vice-governor of Anhui and a member of the faculty at the Chinese University of Science and Technology and the other with Tong Dalin, Vice-Minister of the SSTC. Yang indicated that applied research would be stressed and that no more than 5% of available S&T funds should be devoted to basic research. According to Yang, "the past practice of devoting much manpower and money to isolated sophisticated topics without regard for economic results must change."[42] Tong highlighted five new principles to guide all science and technology work: 1)S&T will be coordinated with the growth of the economy; 2)production technologies and their application will be the key focus of research activity; 3)enterprises should expand their research efforts and strive to popularize research findings; 4)continued efforts should be made at studying foreign S&T developments; and 5)basic research should not be ignored, but should grow at a steady, but gradual pace.[43] Tong went on to note that the future development of S&T and the success of readjustment of the economy are closely linked.

The fullest expression of the new policy was stated in a

Renmin Ribao editorial on April 7th.[44] Summarizing further the results of the December 1980 S&T meeting, the editorial noted that the time has come to move away from only "paying attention to advanced science and technology, ignoring production, and reaching for what is beyond one's grasp and of blindly catching up with and surpassing others." The editorial suggested two reasons to account for China's poor performance with respect to the development of key production technologies: a lack of competition that has fostered a disregard for economic results and the tendency to rely principally on increased capital construction rather than new technology to expand production output.

> What is the aim of scientific research? Some say that it is to probe the unknown. Others say that it is to catch up and surpass world levels. Still others say that it is to achieve good results and train competent personnel. There are grounds for all these sayings. However, what does all this finally boil down to? To increase the forces of production. If we deviate from this fundamental aim, it will be difficult to avoid tendencies such as scientific research for its own sake, catching up with and surpassing others for the sake of doing so and achieving good results just for the sake of achieving them, and in the end, production cannot be benefitted and it will be difficult to develop the economy and go on with scientific research.[45]

A more severe criticism of on-going practices within the S&T sector was presented in another editorial in the Liberation Daily based in Shanghai in June 1981. The article, which blamed many of China's problems in the S&T realm on the continued influence of leftist elements, pointed to five problems that had affected the implementation of the program for S&T modernization:

a)placing too much emphasis on blindly catching up with the West;

b)failure to pay adequate attention to the quality of research;

c)impatience for success;

d)continued duplication of research; and

e)neglecting the links between science & technology and the economy.

The last problem, however, continued to be the key to what both economic planners and administrators believed was the real failure of Chinese S&T modernization efforts--a primary cause of which was the lack of formal institutional linkages between those responsible for determining economic needs and objectives on the one hand and those responsible for setting research priorities on the other hand. Highly-focused consultation and coordination between members of the SSTC and their counterparts and the State Planning and Economic Commissions were a rare occurrence, except for broad planning purposes.

More important, all of the problems cited in the Liberation

Daily, in one way or another, owed their existence to the inability of Beijing to effectively monitor the implementation process and to ensure adherence to the policies being formulated by the central authorities. The State Science and Technology Commission, which had been given the mandate to oversee the rehabilitation and revitalization of the S&T system, had proven itself relatively ineffective at managing national science and technology activities. Public criticism of the SSTC emerged at both the 3rd and 4th Session of the 5th National People's Congress.[46] Criticism of the SSTC was particularly strong at the 4th Session in December 1981 when CAS Vice-President Li Xun seized the opportunity to castigate the SSTC. Even though Li's comments were partly motivated by the traditional rivalries between the SSTC and the CAS, his point that the SSTC had failed to unify research and that institutes were scrambling for research projects without overall coordination was an accurate one.[47]

The situation regarding implementation of science and technology policies in the provinces was even more unsettled. The SSTC, acting through its provincial counterparts, continued to be unable to bring about desired changes regarding personnel policy and the setting of research priorities. In a recent paper dealing with China's provincial science and technology administration, Howard Klein documents the basic inconsistencies between the policies coming out of Beijing and how these policies were being handled at the local level.[48] In a select number of provinces, such as Sichuan, local officials, in conjunction with the provincial branch of the Communist Party, responded in a positive fashion to Beijing's policies. [49] In a large percentage of the provinces, however, the slower pace at which the local S&T system had been restored in comparison with what had transpired in Beijing since early 1978 and the need to depend on cadres with questionable commitment to Deng, produced a persistent uneveness in the acceptance and promotion of centrally-derived policies. [50]

B. Altering the Implementation Environment

Although the decision to initiate a fundamental revision in the approach to S&T modernization meant that new attention would be focused on the development and application of production technologies, the fact remained that critical changes in the style and criterion of economic management would be necessary to facilitate successful implementation of the new policies for science and technology. Discussions about how best to effect a change in managerial behavior were an intimate part of the leadership's internal debates concerning the essence of readjustment and economic reform. [51] Beginning in mid-1981, the discourse coming out of Beijing reached a new level of sophistication, with the debate focusing on the proper relationship between the plan and the market. [52] One group of decisionmakers, perhaps led by Chen Yun, viewed the plan as the inviolable principle of economic management.[53] Another group, supported by Xue Muqiao and apparently Zhao Ziyang, were convinced that over--centralization of decision-making was a major source of China's economic stagnation. They advocated relaxation of the plan so that market forces could be allowed to determine economic behavior.

The willingess of top leaders to allow some market forces to operate was a signal that excessive reliance on so-called "administrative methods" in the past had not produced the type of dynamism in the economy needed to sustain future economic growth. China's leaders were anxious to develop a formula that would harness the "enthusiasm" of the enterprises and at the same time prevent excessive deviation from state guidelines in areas such as new capital construction.

One of the key mechanisms adopted to facilitate these changes was the introduction of the economic responsibility system into the industrial sector. As David Zweig has shown in his paper, the response of the peasants in the rural areas to the agricultural responsibility system had been quite positive, though there were some undesireable side effects. Indications that the responsibility system would be widely applied in the industrial sector apparently first appeared at a national conference on industry and transport held in Shanghai in April 1981.[54] Reliance on the notion of economic responsibility at the level of the factory would mean that enterprise managers (and workers) would have a material interest in the productivity of their respective firms.[55] Moreover, it would also mean that the basic operating criteria of the past, i.e. meeting output quotas, could no longer be the sole consideration in the minds of workers or managers.

Introduction of the economic responsibility system was accompanied by several other changes in economic policy--many of which had important implications for science and technology. First, and most important was the shift in industrial policy from "extensive" to "intensive" development. No longer would productivity increases be sought through the construction of new plants or the importation of whole plants from abroad.[56] Rather, the key to desired increases in productivity would be factory renovation and modernization. Old, obsolete, or poorly-maintained equipment would be replaced by more modern, sophisticated items.[57] Efforts would be made to rationalize plant layout, upgrade management, and modernize manufacturing techniques. Achieving significant improvements in energy efficiency also assumed a high priority. To accomplish all of these objectives and to realize economic gains, expanded application of science and technology would be required.[58]

In order to assist with the financing of plant renovation efforts, the central authorities increased the availability of bank loans and other forms of credit to help pay for acquisition of new items. [59] In addition, a major controversy developed over the existing rate of depreciation in China's industrial plants. [60] Many economists, lead by the aged Sun Yefang, claimed that China's depreciation rate was inadequate in comparison with most of the industrialized nations and that the leadership could not expect modernization of plant and facilities to occur if the period of depreciation remained so long and the rate so low. [61] While Sun's point was well-taken, a lengthening of the depreciation period would increase locally retained funds, possibily providing the financial wherewithal for localities to further subvert central government priorities in areas such as capital construction. [62]

Discussion over finances also engendered significant debate over the issue of prices--perhaps the most politically sensitive issue in the relam of Chinese economic policy. Although the leadership was unable, if not unwilling, to come to any agreement on when and where to begin, there was a general consensus that major price adjustments would be a necessary prerequisite to achieving significant improvements in plant operation and efficiency. In many cases, these improvements would ultimately be achieved through introduction of newly-stimulated innovations as sensitivity to technology-derived productivity gains would likely substantially increase.

Second, new emphasis was placed on improving product quality.[63] Chinese leaders initiated several procedures, including a system of product licensing in order to ensure that substandard items were not longer being manufactured. At a broad level, the State Economic Commission assumed part of the responsibility for making certain that the past practice of producing and over-stocking useless goods was abolished. Yet, given the new role of profit and loss within Chinese enterprises, the adept factory manager also bore a good deal of this responsibility. In particular, managers would have to be concerned about the marketability of their products given the growing availability of consumer goods throughout the country.

Third, there was a movement towards enterprise consolidation. This was being encouraged to close down many of the small and inefficient plants that remained on the scene year in and year out despite their poor economic performance. One good example of a successful effort is the television industry in Shanghai. One of Beijing's aims appears to have been to confront the "small producers" mentality that has been so pervasive in Chinese industry. It also was meant to address the issue of those factories that had pursued the practice of "small and complete" by fostering greater greater specialization. In addition, factories with many geographically dispersed components were told to bring their various plants under one roof or within closer proximity of one another.

A fourth move to strengthen productivity was embodied in the effort to break down the barriers between the civilian and defense industrial sectors. China's defense sector has been the recipient of the country's best resources, receiving high priority throughout the last thirty years. According to a report by China's Ministry of Ordnance, the military sector has had appreciably more and higher quality manpower, better and more modern manufacturing and testing equipment, and greater financial and political support. Given these advantages and the availability of large amounts of unused production capacity in the defense sector, the leadership has encouraged greater cooperation with civilian institutions. Whereas in the past, central tasking had been the major vehicle for achieving cooperation between the two sectors, within the new environment, but within the bounds of security considerations, the scope and timing of cooperation would be left to the individual components themselves.[64]

Support for building bridges between the two sectors has come from the highest levels in the Chinese leadership. Zhang Aiping, Minister of National Defense and former head of China's National Defense Science and Technology Commission, has viewed the development of a civilian R&D capability as an integral part of the overall national modernization drive.[65] Zhang's position appears to be that the sharing of information and resources is a two-way street.[66] This point was implicitly stated in an article by Zhang in Hongqi in March 1983. Stressing that China cannot rely on other nations for acquisition of desired technologies, Zhang emphasized the need to strengthen the country's scientific and technological research base to meet Chinese needs as they arise. [67] Computer and electronics development appears to be one specific area where this bridge-building is being emphasized. [68]

C. Freeing Up S&T Resources

The launching of the various economic reforms has important consequences for the reform of the S&T system. In response to, and in some cases as a result of the freeing up of economic resources, similar types of complementary actions were taken vis-a-vis the science and technology system. Most important has been the initiation of a formal contract system. Under existing guidelines, factories and research institutes may sign agreements for the exchange of services. Each contract specifies a certain formula for compensating the research institute for its contributions. This emphasis on contract-related research is part of an effort to encourage greater cost-consciousness within the research unit as well as to assist the research sector in obtaining funds that cannot be supplied by the central government.

Three forms of contracting appear to predominate: 1)the institute sells its rights to a new technology directly to the factory and receives a fee; 2)the institute signs a contract with a factory to provide technical assistance and receives a percentage of the profit at an annually decreasing rate, such as 20% the first year, 10% the second year, etc.; and 3)an institute provides technology to a factory and receives a percentage of sales as compensation, once again at a decreasing rate. These types of arrangements link the productivity of the factory to the resourcefulness of the research unit and visa versa. In addition, it also serves as a vehicle for "capitalizing" technology---something the Chinese system lacked prior to the introduction of the research contract system.[69]

Where enterprises and research units have sought to go beyond the limited, short-term features of the contract, they have formed cooperative ventures called "alliances," brain-trusts, research--production unions, and "coalitions."[70] The distinguishing feature of these new organizational forms is that the member organizations do not relinquish their formal institutional affiliation. They are structured to facilitate both joint planning and selection of projects. The research that occurs is production--oriented, involving both horizontal and vertical integration. Profits and loses are jointly shared, once again providing both partners with a vested interest in a successful venture.

A third policy innovation designed to promote the implementation of policies for science and technology deals with the new provisions for labor mobility and consulting.[71] In an attempt to expand the availability of technical expertise to both enterprises and government agencies, scientists and engineers have been given the opportunity to sell their services on a fee basis. Research units have been instructed to allow their personnel, after completion of their regular jobs, to serve as consultants on a part-time basis.[72] In addition, research societies under organizations such as the Chinese Association for Science and Technology can perform a technical advisory role. This role was formalized in early 1983 with the formation of the China Science and Technology Consultative Service Center in Beijing.[73] The center will serve as mechanism for bringing together multi-disciplinary teams of experts to advise on technical and economic matters.[74]

These three new features on the science and technology scene--research contracts/cooperative ventures with enterprises/technical consulting--are all designed to stimulate research units to make a sustained effort to insure that their projects have some economic purpose. By encouraging the commercialization of research while at the same time promoting the economic responsibility system in industry and facilitating cooperation between civilian and defense units, the leadership has introduced several new dimensions to the research-production interface previously absent in the Chinese system. So far, as the experience in such provinces as Liaoning indicates, the results have been appreciable, with various new amalgams of research and production units being formed on a regular basis.[75] In addition, municipalities with a strong scientific and technical base such as Shanghai have taken to offering technical guidance and expertise to other geographic areas throughout the country.[76]

These efforts to "deregulate" the research system have been complemented by a program to build a strong research capability within the university system and to link that capability with the technology needs of various enterprises.[77] Faced with a shortage of funds to acquire new equipment and to modernize existing facilities, education institutions, such as Jiaotong University in Shanghai, have taken to the rendering of consulting services as a means to raise needed monies. In 1982, the Department of Technical Services at Jiaotong earned over 1.5 million yuan from consulting activities.[78]

One other effort being pushed by the Dengist leadership to promote more effective policy implementation is the placing of persons with technical credentials in positions of power and authority. In May 1981, the Chinese Academy of Sciences held a major election in which many management positions were restaffed with scientists rather than administrators. Fang Yi, former CAS President and Minister-in-Charge of the SSTC, but a non-scientist, was replaced by Lu Jiaxi, a chemist trained in the West. These changes also have occurred within the government apparatus. In Liaoning, for example, two engineers were named deputy governors.[79] The Communist Party also has been stepping up its efforts to recruit scientists and technicians. Since 1979, the Fujian Provincial Branch of the CCP has admitted almost 10,000 professionals as part of its attempts to dampen the legacy of the Cultural Revolution and reduce the potential for party errors in the face of the increasing amount of technical decisions that must be made.[80]

In spite of the fact that Beijing's new policies have been well received by both factories and research institutes, implementation has not proceeded smoothly in all cases. For example, the situation regarding intellectuals remains quite difficult as far as their having an appropriate environment within which to work.[81] The fact that intellectuals continue to experience harassment and discrimination was discussed in an editorial in Hongqi in September 1982:

> We should realize that many people are suffering from "short-sightedness." The longstanding leftist ideas of belittling science, culture and the intellectuals, and the pernicious fallacies about the intellectuals spread by the "gang of four" are still affecting the minds of some comrades. Much effort is needed to eliminate this influence. Today, this influence is manifested in: 1)Ideologically and theoretically, some people have not yet truly realized that the great majority of intellectuals are components of the working

> class who have mastered relatively more knowledge in science and culture. 2)Some people do not really understand that the further we go with modernization, the more we need intellectuals. They even think that "without intellectuals, production will be carried on and houses will be built just the same and so on. It is high time this kind of prejudice and narrow-mindedness was gotten rid of.[82]

Problems also have arisen with respect to the compensation due several scientists and engineers for their consulting activities. In one case reported in China Daily, a Shanghai technician was accused of illegal economic dealings when he accepted money for technical assistance he had rendered to a local rubber product research institute.[83] Although he was later acquitted of the charges, the very fact that such an incident occurred could be enough to dissuade other engineers from engaging in similar advisory positions. In another example in Guangxi, three technicians were admonished for accepted a 300 yuan renumeration for designing a barge for a local company in Nanning. Here again, they were acquitted, but only after severe public ostracism.[84]

The "commercialization" of research also has led to the formation of so-called "technological blockades" in several regions.[85] Spurred on by the potential profitability of developing or possessing various marketable technologies, certain research institutes and enterprises have become reluctant to share their information with their counterparts locally or in other parts of China. The absence of a strong domestic patent law to protect "proprietary" information makes the hoarding of technical information economically rational within the prevailing environment. Given the leadership's recent encouragement of intra-country "technology transfers," the new economic realities of the situation have worked against Beijing's stated objectives.

The on-going program to increase the efficiency and effectiveness of research units also has experienced some problems. One source of these problems continues to be administrative and political interference in research.[86] In one example, the work of a research scientist at Shandong Normal University was sabotaged by the deputy director of the scientist's research institute.[87] In other instances, scientists themselves have falsified research findings or violated the scientific ethics of the research community.[88] Lastly, the administrative groups within various research institutes have taken a "percentage" of the rewards received by some scientists for their research accomplishments--discouraging many scientists from moving beyond the "egalitarianism" that characterized the research sector during the Maoist period.[89]

Finally, in spite of the new incentives to develop and apply science and technology to production, political attitudes continue to lag and responsiveness to certain centrally-derived policies has not improved. Owing to the continued inability of the SSTC to effectively implement policies for modernizing science and technology, the cause of which may be both a function of the large size and dispersed nature of the research system, the leadership decided in January 1983 to form a new supra-ministerial level organization to handle the country's major S&T-related matters. [90] The new body, which is headed by Premier Zhao Ziyang and is composed of members from all of China's leading civilian and defense organizations, brings to the S&T front the authoritative stamp of the premier's office on many policy issues. [91]

The decision to form this new body is apparently a reaction to the continued foot-dragging and political infighting that have remained as important constraints on scientific and technological progress. One might suggest that the emergence of a new centralized body to direct S&T activities stands in direct contradiction to the "ascending" nature of implementation responsibility. In some respects, this is true. Pressures for re-centralization in the S&T area haven arisen because under a decentralization environment, Beijing lacks the tools to insure consistent adherence to its policies. Within a setting where the financial and personnel resources to advance S&T modernization are scarce, the leadership cannot risk extensive waste or departures from central priorities.

According to official Chinese statements, the primary function of this new entity will be policy formulation and articulation. It will not directly intervene in the realm of implementation unless obvious deviation from central guidelines takes place. Pending the response of local research units to the efforts of this new leading body, however, its existence may not be temporary. In the final analysis, Beijing's goal is to find the best formula to achieve its objectives vis-a-vis S&T activities. If a decentralized approach will not yield desired results, the presence of such high-level, policy-oriented groups will remain a permanent part of the scene.

IV. Prospects and Conclusion

> The challenge for reformers... lies in utilizing the discipline inherent in a closed system to loosen the structure and thus to permit the system to adapt and learn rather than remain persistently sealed from the social forces in its midst. [92]

The literature on policy implementation suggests that environmental context is an important determinant of implementation success or failure. Because of the nature of the prevailing economic or political climate, identical programs in content may be implemented differently within various systems. One of the keys variables in explaining the different outcomes within alternative environments is the varying degrees of central control. Some regimes opt for a decentralized approach in order to provide the widest flexibility in policy execution. Yet, as Grindle indicates, under these circumstances, national leaders must rely on local leaders who may act according to the dictates of their local situation rather than centrally-derived directives. [93]

The experience of China regarding the implementation of policies for modernizing science and technology suggests that movement towards a decentralized approach has yielded greater acceptance of the regime's policies than the earlier experience when centralized directives were used to "push" new policies and programs. Given the vast size of China and the different relationship that each province and municipality has with Beijing, it is often difficult, if not impossible for Chinese leaders to formulate a set of policies that can be equally applicable to all of China. Given the logistical and bureaucratic nightmare of carrying policies from formulation through the implementation stage, an ascending strategy allows for needed regional variation and application. Moreover, with the addition of the economic responsibility system and increased opportunities for earning "profits," the decentralized approach allows for the tapping of local initiative when and where it is available.

In the Chinese case, a more decentralized approach was initiated in order to overcome the structural shortcomings of the S&T system regarding the lack of formal institutional relationships between research units and production enterprises. The decentralized approach, however, only served to further compound the regime's inability to manage the political dimensions of the implementation problem. As a result of the granting of greater local autonomy, power increasingly devolved into the hands of local officials, some of whom remained committed to the policies and practices of the Maoist era. This trend only helped to further undermine Beijing's program for modernizing science and technology. The continued difficulties being experienced by intellectuals throughout China is indicative of the costs incurred by adopting a decentralized approach. This is not to suggest that centralized efforts would have met with any greater success, but only to highlight the tradeoffs when dealing with implementation variables that have different systemic origins.

To overcome the problem of deviation from national priorities, the regime found it necessary to create a high-level S&T body to intervene when and where necessary. If one looks at Beijing's actions since the May 1982 government reorganization, it becomes apparent that the move towards decentralization also has been accompanied by an increase in the number of new organizations responsible for handling high priority projects that cannot be left to the vagaries of the "non-planned" aspects of the system. The "leading group for science and technology" has been joined by a "leading group for computer development" and several other State Council-level entities, suggesting that Beijing recognizes the need for a "mixed" implementation strategy that combines elements of both central guidance and local initiative.

One of the most interesting of these new bodies is the Center for Techno-Economic Research. This research/policymaking organization is particularly important because of the oversight role that it plays in the selection and appraisal of national projects. Headed by Ma Hong, who is also President of the Chinese Academy of Sciences, the group is designed to conduct feasibility studies of projects that involve a large commitment of personnel and financial resources. It is composed of natural scientists, engineers, and social scientists in the hope of providing an interdisciplinary perspective on various proposed projects. The need to create and maintain such bodies underlies Beijing's continued apprehension over the "deregulation" of various aspects of the economy.

Its emergence also underscores two other related considerations. First, is the reality that much more remains to be done before the leadership's policies will be consistently implemented in the spirit in which they were introduced. There is too much "short-term" thinking in China as both local and national leaders search for quick fixes to problems that are only amenable to long-term solutions. Second, as a result of this tendency, the problems of policy implementation are significantly enhanced because the policies under consideration are frequently lacking in consistency or coherence. The Techno-Economics Center is in place to ensure that "good" policies are being produced in Beijing so that the uncertainties of implementation are not exaggerated by poorly formulated policy--a problem that characterized the initial phases of China's modernization drive in 1978.

At the beginning of this paper it was suggested that the effort to implement science and technology policy would require fundamental attitudinal and political changes in Chinese society.

It is clear from the information presented that additional significant behavioral changes will still be necessary before those charged with the responsibility for implementation will be able and willing to produce desired results. These modifications, however, will not come until China's program of institutional reform and reorganization is stabilized and consolidated. The anathema to all value and behavior change in Chinese society is the uncertainty that appears when institutions are in flux. Concerned about the potential for abrupt and rapid political reversals, many scientists as well as others in China remain reluctant to move too far too fast, if they are willing to move at all.

The difficulties encountered by the Chinese leadership in producing these changes will be compounded by the continued influence that the foreign scientific community in the West and Japan will have on China's modernization thinking. Although Chinese leaders appear to be aware of the dangers associated with the "open-door" to bilateral and international scientific contacts, at the international level there is little they can do short of "closing" the door without jeporadizing a loss in the transfers of knowledge and information that accompany these activities.

At the same time, the signals eminating out from Beijing regarding the objectives and priorities for S&T modernization indicate that there are incentives and rewards for ignoring these distractions and pursuing a "Chinese-style" path to development. The decision in this paper to focus on the "facilitative" aspects of China's implementation strategy was made because it sheds light on the means adopted by the Chinese to achieve higher levels of compliance with national level priorities. Since Chinese authorities in Beijing have not had the power or the capability to ensure implementation, contextual reforms, along with continued reaffirmation at the central level of the content of the policy, i.e. S&T serving the economy, have proven to hold the most promising results. This finding supports the work of Grindle and others who have noted that political leaders can increase the effectiveness of their implementation efforts by either manipulating the content of the policy or its political context.

China's experience also highlights the continued tension within socialist regimes in particular between the imperatives of control and innovation. The ability to maintain control becomes extremely difficult when external actors are allowed to participate within various policy arenas. Additionally, the Chinese case underscores the need to mobilize sufficient political support at all levels to successfully execute a central policy decision. Science and technology as a social activity, unlike economic activity, does not have a readily consummable output that can be utilized by a wide spectrum of the populace. And, in most instances, the output that is produced yields long-term rather than immediate gratification or satisfaction. As a result, the payoffs for expending resources must be made clear from the start. Both China's scientific community and economic managers have had a different sense of what these payoffs are and should be. The challenge facing Beijing, therefore, will be to design an appropriate structure of new incentives while at the same time balancing off centralized restraint with selective intervention.

NOTES

1Merille Grindle, Politics_and_Policy_Implementation_in_the_Third World (Princeton: Princeton University Press, 1980).

2Charles Lindblom, Politics_and_Markets (New York: Basic Books, 1982). Lindblom provides both a top-down and bottom-up analysis of the differences between plan-led and market-led societies.

3Roy Rothwell and Walter Zegveld, Industrial_Innovation_and__Public Policy (London: Frances Pinter Ltd., 1981).

4Joseph Berliner, The__Innovation__Decision__in__Soviet__Industry (Cambridge: MIT Press, 1976). Berliner suggests that to better understand the determinants of innovation in socialist systems, we must not merely concentrate on the central bureaucracy, but must also focus on four additional factors: prices, decision rules, incentives, and organizational structure.

5Charles Weiss, "Mobilizing Technology for Developing Countries," Science (March 16, 1979), pp. 1083-1089.

6C.A. Tisdell, Science__and__Technology__Policy:__Priorities__of_ Governments (London: Chapman and Hall, Ltd., 1981). Tisdell provides a well-developed explanation for the differences between science policy and technology policy.

7Richard P. Suttmeier, Research and Revolution (New York: Lexington Books, 1974).

8Jon Sigurdson, Technology and Science in the People's Republic of China (Elmsford, New York: Pergammon Books, 1980).

9This point was underscored with the announcement in late 1982 of the goal of quadrupling the value of industrial and agricultural output by the year 2000. China's leaders have acknowledged that at least half of the gains towards achieving this goal will depend on expanded application of new technology. See "Create New Wealth Through Relying on Advances in Science and Technology," Renmin Ribao (People's Daily), (November 7, 1982) translated in FBIS-PRC (Foreign Broadcast Information Service-People's Republic of China), (November 10, 1982), pp. K5-K12.

10For an interesting example of the trials and tribulations of one scientist see Shi Xiyuan, "Strive for the Right of Scientific Research," Ziran Bianzhengfa Tongxun (Journal of the Dialectics of Nature), Number 1 (1980) translated in JPRS (Joint Publications Research Service) 78995 (September 16, 1981), pp. 49-58.

11Leo Orleans, "Science, Elitism, and Economic Readjustment in China," Science (January 29, 1982), pp. 472-477. See also Sun Cang, "Intellectuals and Getting Cocky," Renmin Ribao (April 22, 1983) translated in JPRS 83775 (June 28, 1983), pp. 67-68.

12One typical example serves to illustrate this point. Within the CAS-affiliated Dalian Institute of Chemical Physics, the average age of senior researchers in 56.8 years, while the average age of mid-level and junior researchers is 46 years and 39 years respectively. The problem would not be so serious if it were not for the fact that many of those in the mid-level category and below lack in-depth training as a result of the Cultural Revolution. See "Bring Out the Positive Factors of Middle-Aged S&T Personnel," Guangming Ribao (February 27, 1982) translated in JPRS 81364 (July 26, 1982), p. 19.

13Xia Yulong and Liu Ji, "It Is Also Necessary to Eliminate Erroneous Leftist Influence on the Science and Technology Front," Jeifang Ribao(Liberation Daily), Shanghai (June 2, 1981) translated in FBIS-PRC (June 11, 1981), pp. K8-K12.

14For an assessment of these problems in the case of Shanghai see "Ten Problems That Urgently Need to Be Solved in Shanghai At Present," Kexuexue Yanjiu Lunwen Xuan(Selected Papers on the Study of the Science of Science), Number 4 (1980), pp. 153-162.

15Dan Qin, "Energetically Study and Grasp Modern Scientific Management," Tianjin Ribao (May 27, 1980) translated in JPRS 76161 (August 5, 1980), pp. 1-6.

16Huang Wei and Zhang Jieyu, "The Structure of China's Scientific and Technical Ranks and Current Measures of Readjustment," Kexuexue_Yu_Kexue__Guanli__Yanjiu(Scientology and the Management of Science and Technology), Number 4 (July 20, 1982) translated in JPRS 83240 (April 12, 1983), pp. 230-237.

17Tao Kai and Ceng Qing, "On the Question of Directional Flow of Scientific and Technical Personnel," Guanming__Ribao (July 12, 1982) translated in JPRS 83240 (April 12, 1983), pp. 245-250.

18Xia Yulong and Liu Ji, pp. K8-K12.

19For example see "Deng Xiaoping Meets Overseas Chinese Scientists," Xinhua(New China), (June 18, 1983) translated in FBIS-PRC (June 20, 1983), pp. A1-A2.

20Wang Chiwei and Liu Mingdong, "Import of Foreign Technology and Economic Effectiveness," Caijing__Wenti__Yanjiu(Research on the Problems of Finance), (July 1982) translated in JPRS 82364 (December 1982), pp. 23-28.

21Richard P. Suttmeier, Science,__Technology__and__China's__Drive for_Modernization (Stanford: Hoover Institution Press, 1980).

22Sigurdson, Technology_and_Science.

23The eight priority areas include agriculture, computers and electronics, space, genetics, physics, materials science, energy, and lasers.

24This point is also made in "Planting a Tall Tree: Science in China," Nature, Volume 301 (January 27, 1983), pp. 280-284.

25This project was ultimately cancelled and replaced by a more modest project to build a +2/-2 electron positron.

26One merely has to examine the criticisms of the CAS, particularly the comments made at the May 1981 meeting of the Scientific Council to understand how the CAS had helped set S&T priorities during the initial phase of the S&T modernization program. See China Examines Science Policy (Springfield, Virginia: Foreign Broadcast Information Service, January 1982), pp. 143-172.

27Zhang Qiang, "An Important Issue on the Readjustment and Reform of Our Country's Scientific Research System," Hebei Daxue Xuebao (Journal of Hebei University), (January 25, 1981) translated in JPRS 79432 (November 13, 1981), pp. 26-36.

28"National Scientific and Technological Conference in Beijing," Xinhua (December 5, 1979) translated in FBIS-PRC (December 6, 1979), p. L11.

29"The Entire Party Should Accord the Proper Importance to Science and Technology," Guangming Ribao (April 18, 1981) translated in JPRS 78147 (May 22, 1981), pp. 1-5.

30At a forum on scientific achievement held in Beijing in late 1980 there was a large amount of concern expressed regarding continued "administrative interference" in research activities. "Forum on Scientific Achievement Held in Beijing," Xinhua (December 21, 1980) translated in FBIS-PRC (December 22, 1980), p. L40.

31The circulation of popular scientific magazines and journals has increased ten-fold since 1966. There are 109 scientific journals with an overall circulation of 16.5 million and 34 national/local S&T newspapers with a circulation of almost 5 million. In spite of the fact that many of these serve as valuable education tools, a large percentage offer very little in the way of useful "technical" information to the potential readers. See China Daily (August 7, 1981), p. 3.

32Denis Fred Simon, "China's Capacity to Assimilate Foreign Technology," United States, Joint Economic Committee, China Under the Four Modernizations, 97th Congress, 2nd Session (August 13, 1982), pp. 514-552.

33Guo Xinchang and Yang Haitian, "China's Unfavorable Position in International Technology Transfer Should Be Changed As Quickly As Possible," Caimao Jingji (Finance, Trade and Economics), Number 1 (January 10, 1982) translated in JPRS 80736 (May 5, 1982), pp. 31-37.

34"On the Requirement that Technology Be Advanced and the Problem of Economic Rationality," Jingji Yanjiu (Economic Research), (November 20, 1980) translated in JPRS 77285 (January 30, 1981), pp. 34-43.

35By May 1979, 332 computers had been imported at a cost of almost 500 million yuan. Less than 1/3 were used as many as ten hours per day; out of 24 computers in Anhui only 3 were used more than eight hours per day. See Guan Weiyuan, "Formulate Scientific Programs in Accordance with the Demands of the National Economy," Ziran Bianzhengfa Tongxun, Number 2 (1981) translated in JPRS 79115 (October 1, 1981), pp. 36-45.

36Wang Chiwei and Liu Mingdong, "Import of Foreign Technology and Economic Effectiveness."

37For a discussion of the Baoshan steel project see Martin Weil, "The Baoshan Steel Mill: A Symbol of Change in China's Industrial Development Strategy," in China Under the Four Modernizations, pp. 365-393.

38According to a speech by Fang Yi in December 1979, "to implement the principle of readjustment, restructuring, consolidating and improving the national economy, scientific and technological work should not be weakened but strengthened." See "National Scientific and Technological Conference in Beijing," Xinhua (December 5, 1979) translated in FBIS-PRC (December 6, 1979), p. L10. For a discussion of how the CAS interpreted the call for economic readjustment see "Academy of Sciences Calls Work Forum To Discuss Measures to Implement Eight-Character Policy," *Guangming Ribao* (August 7, 1979) translated in *JPRS* 74313 (October 4, 1979), pp. 1-5.

39A short but focused discussion of the situation as it existed prior to readjustment is provided in "Factories Apply New Technology in Production," *FBIS-PRC* (September 19, 1980), p. L26.

40"Scientists Urged To Contribute to Production," *Xinhua* (February 26, 1981) translated in *FBIS-PRC* (February 27, 1981), p. L10.

41"Beijing Radio Stresses the Use of Science in the Economy," translated in *China Examines Science Policy*, pp. 1-2.

42"Applied Science to be Emphasized," *Xinhua* (January 29, 1981) translated in *FBIS-PRC* (February 5, 1981), pp. L8-L9.

43"Xinhua Interviews Science and Technology Official," translated in *China Examines Science Policy*, p. 11.

44"Further Clarify the Policy For the Development of Science and Technology," *Renmin Ribao* (April 7, 1981) translated in *China Examines Science Policy*, pp. 16-19.

45"Further Clarify the Policy For the Development of Science and Technology."

46For a description of the events at the 3rd Session of the 5th NPC see Howard Klein, "National People's Congress Meets in Beijing," China Exchange News, Volume 8, Number 5/6 (October/December 1980), pp. 2-3.

47Klein, "National People's Congress Meets in Beijing." During this period Chinese scientists in the CAS were quite unhappy about the efforts of the SSTC to diminish funds for basic research. CAS personnel were distressed by the actions of the SSTC because they claimed that that organization was staffed not by scientists, but by administrators who did not fully understand the nature of scientific inquiry.

48Howard Klein, "An Assessment of Provincial Science Organizations: Current Status and Future Trends," China Consulting Associates (May 1983), unpublished manuscript.

49"Sichuan Province Decides to Reform Further the Present System of Scientific Research," Guangming Ribao (September 23, 1980) translated in China Examines Science Policy, pp. 123-124. The case of Sichuan is interesting because it also is the province where economic reforms and readjustment appear to have proceeded the most rapidly in China.

50Referring to the leadership's dilemma regarding the situation among the leading cadres, one writer noted "they lack the knowledge of science and technology needed in undertaking the four modernizations, but they still have to lead the four modernizations."

See "Learn Respectfully and Honestly," Renmin_Ribao (August 15, 1980 translated in FBIS-PRC (August 18, 1980), pp. L5-L6.

51See Jack Gray and Gordon White, ed., China's__New__Development Strategy (London: Academic Press, 1982). In many ways, the goals of readjustment and reform were contradictory to one another. Reform was aimed at expanding local autonomy and responsibility while readjustment was designed to improve economic results and limit deviation from central policies. Centralization versus decentralization became a core issue as the leadership tried to bring "macro" and "micro" economic behavior into coordination with one another. See Wang Jiye and Wu Kaitai, "Resolutely Implement the Strategic Policy of Readjustment," Renmin_Ribao (December 23, 1980) translated in FBIS-PRC (January 6, 1981), pp. L18-L24.

52Premier Zhao Ziyang's report to the 4th Session of the 5th NPC brought the debates into full swing. In his speech, Zhao no only addressed the issue of improving economic results, but also commented on the all-encompassing role of the centrally-directed economic plan. See "Text of Zhao Ziyang Government Work Report," FBIS-PRC (December 16, 1981), pp. K1-K35. See also Xu Dixin, "The Current Problem of Economic Readjustment," Jingji_Yanjiu (June 20, 1981) translated in JPRS 78880 (September 21, 1981), pp. 3-12.

53Fang Weizhang, "An Inviolable Basic Principle--Some Understanding

On Upholding the Policy of Relying Mainly on the Planned Economy and Supplementing It With Regulation by Market Mechanism," Hongqi (Red Flag), (May 1, 1982) translated in JPRS 81379 (July 26, 1982), pp. 20-31.

54"Industrial Production and Transport Conference Opens," Xinhua (April 15, 1981) translated in FBIS-PRC (April 16, 1981), pp. K1-3.

55According to Yuan Baohua, former head of the State Economic Commission, the economic responsibility system in industry would allow retention of profits and accountability for losses by large and medium enterprises as well as greater managerial autonomy. See "Industrial Production and Transport Conference Opens."

56The new emphasis in technology imports was on the acquisition of know-how and design information rather than large quantities of equipment. Authority for import decisions was to fall out of the hands of the major trading companies. Even though decentralization of decision-making had posed some problems in 1978-79, it was believed that the addition of greater local accountability would alleviate some of the problems of waste that occurred in the past.

57According to one study, 60% of the equipment in Chinese industry dates back to the 1940s and 1950s, 35% from the 1960s, and only 5% from the 1970s. See Ding Changqing, "The Machine-Building Industry and Technology Transfer in the National Economy," Jingji Yanjiu (July 20, 1982) translated in JPRS 81724 (September 8, 1982), pp. 1-10.

58In some cases because of the restrictions applied on further capital construction, several enterprises used the guise of technical transformation as a means to undertake the building of new plants. See "A Second Front Not To Be Ignored," Jiefang Ribao (February 3, 1981) translated in FBIS-PRC (February 5, 1981), p. O5.

59"Using Science and Technology To Improve Recovery," Renmin Ribao (November 7, 1982) translated in FBIS-PRC (November 10, 1982), pp. K5-12. According to a Xinhua report in late 1982, the China Construction Bank provided 1.2 billion yuan in 1982 and 2.0 billion yuan in 1983 in loans for technical transformation of enterprises. See FBIS-PRC (December 29, 1982), p. K20. These funds were supplemented by 11.47 billion yuan in foreign exchange loans provided by the Bank of China between 1979-1982. The Bank of China also provided 1.259 billion yuan in renminbi loans for domestic production of parts and equipment for imported items--all of which was to be used for technical renovation. See "Loans Used for Technology," China Daily (December 20, 1982), p. 2.

60Liu Guoliang, "Reform of Fixed Assets Depreciation System," Caizheng (Finance), (December 5, 1981) translated in JPRS 80050 (February 8, 1982), pp. 26-27. See also Meng Lian, "Views on Improving the Management of Depreciation Funds of Fixed Assets," Jingji Yanjiu (May 20, 1982) translated in JPRS 81215 (July 6, 1982), pp. 34-39.

61According to one assessment, China's depreciation rate is only 4.2%; the depreciation rate of fixed assets in China includes factory buildings and other utilities beyond production equipment. If it was adjusted to accord more with the Western definition, i.e. to include only production equipment, the rate would still be less than 6%--still on the low side. See Sun Shangqing, "Exploration on Technical Transformation," Jingji Yanjiu (February 20, 1982) translated in JPRS 80512 (April 7, 1982), pp. 22-35.

62In 1982, for example, even though state investment in capital construction declined to 49.8% compared with 56.8% in 1981, overall outlays for capital construction increased by 11.2 billion yuan as a result of the enlarging of local autonomy. See Xu Ming, "Ten Billion Yuan: A Warning Mark for Capital Investment," China Daily (July 16, 1983, p. 2.

63"Quality Controllers Congress Opens in Beijing," Xinhua (September 22, 1982) translated in FBIS-PRC (September 23, 1982), pp. K9-K10.

64"Institute Urges Combining Military and Civilian Research," Keyan Guanli (Scientific Research Management), (July 1982) translated in JPRS 82108 (October 28, 1982), pp. 53-63. One of the risk associated with providing defense factories an opportunity to manufacture civilian consumer goods in that it may be difficult to get them to return to defense production if they have been succesful and earned large profits.

65In mid-1982, the National Defense S&T Commission and the National Defense Industries Office were combined to form the National Defense Science, Technology and Industries Commission(NDSTIC), led by Chen Bin.

66"Zhang Aiping Stresses PLA's Modernization," Xinhua (December 26, 1982) translated in FBIS-PRC (December 27, 1982), p. K4.

67"Zhang Aiping on National Defense Modernization," Zhongguo Xinwen She(China News Service), (February 28, 1983) translated in FBIS-PRC (March 1, 1983), pp. K8-K9.

68"Zhang Aiping Hails Electronics Industry Role," Xinhua (March 2, 1983) translated in FBIS-PRC (March 4, 1983), pp. K14-K15.

69Wang Cailiang, "A Number of Problems in Managing Industrial Research with Economic Methods," Kexuexue Yu Kexue Jishu Guanli, Number 1 (1982) translated in JPRS 81724 (September 8, 1982), pp. 49-53. Some reservations were expressed at the time regarding the possibility for excesses if adequate political work did not accompany the new emphasis on economic rewards.

70Zhou Jinquan, "Bright Future for Implementing Joint Ventures in Scientific Research and Production," Kexuexue Yanjiu Lunwen

Xuan, Number 2, (1981), pp. 49-55.

71"Consultancy," translated in Summary of World Broadcasts--Far East, FE/W1198/A (August 18, 1982), p. 12.

72"Organization and Leadership in Scientific and Technical Consulting Services," Wen Hui Bao (December 3, 1981) translated in JPRS 80479 (April 2, 1982), pp. 5-8.

73"Scientific Consultancy Service Expanded," Xinhua (January 28, 1983) translated in FBIS-PRC (January 30, 1983), pp. K6-K7.

74See also "Fang Yi at Opening of Scientific Service Center," translated in FBIS-PRC (March 22, 1983), pp. K6-K7.

75Zheng Shen, "Cooperation with Research Units Raises Production," China Daily (May 2, 1983), p. 2.

76"National Economic Meeting Opens," Xinhua (January 27, 1983) translated in FBIS-PRC (January 28, 1983), pp. K7-K10. Over 17 provinces are cooperating with Shanghai. In 1982 over 105 technical delegations from around China visited Shanghai to discuss possible technical exchanges.

77Liu Dong and You Huadong, "Enterprises Must Develop New Technology in Coordination with Institutes of Higher Education," Jingji Guanli (Economic Management), (August 15, 1982) translated in JPRS 82045 (October 21, 1982, pp. 12-15.

78"University Faculty Receives Bonus for Consulting Work," China Daily (February 10, 1983), p. 3.

79"Technical Experts Appointed to Leading Posts," Beijing Review (May 17, 1982), p. 5. Similar appointments have been made in other provinces and municipalities throughout China.

80"Fujian Intellectual Party Members," translated in FBIS-PRC (July 14, 1983), p. O7.

81"Scorn for Intellectuals Is Sign of Backwardness," China Daily (December 20, 1982), p. 4.

82"A Major Problem in Implementing the Policy Toward Intellectuals," Hongqi (September 1, 1982) translated in JPRS 82121 (October 29, 1982), pp. 22-26.

83"Spare-time Work Lands Technician in Trouble," China Daily (December 25, 1982), p. 3.

84"Unjust Punishment of Technicians Criticized," Guanxi Ribao (March 10, 1983) translated in JPRS 83145 (March 28, 1983), p. 27.

85Xu Guoquan, "How to View the Keeping of Technical Secrets," Wen Hui Bao (February 11, 1981) translated in FBIS-PRC (February 27, 1981), pp. O2-O3. See also Shen Junbo, et. al, "Three Problems in Technical and Economic Cooperation," Jiefang__Ribao (July 15, 1982) translated in JPRS 81927 (October 5, 1982), pp. 7-10.

86Lu Jiaxi, "Several Problems Concerning Current Scientific Research Management," Keyan__Guanli (July 1982) translated in JPRS 82108 (October 28, 1982), pp. 1-9.

87"Conduct Hampering and Sabotaging Scientific Research Definitely Not Allowed," Renmin__Ribao (November 25, 1982) translated in JPRS 82643 (January 14, 1983), pp. 156-158.

88"Ethical Norms for Scientists," Beijing__Review (September 6, 1982), pp. 24-25,30.

89"Science Awards Cut to Ribbons," China__Daily (February 19, 1983), p. 3.

90"Zhao Ziyang to Head New Scientific Work Group," Xinhua (January 30, 1983) translated in FBIS-PRC (January 31, 1983), pp. K8-K9.

91Since mid-1982 Premier Zhao appears to have taken a more direct interest in the situation regarding science and technology. See Zhao Ziyang, "A Strategic Question on Invigorating the Economy," Beijing_Review (November 15, 1982), pp. 13-20.

92Peter Cleaves, "Implementation Amidst Scarcity and Apathy," in Merliee Grindle, Politics__and__Policy__Implementation__in__the

Third World, p. 301.

93Grindle, Politics and Policy Implementation in the Third World, pp. 18-19.

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