Scientific Cooperation and Conflict Management in U.S.–China Relations from 1978 to the Present

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INTRODUCTION

Since the reestablishment of diplomatic relations between China and the United States in 1979, cooperation in science and technology has been a notable feature in the ties between the two countries. While of secondary importance to the cardinal political, security, and economic issues facing the relationship, U.S.–China S&T relations are nevertheless broad and deep. They have served as an important glue keeping the two sides in touch during periods when political relations were strained. This was especially true in the period following the 1989 Tiananmen events, when most other government–government ties of significance were suspended. The S&T relationship has been likened to rocks at the seacoast by one Chinese official long active in U.S.–China scientific relations. During periods of good political relations, the importance of the S&T ties is less visible; at times of tension, they are considerably more prominent.

Government-to-government S&T relations have been—and continue to be—a central, structuring element of the overall S&T relationship. However, unlike China's S&T relations with other states, which tend to be driven from the top and highly centralized, China-U.S. relations are much more decentralized.[1] Sino–American science and technology cooperation extends well beyond that prescribed in official agreements to include extensive academic and commercial ties and relations between professional societies. The enduring integrative importance of the S&T relationship may be a function of the decentralized, "bottom up," and pluralistic nature of these links.

As discussed below, the S&T relationship continues to evolve; in both countries, much has changed since 1978 with regard to domestic politics, perceptions of international security issues, economic development issues, and research and development needs and capabilities. In addition, science and technology are becoming more important as factors influencing the political, economic, and, increasingly, environmental issues of "high politics." This is likely to open up new opportunities for S&T cooperation with higher levels of political support. At the same time, there is a risk that increased political importance of S&T may contribute to the politicization of S&T relationships in ways that may increase bilateral conflict rather than lessen it, as conflicts over the export of strategic technologies and the protection of intellectual property illustrate.

U.S. AND CHINESE INTERESTS IN S&T COOPERATION

Events preceding and following the normalization of relations between the United States and China set in course new approaches to the use of S&T cooperation in diplomacy (see Kathlin Smith's chapter in this volume). After almost three decades of mutual hostility and isolation, the U.S.–China intergovernmental S&T relationship suddenly blossomed. By the early 1980s, the relationship with China had become the largest and most ambitious of all bilateral S&T relations maintained by both the United States and China. While rapidly improving political relations in the late 1970s were driven in the first instance by a common desire to contain the Soviet Union, scientific and technological cooperation also had a special appeal to the two countries as the process of normalization proceeded. A brief review of why this was the case is helpful.

From the Chinese side, interest in cooperation with the United States in S&T was inseparable from the complex consequences of the Cultural Revolution, and of Maoist doctrines of antiprofessionalism and self-reliance for Chinese S&T. The two most important of these were the disruption of the Chinese R&D and higher educational enterprises and the increasing relative backwardness of Chinese industrial technology. With regard to the former, the radical politics of the Cultural Revolution produced a highly unstable environment for research over the course of more than ten years, as scientific organizations were disrupted, reorganized, and/or shut down. More importantly, the disruption of the higher education system meant that the pool of technical manpower was not being replenished and that a cohort of scientists and engineers was lost.

These problems came at a time of dramatic advances in science and technology internationally, and at a time when instrumentation and the technologies of research more generally were being revolutionized in the advanced industrialized countries. With the initiation of scientific exchange visits after the Nixon trip to China in 1972, Chinese technical personnel had new opportunities to observe first hand just how far China had fallen behind as a result of Maoist excesses. As the decade wore on, it became clear that self-reliance would have to be abandoned, especially with regard to the problem of bringing the training of new generations of scientists and engineers up to world standards as quickly as possible. Mao's death in 1976 and Deng Xiaoping's ascendancy in 1977–78 cleared the way for the new "open" policy and new opportunities to work with the United States.

A similar story could be told with regard to industrial technology and serious problems of declining rates of industrial productivity in the 1970s. The inherent innovation problems of the Soviet model for research and industrial production had long plagued Chinese industry, and continued to do so even as China made its own modifications to the Soviet model. These problems were compounded by Cultural Revolution radicalism and assaults on technological and managerial expertise. Again, the lost opportunities and radical disruptions in China occurred at a time when high-technology industry was beginning to come into its own in the advanced industrial countries, and when successful experiments in rapid industrial development and technological enhancement were becoming well established among China's Asian neighbors and in its "renegade province" of Taiwan. Although China had begun to relax its technological self-reliance principles in the early 1970s with the selective importation of advanced technologies from Japan and Europe, U.S. science and technology held a special allure, and Chinese elites believed they needed access to it.

In the United States, the decision to give S&T the prominence it came to have in the process of renewing relations with China was driven by a number of factors. First, because the United States understood the situation in China, described above, it knew that access to U.S. science and technology could be used as an incentive for improving political relations. During the Carter administration, there was much talk of building a "web of relations" with China that would go well beyond formal government–government ties and that would create constituencies in both countries for close political relations. The encouragement of S&T ties was seen as an important strand in this web.

In addition, U.S. policy thinking about China in the late 1970s already contained "global commons" concerns of relevance to international scientific cooperation. While environmental protection issues were not prominent at that time (as they have become), the amelioration of food, energy, and population problems in China through S&T enhancement was seen as consistent with U.S. interests in attacking these issues internationally; the reduction of China's demands on global food and energy supplies as a result of its own scientific and technological development, for instance, would mean greater availability for others.

While the quality of Chinese research in most fields was not initially a significant attraction to the United States, access to unique Chinese data sources and distinctive Chinese natural and human phenomena—flora and fauna, topography, village life, archives etc.—held considerable appeal to biologists, medical scientists, geophysicists, meteorologists, historians, and social scientists. As Kathlin Smith's chapter documents, in the preparatory period leading up to the re-establishment of diplomatic relations, natural scientists and social scientists in the United States found common cause in the improvement of scholarly relations with China. Common as well was the belief that rebuilding and revitalizing the Chinese scholarly enterprise after the ravages of the Cultural Revolution were both in United States interests and, reminiscent of the "missionary impulses" in U.S.–China relations earlier in the century, a worthy calling in their own right.

In U.S. thinking about the building of S&T ties as part of the hoped-for web of relations, the presence in China of a substantial number of Chinese scientists and engineers who had been educated in the United States prior to 1949 represented an important resource. It was correctly assumed, that there was a reservoir of good will and understanding of U.S. society among these senior, and often more prestigious, members of the Chinese technical community. If these U.S.-trained personnel from an earlier period could be seen as a resource for building a new relationship in the late 1970s, then the replenishment of that resource for an ongoing close relationship of cooperation warranted high-level attention. Thus began the opening up of U.S. institutions of higher education to the roughly 220,000 Chinese students and scholars who started coming to the United States at the end of the 1970s, a stream of personnel which continues today.[2]

THE VARIETY OF INTERACTIONS

In reviewing the nature of U.S. and Chinese interests in building a strong S&T relationship, it is helpful to distinguish between *science* and *technology*, between the *natural* and *social* sciences, and between *research cooperation* and *educational exchange*. It is safe to assume that among Chinese decision makers in the 1970s, distinctions between "science" and "technology" were seldom finely drawn. Chinese elites since the mid-nineteenth century had placed great hope in "science" to make China a strong and prosperous society without ever examining carefully the relationships between science and technology and, in particular, the relationships between scientific research and technological innovation. Faulty understandings of the nature of technological innovation were reinforced by the embrace of the Soviet model in the 1950s, a decision that established and maintained the key institutional features of the research and production systems until the major reform programs of the 1980s.

From the point of view of China's national leaders in the 1970s, there was less interest in science for the sake of science—and, thus, scientific cooperation with the United States for the sake of science—than in the longer-term practical benefits that a modernized scientific establishment would bring to China *and* in the more immediate benefits which U.S. advanced technology, once transferred to China, would bring. But in blurring distinctions between science and technology, Chinese leaders also did not immediately grasp the nature of institutional arrangements in the United States, which stem from distinctions made between "science" and "technology" in the West. Of particular importance is the notion of separate realms of public and private knowledge, and the fact that access to the latter is only indirectly subject to influence by government action. While many in China thought that the initiation of S&T cooperation with the United States via government-to-government agreement would open up access to usable industrial, communications, transportation, and other technologies, the reality was that many of the technologies of greatest interest to China were in private hands, and that access to them would be a function of business decisions, not government policy. On the other hand, when China began to devise business agreements with private companies that involved the transfer of advanced technologies, it also discovered that the government could under some circumstances assert a public interest over the transfer of technology through export controls when national security concerns were involved. Interestingly, therefore, while *scientific* cooperation has generally been a conflict-reducing, integrative factor in the bilateral relationship, issues of *technological* cooperation have at times been matters of misunderstanding, irritation, and conflict.

Distinctions between the *natural* and *social* sciences have also been important in the S&T relationship. As noted above, in the United States, natural and social scientists found common ground in their desire for improved relations with China. The sponsorship of the Committee on Scholarly Communication with the People's Republic of China—by the National Academy of Sciences, the Social Science Research Council, and the American Council of Learned Societies—was a powerful symbol of this shared commitment. In China, however, the situation was different. The social sciences were in much worse condition than the natural sciences, the development of most fields having been stunted by political *diktats* in the 1950s that there could be no social science independent of class interest. Thus, while many Chinese scholars in the social sciences and humanities looked forward to new ties with U.S. colleagues, Chinese political elites who welcomed the development of an S&T relationship in the late 1970s had little interest in the social sciences. With little social science in China, and a pervasive belief that all social science in the United States was bourgeois social science, the elite saw no utility in developing relations in this area.

This asymmetry in outlook, and the attendant institutional asymmetries, have been a not infrequent cause of conflict in the relationship. From the U.S. point of view, the spirit and letter of the agreements for cooperation entailed research access for social scientists and humanistic scholars as well as natural scientists. Such access was factored into the U.S. calculus of mutual benefits that underlay the agreements, and without it, the United States came to believe that it was giving much more than it received from the relationship. U.S. social science interests were active in pushing their cases and often prevailed on U.S. officials to pressure China to respect U.S. views of reciprocity. For the China of the early post-normalization period, responding to U.S. expectations on these matters was troublesome in the extreme. This was so not only because the Chinese had little use for the social sciences, but also because the opening up of previously guarded historical archives and social science field sites represented a radical shift from the "closed-door" mentality of Maoist China with its tight control over information, distrust of foreigners, and its policies of limiting, monitoring, and controlling their movements. Issues of the social sciences continue to be a problem in the relationship. From 1990 to 1993 there was conflict over the Chinese seizure of survey data gathered by an American investigator operating with NSF support, which disrupted NSF programs with China for more than a year. Nevertheless, China's interest in, appreciation of, and support for at least some areas of the social sciences (e.g., economics) have changed as the reform and open-door policies initiated in the late 1970s evolved.

A final distinction warranting our attention is that between *research cooperation,* and *training and educational exchanges*. As noted above, opportunities for training a new generation of technical personnel in order to "jump start" the resumption of indigenous research and education after the Cultural Revolution was a high priority for the Chinese. The United States was also keen to cooperate in this training mission for reasons of both altruism and national interest. As a result, one of the first agreements signed (October 1978) was the Understanding on the Exchange of Students and Scholars. This agreement signified that the United States was prepared to make a long term commitment to the training of a new generation of scientists and engineers, while also committing China to provide educational opportunities and research access to U.S. scholars wishing to work in China. At the time, of course, it was primarily social scientists and humanists from the U.S.–China studies community who were most interested.

While research cooperation has become a more important part of the relationship with the passage of time, the longer-term scientific, commercial, and political significance of the educational exchanges warrants reiteration. As Wendy Frieman noted in a recent commentary on U.S. educational exchanges with Asia generally,

> International education promotes and supports virtually all major U.S. foreign policy and business objectives, often in subtle and undocumented ways. U.S. businessmen, military commanders, or government officials who are trying to navigate a foreign

> country requently use relationships with former classmates to short circuit what could be a lengthy and expensive process. Scientists and engineers, in particular, seem to form long lasting ties that transcend distance, language and politics. American engineers who visit Thailand or China or Indonesia and contact their former classmates, post-docs, graduate students or lab partners from those countries can tap into special relationships. They sometimes have an entrée with unique access to a country's science and technology infrastructure that is essential for success in collaborative research, joint production and marketing, and even market intelligence. Often the American scientists and engineers involved in this process do not themselves realize the value of the these connections. Without them, however, American business would spend considerable time meeting with senior business executives of Asian companies before getting access to the technical staff. Asian firms tend to be more formally and hierarchically managed than most U.S. high technology firms; a preexisting relationship among scientists and engineers is often a way to cut through layers of the system.[3]

When one considers the large numbers of Chinese students and scholars who have come to U.S. universities since the end of the 1970s, the potential for long-term cooperation and conflict management through the mechanisms identified by Frieman is quite significant. This is especially true with respect to China, where personal relationships (*guanxi*) play such an important role in facilitating communications and collective action.

THE STRUCTURE FOR S&T RELATIONS AFTER NORMALIZATION

Prior to the establishment of diplomatic relations between China and the United States in January 1979, the momentum for an ambitious new S&T relationship was already building. As noted by Kathlin Smith, an important event in this process was the visit to China, in July 1978, of a delegation of the heads of the technical agencies of the U.S. government led by then science adviser to President Carter, Dr. Frank Press.[4] This visit was important for a number of reasons, not the least of which was the symbolism of high-level, government–government contacts *prior* to the establishment of diplomatic relations.

It should be recalled that prior to normalization, both sides took great care, to the extent then possible, to avoid contacts that were "governmental" or "official," relying instead upon nominally nongovernmental organizations to conduct S&T exchanges after the 1972 Nixon visit. In China, responsibility for S&T contacts with the United States lay in the hands of the China Association for Science and Technology (CAST), the peak organization of professional societies, nominally analogous to the AAAS in the United States, but in actuality, an arm of the Communist Party.[5] In the United States, the leading national organization was the Committee on Scholarly Communication with the People's Republic of China (CSCPRC) which, though nongovernmental, received some of its financial support during this period from the U.S. government and maintained regular liaison with officials responsible for China policy within the government.

The Press mission, which was received by Vice-Premier Deng Xiaoping, thus broke new diplomatic ground, and programatically, it laid the foundations for the expansive intergovernmental program which came into being following normalization. But even before the re-establishment of formal diplomatic relations, the Understanding on the Exchange of Students and Scholars was signed in October during a visit to the United States by physicist Zhou Peiyuan, the Understanding on Agricultural

Exchange was signed in November, and the Understanding on Cooperation in Space Technology was signed in December. In addition, the details for a cooperative program in high-energy physics, which was formalized in a signed agreement in January 1979, were worked out during a late fall 1978 trip to China by Secretary of Energy, James Schlesinger.[6]

Coincident with the re-establishment of formal diplomatic relations in January, Deng Xiaoping and President Jimmy Carter signed the Agreement between the Government of the United States of America and the Government of the People's Republic of China on Cooperation in Science and Technology, which in turn provided for the establishment of a Joint Commission on Scientific and Technological Cooperation. Through an exchange of letters, the two governments agreed to subsume the student and scholar exchange and the agricultural and space understandings under this new "umbrella agreement." In the months that followed, U.S. technical agencies were encouraged by the White House to seek new agreements with Chinese counterpart agencies, a process that continued after the change in administrations in 1980 and that today has resulted in close to 30 protocols (with numerous annexes) under the umbrella agreement in areas as diverse as basic sciences, occupational health and safety, and scientific information. Since 1979, these have led to over 1000 cooperative projects involving over 10,000 scientists and engineers. At the seventh meeting of the Joint Commission in October 1996, the umbrella agreement was extended for another five years

While there certainly were nongovernmental S&T interactions with China prior to normalization, as we have seen, the establishment of official government–government ties catalyzed much more energetic efforts outside of government to build bridges between the technical and educational communities of the two countries. This was especially true of universities, which, once they began to receive students and scholars from China, sought out formal relations with Chinese institutions of higher learning. Professional societies and the National Academy of Sciences (which entered into an agreement with the Chinese Academy of Sciences in 1980) also followed suit. With the signing of bilateral agreements for economic cooperation and for trade and investment as well, U.S. firms expanded their operations in China and selectively began to engage in various forms of technology transfer. The policy designers' dream of creating a "web of relations" thus became a reality in the post-normalization era.

As Kathlin Smith has noted, American scientists of Chinese descent played an important role in the pre-normalization period with some, such as Yang Chen-ning, having access to China's highest leaders. After normalization, the importance of these individuals as bridges between two cultures increased and contributed to many of the successes that have come out of the relationship. Chinese-American scientists and engineers in government agencies and private companies were recruited into the service of the relationship, and those in universities played an important role in the recruitment, reception, and training of Chinese students and scholars coming to U.S. institutions of higher education. An especially prominent example of the latter was the T.D. Lee scholars' program, initiated by Nobel laureate Lee Tseng-dao of Columbia University, which has sought to identify the best and brightest young physicists in China and to insure that they were placed in the premier U.S. physics programs.

Institutional and Cultural Asymmetries

In discussions of U.S.–Japan S&T cooperation, problems of institutional asymmetries, and the consequences those have for reciprocity in the access that researchers from one country have to the institutions of the other, have been a source of conflict. For instance, since a great deal of important precompetitive research is conducted in the private settings of Japanese companies, in contrast to the public settings of U.S. universities and government research institutes, the United States has been concerned that exclusion from corporate laboratories creates problems of asymmetrical access, which creates a disadvantage to the United States in the relationship.

Issues of asymmetrical access exist in the U.S.–China relationship as well, but they are the product of markedly different conditions. To understand these, it will be helpful to reflect briefly on the cultural values and institutional arrangements both countries brought to the relationship. The United States initiated S&T cooperation with China from a position of strength and confidence in the realization that its science and technology were at the leading edge internationally in most fields. It brought to the relationship a legacy of institutional pluralism and decentralization that was internationally distinctive, with the great American research universities being in many ways the crown jewels of the system. These were institutions whose greatness was inseparable from the values of openness, cosmopolitanism, and internationalism, and the tradition of investigator-initiated research.

Early post-normalization China could hardly have been more different. That the relationship has worked as well as it has may be a good measure of the extent to which many Chinese were committed to change, and saw in the relationship opportunities to pursue an agenda of reform. The China that emerged from the Cultural Revolution was one that had lost confidence in its ruling values and institutions. The great hope for scientific and technological development, which added vibrancy to China's optimistic society of the 1950s, had been dashed by two decades of radical political excess and by the militarization of science as a result of high-priority national security projects. Secrecy and the protection of narrow, parochial interests were the order of the day. When the U.S.–China relationship was established, things foreign were objects of distrust. Institutionally, the Chinese university was still recovering from the disruptions of the Cultural Revolution and, as a result of a series of decisions taken in the 1950s in emulation of the Soviet Union, their research role was markedly secondary to those of the Chinese Academy of Sciences and the mission-oriented institutes of government ministries. Whereas the logic of the U.S. system emphasized openness, decentralization, pluralism, and investigator initiative, that of China emphasized central planning and the compartmentalization of information.

Given these asymmetries of values, institutions, and capabilities, it is remarkable that a program based on the principle of mutual benefit could make progress. It did, however, though not without conflict and accommodations. Access to Chinese data sources has been an ongoing problem in the social sciences and humanities, and has also been an issue in some areas of natural sciences such as those involving germ plasm and the ingredients of the traditional Chinese pharmacopeia. Interestingly, as Chinese society became more open and commercially oriented during the 1980s, the nature of the access problems changed in ways that were perhaps more conflict-inducing. With institutional budgets being cut in keeping with reform objectives (see below), and with the "cost-internalizing" logic of the market economy beginning to take hold, Chinese research organizations began to charge U.S. investigators ever higher fees for access. Since this was often done in a less than transparent manner, it was not unusual for resentment to develop among researchers and administrators over what were believed to be excessive and unfair charges.[7]

Access to U.S. facilities and events has also been an issue at times when U.S. policymakers determined that aspects of the S&T relationship with China verged on compromising national security objectives. Interestingly, while export controls over the transfers of technologies were—and continue to be—maintained, efforts to control the activities of Chinese students and scholars in universities and at professional meetings were resisted as much by U.S. scientists as by the Chinese government.

National Program Coordination

Issues of asymmetry are also evident in the institutions charged with conducting the relationship at the government level. In the United States, until the Tiananmen events of 1989, there was a gradual decentralizing devolution to the technical agencies in the conduct of the relationship, leading to vital, enduring, operational relationships between the technical agencies of the two governments. The White House Office of Science and Technology Policy (OSTP) had overall responsibility for U.S. government S&T relations with China, but after the energetic, proactive leadership from OSTP during the Carter administration, its role diminished somewhat as the relationship became more routinized and as policy priorities evolved. The Bureau of Oceans, Environment and Scientific Affairs (OES) of the State Department was entrusted with serving as the secretariat for the United States in the Joint Commission and for coordinating the activities of the technical agencies with regard to implementation of the agreements and low-level policy matters. Meanwhile, in keeping with the traditions of U.S. society, nongovernmental institutions continued to expand their contacts with China as their own interests dictated. The CSCPRC, for instance, continued to expand its programs—with considerable support coming from government—and served as something of a clearing house for information about what various sectors in the United States were doing in relations with China during the 1980s. However, because the number and range of activities across the nation in so many different sectors is so large, this effort was inherently limited by the availability of resources.

Thus, the United States had, at best, limited central policy and coordinating mechanisms for its S&T relations with China, although informal ties among scholars, government officials, representatives of private foundations, and members of the business community—with the NAS and the CSCPRC often playing important facilitating roles— produced more coherence in national purpose than the formal arrangements themselves would have led one to expect. Consistent with this decentralization of policy and coordination was the decentralization of funding. In spite of the high priority given to the role of S&T relations in the broader U.S.–China relationship, the U.S. government has approached China ties in much the same way it approached bilateral S&T relations with most other countries. The operating principle has been that the technical agencies' activities with China must be consistent with their overall missions. To insure adherence to this principle, the agencies have had to finance their relations with Chinese counterparts out of their regular budgets, thus forcing China- related projects to compete with domestic and other international projects on the basis of technical merit rather than political appeal. Where there has not been a true mutuality of interests, but where one side had an interest in an activity, the principle of "benefiting side pays" has prevailed. While this approach may have led to some lost opportunities for political benefit in the short term, it has probably enhanced the long-term value of the relationship for both countries, since it has led to cooperation based on real interests which can outlast the changing political moods that have characterized Sino-American ties at the level of high politics.

While a decentralized approach to S&T relations with China has had a number of benefits, the costs of decentralization are less apparent. Intuitively, though, they seem to exist and may warrant attention. There have certainly been opportunity costs from decentralization, especially with regard to marrying programs for S&T cooperation with opportunities for building new commercial relationships. While the Clinton administration has shown an interest in building on the former to enhance the latter,[8] for most of the period since 1979, there has not been a carefully coordinated effort to wed S&T and commerce.

A second area where the costs of decentralization have yet to be estimated is in the problem of assessing the overall national or collective benefits accruing to the United States from its multifaceted S&T ties with China. Such an assessment, in fact, would be difficult and may not even be desirable. But the United States is left with the unanswered question of whether individual programs of government agencies, universities, foundations, corporations, etc.—which by themselves are rational and justifiable—are collectively in the national interest.

The costs of decentralization are undoubtedly higher than they might be as a result of the fact that those parts of the U.S. government that have the coordination and general oversight functions, the OSTP and OES, experience frequent personnel changes. While officials in the technical agencies often have many years of dealing with Chinese counterparts, at the policy and coordination levels, institutional memories are often weak or nonexistent. Given that OSTP personnel change with changes in administration, and OES staff are typically rotated according to Foreign Service schedules (and that for most incumbents, the time spent in OES is not regarded as career enhancing), it is not surprising that the Chinese side has often been frustrated and annoyed at what it regards (especially after changes in administrations) as a certain amateurism among U.S. officials.

As one would expect from the nature of the Chinese government and the conditions of Chinese society, the situation with regard to policy and coordination in China is somewhat different, with more centralization, planning, and specialized budgeting. As noted above, prior to normalization, a key organization in S&T relations with the United States was CAST. Once government–government relations were established, however, other players entered the game and began to play more important roles. Although the CAST–CSCPRC relationship continued for a few years (CAST continues relations with AAAS), it gradually faded in importance as CAST itself changed. The new Chinese actors were the Chinese Academy of Sciences (CAS), the State Education Commission (SEDC), and the State Science and Technology Commission (SSTC). The SSTC became the coordinating center for relations with the United States and served as the secretariat for the Chinese representatives to the Joint Commission.

Unlike the OES at the State Department, however, SSTC is a science agency; it has a staff with strong career commitments to the Commission, and it has a special budget for the conduct of international S&T relations, including those with the United States. In the early post-normalization period, access to the institutes of the CAS and to universities under SEDC was also highly centralized through the specialized foreign affairs offices of these two organizations, both of which had dedicated budgets for international cooperation. As time passed, however, and as the relationship became more complex and multifaceted, and as China itself became more decentralized, the institutes of CAS and the universities acquired more autonomous discretion in the nature of their international contacts. With the establishment of the National Natural Science Foundation of China and the pluralization of funding sources for research, this reformist decentralization now gives individual investigators the autonomy and access to resources to engage in a broad range of cooperative projects with investigators abroad. Nevertheless, central oversight over these activities is still maintained by the units noted above, with the result that China exhibits a clearer sense of coherent policy purpose in its relations with the United States than the United States does in defining its stance toward China. At the implementation stage, however, the differences may be less apparent; like the United States, China is a large complex country which increasingly defies unified central governance, and interagency coordination in China can be notoriously abysmal.

Trends during the 1980s

The euphoria surrounding China–U.S. reconciliation and normalization gave way to serious strains in the relationship during the first two years of the Reagan Administration, with disagreement over U.S. arms sales to Taiwan being perhaps the main cause.[9] The S&T relationship could not prevent conflict over such an important political issue, but activities in the S&T relationship were continued during this difficult time. S&T relations did not play a major role in the resolution of the conflict directly, but Chinese interest in gaining access to U.S. technology and to training opportunities—factors that helped define China's stake in relations with the United States in the late 1970s—were certainly on Chinese minds when China's leaders agreed to accept the terms of the Joint Communique on U.S. Arms Sales to Taiwan in August 1982.[10] In addition, with the temporary resolution of this difficult matter, mutual interests in the S&T relationship contributed to the revitalization of U.S.–China relations in late 1982 and 1983.

After the settlement of the Taiwan dispute, relations between the countries became more dynamic and exciting. New nongovernmental programs were initiated, such as the American Physical Society's effort (with cooperation from the New York Academy of Sciences) to provide advanced laboratory training for promising Chinese physicists whose educational careers had been disrupted by the Cultural Revolution. The number of government-to-government S&T programs increased, regulations for the export of advanced technologies to China were liberalized, U.S.

investment in China increased, and, importantly, the number of Chinese students and scholars coming to the United States (now, typically, for full graduate degree programs paid for by U.S. sources rather than the shorter one or two advanced training visits paid for by China of the first few years after normalization) began to increase rapidly.[11] Yet, as Harry Harding has rightly observed of this period, the progress of U.S.–China relations was increasingly hostage to the progress of Chinese domestic reforms.[12]

This was true in a variety of areas. The renewed enthusiasm for China among U.S. investors faced a Chinese investment climate that turned out to be filled with problems for the foreign business person. Liberalization of export controls affecting technology transfers faced a lack of transparency concerning the true end-users of advanced dual-use know-how. Moreover, the growing awareness in the United States of the importance of protecting intellectual property rights, had yet to become a serious topic of discussion in China. With the Chinese academic and research environments still rather impoverished and poorly managed, their allure to Chinese students studying abroad was limited, and the prospects of an increasingly serious brain drain began to loom.[13] Indeed, by 1986, China began accusing the U.S. government of encouraging one.[14] Thus, in interesting ways, the positive orientations that both countries had for expanding and deepening S&T cooperation also engendered their own irritants and problems.

It was also during this period that human rights issues began to assume a more central place in the relationship, and this too was a function of the uneven pace of change in China. By the mid-1980s, China had become a much freer place than it had been just a few years before. But the liberalization that had made this freer atmosphere possible was not fully institutionalized, and explicit understandings of political rights were still a long way from being recognized. Discussions within the intellectual community for a clearer sense of rights and greater liberalization began during the 1980s.[15] While these were not solely the stirrings of the scientific community, certain key scientists became active in dissent over the course of China's reforms. Important debates began to unfold in key publications, such as *Dialectics of Nature*, over the relationships between scientific and technological development and democratization and political liberalism. For historian of science and translator of Einstein, Xu Liangying,

> Science and democracy were mutually supportive: political democracy provided the open social context required for science's pursuit of the truth free from external pressure or constraint, and science supplied society with the ideals of rational inquiry and respect for the truth at all costs that made democracy feasible.[16]

Unofficial discussions of such topics became more widespread in China's universities, and in late 1986 they led to student demonstrations at various locations around China—demonstrations that were promptly suppressed. Among the scientists involved, a key figure in these developments was astrophysicist, Fang Lizhi. Fang had been the Vice President of the CAS's University of Science and Technology at the time of the December 1986 student demonstrations, in which he was implicated. He was subsequently removed from that office and given a research position at the Beijing Observatory, but he continued to be active in discussions within the academic community over the prospects for a new liberal order in a modernized China. Fang's importance as a human rights figure in the American consciousness increased in early 1989 when he was added to the list of invitees to a major reception given by the United States on the occasion of President Bush's visit to Beijing. The Chinese government was extremely annoyed at this move and took steps to prevent Fang, his wife, and Perry Link, the director of the CSCPRC office in Beijing, from attending. Attention to Fang's role as a symbol of the human rights struggle in China grew within the U.S. technical community after he took refuge in the U.S. Embassy following the Tiananmen events.

TIANANMEN AND THE IMMEDIATE AFTERMATH

While the period leading up to the tragic events of June 4, 1989 began to awaken human rights concerns among Americans, it was the televised images of the repression of the Tiananmen demonstrations which seared Chinese human rights violations into U.S. public consciousness. The result has been that human rights issues have come to occupy a central and highly conflictual position in U.S.–China relations.

The U.S. government responded to the Beijing events with a variety of sanctions which had the effect of temporarily suspending most S&T activities. The National Science Foundation, for instance, discontinued staff travel to China, urged its grantees to defer China travel, and reduced travel funds for visits to China.[17] The National Academy of Sciences also responded very quickly. On June 5, the following message was sent by NAS President Frank Press to CAS president (and NAS foreign associate) Zhou Guangzhao:

> We are shocked and dismayed by the action of Chinese government troops against peaceful demonstrators in Tiananmen Square and elsewhere in Beijing, with such great loss of life. While we earnestly hope to maintain our cooperation with your Academy and other Chinese institutions, we must suspend all activities for the time being. We do so in outrage and sadness.[18]

Similar messages were sent to the other Chinese agencies with which NAS and CSCPRC had relations: the State Science and Technology Commission, the State Education Commission, the Chinese Academy of Social Sciences, and the Chinese Association of Science and Technology.[19] In addition to the actions of the government and NAS, a number of professional societies expressed dismay at the crackdown and, with many universities, suspended programs and activities with Chinese counterparts. Many U.S. researchers who had dealt with China before Tiananmen felt revulsion at what had happened and, like much of the American public, found their positive orientations towards China being replaced by negative ones. At the same time, some scientists felt that a distinction should be made between relations with the government and those with professional colleagues. Yang Chen-ning, for instance, was quoted as supporting the Bush Administration suspension of high-level contacts, but as favoring the maintenance of "scholarly exchanges … to keep traffic and intercourse with China going as much as possible."[20]

Many Chinese intellectuals who sympathized with the student demonstrations of the spring of 1989, and were themselves shocked and saddened by the actions taken by their government, welcomed the strong U.S. responses. However, many others did not.[21] In the weeks and months following June 4, many members of the Chinese academic community feared harsh reprisals from the regime and the reinstatement of policies that would have led to greater relative isolation than they had become accustomed to during the 1980s. Although they might have lost most of their residual sympathies for the Chinese government as a result of its actions at Tiananmen, they both feared isolation and felt that in the interest of China's development as a modern open society, S&T relations had to be maintained. Although some of the Chinese organizations responded to the communications they had received from the NAS by repeating the harsh language adopted by the Communist regime about the need to put down the "counter revolutionary uprising," the CAS responded in a more conciliatory fashion, expressing the importance it attached to its relations with the NAS and appreciation of the efforts made by both sides to build it over the course of some 20 years.

By the Fall of 1989, travel between the two countries by elite scientists was beginning to resume, and with it came the recognition that the resumption of programs of cooperation were both possible and desirable. Zhou Guangzhao visited the United States in the Fall and indicated that the Chinese side wished to resume activities and that conditions within the Academy had pretty much returned to normal.[22] Reportedly, Zhou was able to insulate CAS staff from much of the worst post-Tiananmen political inquisition, something that leaders at the Chinese Academy of Social Sciences and at many universities, especially Peking University, were unable or unwilling to do. More generally, although the regime's reprisals against some institutions and individuals were quite draconian, the worst fears of many intellectuals in the summer of 1989 were not realized as a degree of "normalcy" was reinstituted and as the regime sought to demonstrate that the basic course of its "open" policy was unchanged.

The acceptance of these assurances by the United States was slower in coming, and when it did, it came with qualifications. In August,1989, acting CSCPRC director Robert Geyer went to China to assess the situation. Largely on the basis of his report, which painted a mixed picture of the state of academic life in China at the time, the CSCPRC resumed its program of sending graduate students to China for research and advanced training. Since the NAS had not yet lifted its ban, this resumption of activities was done in the names of the SSRC and ACLS. In April 1990, the NAS dispatched Vice President James Ebert (accompanied by Geyer and Victor Rabinowitz) to China to assess how scientists were coping in the post-Tiananmen environment. In June, 1990, the NAS Council approved a resolution which opened up in a limited and qualified way the resumption of programs and visits in the sciences on a case-by-case basis, which then led to the rescheduling of a joint symposium on gene expression and gene regulation that had originally been set for May 1989.[23]

The U.S. governmental sanctions announced by President Bush in June 1989 included the suspension of high-level contacts between officials from both countries, a decision that was only gradually rescinded by the Clinton Administration. One consequence of this was that normal meetings of the Joint S&T Commission were not held and the umbrella agreement was allowed to lapse. But within a year of the crackdown, cooperative activities under the bilateral agreements were resuming and provided much needed government-government contacts.

The role of S&T relationships in the events leading up to and following the Tiananmen tragedy is difficult to assess. Explicitly, they had very little to do directly with the background of Tiananmen, and their role in the fallout after the events should not be overstated. But, as factors influencing the context of the events in China, they become far more important. As part of the multifaceted opening of China's scholarly and cultural realms in the post-normalization period, S&T relations with the United States helped create very different ways of looking at the world among Chinese researchers, professors, students, and officials, and helped liberalize the institutions in which they worked. We will never be able to document the full nature of this change, but it clearly manifested itself in the scholarly—and not so scholarly—debates and discussions found in journals appealing to the intellectual community, and in the meetings held in academic venues around China from the mid-1980s on.

It is curious that with the exception of a handful of U.S.–China specialists in the social sciences and humanities, the full implications of these debates for human rights in China were not widely apprehended before Tiananmen by a U.S. scientific community which had been so active in supporting the causes of human rights in Eastern Europe and the former Soviet Union. Fang Lizhi came to be referred to as China's Sakharov, but in truth Fang was less known and recognized in the United States. In many ways—most quite understandable in light of the history of U.S.–China S&T relations and the different levels of development of S&T in the two countries—members of the U.S. scientific community were often quite ignorant of the culturally conflicted political environment in which their Chinese counterparts worked. When, in the aftermath of Tiananmen the United States, as represented by the NAS action, responded as it did, it may not have been clear to many in the Chinese technical community what purposes were being served.

The resumption of governmental and nongovernmental S&T contacts in the post-Tiananmen period was clearly ahead of meaningful political "re-normalization" and undoubtedly did serve the "glue" function noted at the outset. But these probably have been of secondary importance to the rapid growth in *commercial* contacts between the two sides after the post-Tiananmen stabilizations of the Chinese economy and the reaffirmation of the reform and open policies that followed Deng Xiaoping's famous 1992 trip to south China. This post-1992 era, indeed, has opened up new and more commercial modalities for S&T ties, discussed further below, which can be said to mark something of a new era in the S&T relationship.

THE EFFECTS OF CHANGING DOMESTIC POLICIES ON THE RELATIONSHIP

Since the launching of an expanded S&T relationship following normalization in 1978, the domestic science and technology policies of the two countries have undergone important changes. In the United States, these have been driven by a combination of factors including new ideological perspectives on S&T policy introduced during the Reagan administration, heightened concerns over federal budget deficits and a strong anti-tax mood within the electorate, the increasingly close relationship seen by many decision makers among S&T policy, the health of the national S&T enterprises, international commercial competitiveness, and the consequences of the end of the cold war.

These changes, while certainly less dramatic than those experienced by China (discussed below), have nevertheless been relevant to the S&T relationship with China. For instance, federal agencies have faced strong budget pressures for a number of years. That China programs have generally survived in the face of these pressures is a measure of the importance attached to U.S.–China ties. On the other hand, budget cuts that lead to less support for graduate students could have implications for the numbers of Chinese students coming to U.S. universities. There already is a decline in these numbers, although no one is quite sure why. In addition, funding cuts contributed to the demise of the CSCPRC, and have led to the reduction in the numbers of U.S. investigators going to China, especially in the social sciences and humanities.[24]

In another area, the growing concern about competitiveness has focused attention on the state of high-value-added, high-technology industry which, in turn, has made the protection of intellectual property rights a very visible issue in the relationship. Well before the high-profile conflict over the commercial pirating of CDs and software, the United States began insisting on the inclusion of stronger intellectual property rights protection in the intergovernmental S&T relationship. This issue has been a significant irritant between the two sides, and had frustrated efforts to renew the S&T umbrella agreement.[25]

Domestic S&T policy change since 1978 in China has, of course, been transformative. Starting early in the 1980s and continuing today, China's S&T system has been the object of a series of major reforms that have altered the funding of research, the structure of research institutions, the distribution of research efforts, and the orientation of R&D. Universities have seen their research roles dramatically increased, a national science foundation has been established, old Soviet-inspired research organizations are being reconfigured as "key" or "open" laboratories or "engineering research centers," and research centers have been strongly encouraged to serve market needs. In addition, leadership in research organizations and scientific institutions is now based strongly on technical achievement criteria rather than political loyalty. Many of the new leaders of China's R&D organizations have had experience in the United States. For instance, a number of the alumni from the American Physical Society program noted above have gone on to become institute directors or chairs of the physics departments of key universities. U.S. education, including doctoral training, is much in evidence among those holding the rank of academician in the CAS.[26]

These domestic changes in China have had complex but generally positive implications for relations with the United States. First, it should be noted that the reforms derive from China's careful studying of the experiences of other countries. While not the only model considered, the United States has certainly been an especially important one, and the extensive governmental and nongovernmental programs between the two countries have given the Chinese many insights into what works and what does not in the U.S. system. Another important factor in the changes in China's system has been the activity of the World Bank. The first World Bank loan to China was focused on upgrading the equipment and overall management of university laboratories. This first "university development loan" was followed by two others. In addition, the Bank has been supporting the upgrading of 133 "key laboratories" in universities, the CAS, and government research institutes, and recently started supporting the establishment of a number of engineering research centers. These World Bank projects have helped foster the qualitative improvement of Chinese S&T. They have also been occasions for additional contacts with U.S. institutions and U.S. practices, through the procurement of U.S. equipment and contacts via the technical assistance, advisory, and consulting provisions of the loan programs.

As with the United States, Chinese research organizations have also had to face severe budget cuts, some of which were part of a reform strategy to make research institutes more productive and economically relevant.[27] As noted above, to the extent that these cuts led to the imposition of research fees which U.S. investigators regarded as excessive, they were a negative influence on the relationship. Overall, however, the cuts themselves do not seem to have had seriously deleterious effects on the relationship with the United States, in part because of the more centralized systems of supporting international scientific cooperation in China which can set and maintain priorities.

The tilt towards commercial concerns found in both countries suggests new directions in the S&T relationship. The strong concern for intellectual property rights protection in the United States is beginning to find its echo in China as the quality of Chinese science continues to improve and the market value of Chinese research comes into sharper focus. There is a growing interest (sometimes resulting from the market-access restrictions of Chinese trade and investment policies) among U.S. companies in Chinese R&D as part of country-specific, regional, and global production and marketing strategies.[28] R&D and other technical services are being procured, and investments are being made by U.S. firms in research facilities in China. Interest has also been shown in participating in some of China's special national R&D programs. This growing interest in Chinese S&T by U.S. companies poses new challenges for Chinese policymakers who both want the U.S. commercial participation, but are concerned that too large a share of the benefits of Chinese brain power may be captured by foreigners with such participation. These challenges are now being examined within China, and new policy directions can be expected. Chinese efforts to limit foreign investment in research in China could become a new source of conflict.

Overall, the changes within China as a result of its domestic S&T policies since the late 1970s have led to a more capable S&T system and to the reduction in the gap between relative capabilities of the systems of the two countries. This should make the nature of S&T cooperation in the future more like that between equals. Whether this will result in relations that are more integrative or conflictual remains to be seen.

LESSONS FROM THE RELATIONSHIP

What does the nearly two-decade Sino-U.S. experience teach us about the role of scientific cooperation in the resolution of international conflicts? As the preceding discussion illustrates, the extent, and the multifaceted nature of the relationship makes the identification of lessons difficult. In an attempt to simplify a complex reality, let us focus the discussion initially on three issues.

The Role of Governments

The establishment of the U.S.–China S&T relationship was part of major foreign policy initiatives taken by both sides to enhance security and advance national interests through the normalization of relations after 30 years of isolation and hostility. The role of the governments in S&T cooperation was thus central from the start, and it continues to be quite important for providing an overall framework for the relationship.

Yet, S&T cooperation between the two sides has also become so much more than the government–government relationship that by the mid-1990s, the importance of the latter is often obscured. In a sense, this is as the U.S. government had hoped in 1978–79, in its efforts to build a web of relations between the two countries. The decentralized and pluralistic nature of the relationship has had the effect of protecting it from the more volatile swings in the political relations between the two countries. At the same time, as illustrated by reactions to the Tiananmen events from within the U.S. technical community, decentralized, pluralistic participation can mean that negative feelings towards the Chinese government and other Chinese institutions can endure even as official relations at the intergovernmental level improve.

Motivations for Cooperative Activities

A number of motives for cooperation can be identified among the various parties on the two sides apart from the original political motives, noted above. One of the more interesting issues in considering the motivations for cooperation is the extent to which motives on the two sides have or have not been symmetrical.

In China, at government and institutional levels, there has been a strong utilitarian thrust to cooperation with the U.S.: a concern for strengthening the country through gaining access to advanced technologies and the training of a new generation of students. At the level of the individual, genuine commitments to cooperative advancement of science and the satisfaction of intellectual curiosity undoubtedly came into play. Yet, here too, utilitarian interests are in evidence, for example, in the form of individual desires to leave China and find new opportunities abroad, gain access though travel abroad to a variety of consumer goods not available in China, and to enhance one's career in China as a result of experience in the United States.

In the United States, utilitarian values have also been in evidence. The government wanted to bind China closer to U.S. interests and create a more welcoming and understanding atmosphere in China for U.S. values. It wished to learn more about China's S&T capabilities as these pertained to military and economic potential, and it also was concerned about the possibilities for creating economic opportunities for U.S. firms that S&T cooperation might facilitate. In addition, a number of government agencies, such as the United States Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and the Department of Agriculture saw a natural convergence of scientific cooperation and the pursuit of their bureaucratic missions.

For non-government actors in the United States, both institutional and individual, considerable excitement was felt over the prospect of bringing the Chinese technical community into the fold of international science. The opportunities to train bright young Chinese scientists not only helped replenish the ranks of graduate students in U.S. universities, but also offered the possibilities of long-term collaborative relationships of value. As with Chinese counterparts, for some in the United States (especially for "China specialists" in the humanities and social sciences), collaborative relations with China offered valuable new opportunities to enhance careers.

With countries as large and diverse as China and the United States, and with the numbers of researchers and research administrators from the two countries being as large as they have been, it is difficult to fully account for all the motivations at work in the relationship. Nevertheless, in light of these size and complexity problems, we should also note the unexpected consequences that arose from the relationship, since what various parties got out of participation was not always what was intended. These unintended consequences, in turn, helped alter motives and expectations in a reiterative process which has yet to run its course. China's utilitarian expectations have not been met in the ways anticipated, although many utilitarian gains have been made. Building a cadre of technical personnel trained at the best U.S. universities to work in China to further national wealth and power, for instance, has been frustrated by the brain drain, but service to China is still being rendered in unanticipated ways by those who have remained in the United States and who are successfully living "the American dream."[29] Whereas U.S. investigators (and their funders) once assumed that special allowances would have to be made for a lower level of development of Chinese research in the crafting and defense of research proposals, this is less the case today.

Implementation

I have noted above that in addition to asymmetrical motivations, there were also asymmetries in the institutions which the two sides brought to the relationship. Nevertheless, in the implementation of cooperative programs, these were not allowed to derail the relationship.

In the government programs, in spite of frequent changes of personnel at the policy level in the United States with changes in administrations, many of the officials in the technical agencies, like their Chinese counterparts, have been in place for a number of years. These officials from the two countries have come to know each other over the years and together they represent a cadre of competent managers for the conduct of the relationship. Since the implementation of the government-to-government accords were allowed to devolve to the technical agencies after the original high-level initiation of the program, implementation tended to be driven by pragmatic agency concerns over program costs and benefits in relation to agency missions. This approach either allowed complementarities in objectives to be found or led to the merciful death of programs that lacked mutual benefit.

Outside of the governmental relationship, there seems to have been a fortuitous combination of good will and self-interest on both sides to push various forms of cooperation to higher levels. This may have been helped by the considerable disparities, especially in the early years, in the various endowments of the two sides. U.S. institutions, with their wealth of human and material resources, could readily afford the new relationship with China, and could look optimistically beyond short-term implementation problems to a bright future of cooperation with Chinese individuals and institutions which would be good for them, for the country, and for science.

Finally, an important part of the implementation story is, again, the role played by Americans of Chinese descent, and by some of the senior Chinese scientists who had been trained earlier in the United States. The role of third parties has been highlighted in some of the other cases considered in this volume. While not literally third parties, it is clear that these two categories of scientists have played a role analogous to that played by third parties elsewhere in bridging political, cultural, and organizational gaps caused by lack of familiarity and distrust. As discussed further below, these two groups of actors, and the roles they have played, have to be seen against a longer historical background.

With asymmetries in motivations, in levels of scientific development and wealth, and in the institutions both sides brought to the relationship, one might have predicted that programs of S&T cooperation would not have done as well as they have. Perhaps this puzzle points to one of the more important lessons of the case. Any attempt to manage these asymmetries and disparities centrally would almost certainly have slowed the progress of the relationship, if not led to its stagnation. The fact that by both design and necessity, the program was allowed to become decentralized meant that if it were to work, many players at the grass roots would have to find the justifications for cooperation in the midst of all the disparities. Perhaps in keeping with U.S. norms, and with the direction of Chinese reforms, we can speak of the S&T relationship being appropriately "marketized" early on, thus allowing participants with disparate "utility schedules" to find "positive-sum," or win–win exchanges in ways that a more centrally planned and directed strategy never could. Yet, for the "market" to work, a framework of political understandings was necessary. In return, the positive- sum outcomes reinforced the framework.

THE FUTURE AS GUIDE TO THE PAST?

It is likely that the role of science and technology relationships between the United States and China will increase in importance in the future. The "new triad" of issues that structure much of post Cold War international relations—security, trade and investment, environmental protection—increasingly are shaped by changes in science and technology, and the importance of these issues is already evident in the bilateral relationship we have been considering here. In principle, the complex web of S&T ties between the two countries that have developed since 1979 should be a useful resource in managing problems that will emerge in both bilateral and multilateral contexts. Yet, as one reflects on the areas of conflict and cooperation in U.S.–China relations since 1979, it is clear that mutual interests in S&T ties have been both integrative forces in managing areas of conflict between the two sides and sources of conflict as well. However, in and of themselves, S&T ties have been of secondary importance to other interests structuring high politics, even when the issues involved (e.g., export controls, proliferation) have substantial technical content.

How we see the future roles of the S&T relationship in U.S.–China relations overall is likely to be influenced by three factors. First, the strength of the convergence and divergence of the national interests of the two sides must be considered. On a range of issues, Chinese and U.S. interests diverge rather than converge. A common interest in checking Soviet power provided the powerful incentive for the two countries to put aside years of animosity and to transcend the enormous differences that divided the two societies. Grand visions of S&T cooperation flourished while the two sides shared this common strategic concern. When perceptions of the Soviet threat began to change, the two sides had more difficulty finding common interests; indeed, this condition has marked the relationship since the early 1980s, and has allowed the many areas of difference and conflict—Taiwan, human rights, aspects of trade policy, strategic exports—to define much of how the two sides interacted. Of interest and importance, however, periods of higher conflict did not necessarily compromise cooperation in S&T. The rapidly growing, stronger, and more capable China of today is likely to be a competitor of the U.S. in an increasing range of areas, a fact that *could* exacerbate the divergence of interests, but that would not necessarily do so.

A second factor has to do with the ways the effects of globalization are treated in the two countries. In both China and the United States, the rise of the global economy has profound effects on domestic society: some members of the two societies are advantaged, some clearly disadvantaged, and many others are left with anxieties over globalization's uncertainties. Globalization for China has the effect of amplifying the importance of the United States in ways that are detrimental to the relationship. The military, economic, and cultural dimensions of U.S. power internationally gives it a special, privileged role in influencing the rules under which globalization occurs, and this makes China uneasy. As China becomes more fully integrated into international society, the United States expects it to observe these rules, but China balks at many of them since it had no voice in their making. Interestingly, globalization conjoined with the image of a "rising China" amplifies the importance of China for the United States because of the former's great size, abundance of cheap labor, and unique potential to challenge U.S. assumptions about how the world's security should be achieved, how the world's economy should be run, how human rights should be defined and protected, and how the world's ecosystem should be sustained. Again, there is considerable potential for conflict growing out of these circumstances.

Whether these potentially conflictual circumstances lead to higher levels of conflict between the two countries depends in part in how the disruptions from globalization are managed domestically and on the types of leaders who emerge to do the managing. It has, unfortunately, become good politics in both countries to play on the fears of globalization, which in China (because of amplification) means that it is good politics to also be critical of the United States. Clearly, it has also become good politics in the United States to conflate fears of globalization and criticism of China as well.[30]

Science and technology have important roles in globalization, and in many ways, those engaged in doing and managing science and technology are among the beneficiaries of globalization. But these roles are often somewhat elusive and can be masked by some of the more immediate social and economic effects of globalization around which negative sentiments can be mobilized. Thus, science and technology—and U.S. and Chinese scientists and engineers—can be made to serve the more conflict-enhancing, rather than conflict-reducing aspects of globalization. A major challenge of leadership in both countries is to clarify the roles of science and technology in globalization as the latter affects U.S.–China relations, and to then mobilize the two technical communities to work on positive-sum solutions to the new problems of globalization. The experiences of the past nearly two decades of S&T programs is an important asset for these tasks, and we are beginning to see joint efforts along these lines being launched, especially in areas such as environmental protection and understanding global change. More enlightened political leadership from the two sides could move these new opportunities for S&T cooperation along at a pace that would be more appropriate to the nature of the challenges. At the Seventh Meeting of the S&T Commission in October 1996, both sides indicated a willingness to exercise such leadership, as a number of problems of global significance—from the environment to the developmental directions of industrial technology—were taken up.[31] Similarly, the NAS and CAS recently reaffirmed their relationship by committing themselves to a program of cooperation built around the challenges of sustainable development, energy policy, and the encouragement of collaboration among young scientists from the two countries.[32]

Experience with arms-control discussions also indicates possible trends in the role of Chinese and U.S. scientists in working on global issues. Since 1988, scientists from China and the United States have been meeting annually to discuss such issues as arms control in space, non-proliferation, and non-first use. These sessions have been held under the auspices of the Scientists' Group on Arms Control under the Chinese People's Association for Peace and Disarmament and the Committee on International Security and Arms Control of the NAS. The Natural Resources Defense Council, the Union of Concerned Scientists, and the Federation of American Scientists have also engaged Chinese technical personnel in arms-control discussions.[33] Efforts have been made by U.S. national laboratories with weapons and security missions to initiate exchanges with Chinese counterpart institutions. Moreover, a series of Chinese-hosted international meetings, in cooperation with the International School of Disarmament and Conflict Resolution (ISODARCO), in the 1990s have allowed technical personnel from the weapons communities in the two countries to exchange views on a range of arms-control and security issues.

It is not clear that these increasing transnational activities of China's still-young arms-control community, with its growing role for technical personnel, have had a major impact on Chinese security policy. It appears, however, that these contacts have led to the injection of new ideas and options into Chinese security thinking, have introduced China to the common discourse used in global arms-control discussions, and constitute an important resource in the pursuit of arms-control objectives.[34]

Third, the questions of diverging and converging interests, and of globalization, are not unrelated to the broader question of what U.S.–China interactions in S&T imply for China's search for a modern political and cultural identity. When S&T relations are seen as important parts of a larger cultural encounter involving basic civilizational values, they become far more important than a more narrow construction would imply.

In the nineteenth century, imperial China was faced with an expansionist and technologically superior West. Growing European and American power in East Asia threatened and impinged upon Chinese sovereignty. But, it also presented challenges to Chinese cultural values and helped induce a crisis of culture that, more than 100 years later, has yet to run its course. Modern science and technology were important parts of this cultural challenge; the Western strength that permitted the humiliation of China was linked in Chinese eyes to Western technological superiority, which in turn was linked to science. For nineteenth- and early twentieth-century Chinese elites, the question became how to foster modern science and technology in China without sacrificing the values of Confucian civilization and Chinese identity. For some, a modernization of China would be possible if Western technical knowledge would serve as societal means to ends set according to the Chinese tradition. For others, the latter was itself in need of overhaul if not abandonment in favor of a more science-based civilization.

While the China of the 1980s and 1990s is a very different place from the China of the 1880s and 1890s, some of the basic dilemmas of means and ends involved in cultural interchange and borrowing remain. Post-Mao China has aggressively sought to build its scientific and technological capabilities and has turned to the international community, especially the United States, for help in this task. At the same time, it has introduced far-reaching economic and S&T reforms domestically. Inevitably, the reforms have drawn inspiration from the broadened international contacts for new organizational arrangements, policy ideas, and institutional models for a reformed S&T system. However, the use of these new forms without also adopting the broader cultural and philosophical contexts in which they occur involves difficult tasks of discrimination, selection, adaptation, and assimilation of the desirable and efficacious elements from the undesirable. Inescapably, such change threatens official ideology and established positions of power, and can be conflict-inducing. Three examples will illustrate the dilemmas that inhere in such "slippery-slope" situations:

- China would like to have a powerful national system of innovation. From its interactions with the United States and other OECD countries, it has come to realize that to have one it needs effective protection of intellectual property rights. But once one begins to recognize rights to intellectual property in the interest of technological enhancement, can one then separate that type of right from the right to property in general? And once economic rights are recognized, can political rights be denied?
- The introduction of a national science foundation and the practices of peer review have been effective reforms (again, inspired from interactions with the United States and others) that have improved national research administration in China. But the emphasis these entail for investigator-initiated research implies a very different image of the technical intellectual in society than that which prevailed during most of the history of the People's Republic. Peer review is a means for improving the evaluation and selection of proposals for research, but peer review presumes the existence of an expert community with a body of knowledge that is beyond the ken of the state. Can one have a vigorous and effective peer review process without recognizing the limits of "official knowledge" and by extension, the need for autonomy for expert communities? But if autonomous group formation among scientists and engineers is to be tolerated for the well-being of science, wouldn't it also make sense to grant greater autonomy to experts in industrial management, in labor, in education, and in agriculture, all of whom know their trades better than state officials and Party cadres? But if such autonomy is granted, don't you begin to have a more vibrant civil society which will challenge and contest the Party/state's claims to the monopolization of political power?
- China's rapid economic growth has led to serious problems of environmental pollution and to a worsening industrial and transportation safety record.

> China's transformation to a market economy means that it needs new regulatory regimes—laws, administrative agencies, technical standards—for managing the environmental and safety problems engendered by the working of a market economy. Again, foreign institutional models and "regulatory science" have provided inspiration for the building of these new regimes. The S&T relationship with the U.S.—which has in place protocols for cooperation with such agencies as the Environmental Protection Agency, the Nuclear Regulatory Commission, the Federal Aviation Agency, and the Departments of Labor and Health and Human Services—has been an important source of such inspiration. Again, however, there are problems of separating the regulatory science and the legal and organizational components of these foreign regulatory systems as models for China. While technical standards, policy models, and organizational arrangements can be emulated—and they have been—can their effectiveness in China be realized without the attendant factors that contribute to regulatory effectiveness in a country like the U.S.? These include, in particular, legislative oversight, an investigative free press, and generally accepted principles of democratic accountability.

Science and technology relations with the United States can be narrowly construed, but to understand how they might pertain to bilateral conflict and cooperation between the two states in the future, it also makes sense to see them as part of a broader pattern of interaction in which the cultural and institutional settings for modern science are also involved. From a U.S. perspective, it is encouraging and gratifying that China should be as interested as it has been in emulating this broader S&T–related societal infrastructure. In principle, this should make future cooperation on a range of projects and problems easier than in the past.

However, Chinese assimilation of this infrastructure will not always follow the path and pace that the United States would expect, and this can cause conflict. From a Chinese perspective, there is much to be learned from the United States about the broader infrastructure for S&T and about the governance of a complex industrial society. But the lessons are not all positive. There is much that doesn't work in the U.S. and much that would be inappropriate for China. That the Chinese side sometimes seems to understand this better than the United States is also a source of conflict and resentment, the United States often seeming to the Chinese as arrogant in its ignorance of its own failings. There are also, of course, ample reasons, stemming from Chinese behavior, for the United States to perceive China as being arrogant in much the same way. Thus, even as S&T, business, and cultural relations become more intimate between the two countries, Chinese concerns are still heightened about "cultural imperialism," "cultural invasion," and "U.S. interference in China's internal affairs."[35] As China comes to share with many of its Asian neighbors a new sense of pride in "Asian values," a sense of satisfaction in Asian accomplishments in the late twentieth century, and an anticipation of an Asian renaissance in the twenty-first century, conflicts over civilizational values are likely to increase, especially if the U.S. is careless in asserting the cultural power it could once use with confidence.

CONCLUSION

The U.S.–China S&T relationship can be seen through various lenses and in different lights. Viewed strictly as a bilateral S&T relationship, it is the largest and most ambitious such relationship that either country maintains. It has served many of the scientific and political objectives that both countries had for it, including its being a vehicle for overcoming many years of isolation and hostility. In this sense, it has been a force for mitigating conflict. It has worked as well as it has because it has allowed complementary interests to be found by a wide range of actors on the two sides.

The government-to-government agreement and the many programs of activities under it have provided an important framework for the overall relationship. By stressing the principles of "mutuality of interest" and "benefiting side pays" (when there is no clear mutuality of interest), the operation of the program may have missed some opportunities, but it nevertheless tapped into the roots of real commitment to cooperation which has weathered well the ups and downs of the political relationship. But, of course, the government–government programs, while providing a framework, do not exhaust the range of activities that make up the S&T relationship; indeed, overall, it is a small part of the whole. The broader ties which wind through the academic communities of the two countries, and increasingly into the industrial sectors, further contribute to the relationship's resilience.

As we have seen, however, the S&T relationship has not only been a positive force for integration and conflict reduction, but has generated tension as well. At one level, this has been the normal conflict one might expect in the implementation of any cooperative endeavor between two very different societies. But the deeper and more significant conflict is best understood when we realize that the S&T relationship is more than what it appears to be when narrowly construed.

One does not do justice to the importance of the S&T relationship without recognizing its symbolic value as a point of entry into a much more complicated cultural encounter that is loaded with historical background and psychological and emotional significance. It is in many ways an encounter that is unique to these two countries. It cannot be understood apart from the U.S.–China relations of the past century, the special roles that science and education have played in those relations, the large numbers of Americans of Chinese descent in science and engineering who emerged from those relations, and the large number of technical intellectuals in China whose training in the United States was also a product of these relations. In addition, understanding the encounter also requires that we recall the special significance that has been attached to science and technology by Chinese elites since the nineteenth century as means to restore China's greatness—militarily, economically, and culturally—and the fact that it has been nearly axiomatic among the Chinese that of the countries of the West, it has been the United States, the "beautiful imperialist," that has been the embodiment of a science-based civilization and the font of technological revolution.[36] This kind of background means that more than instrumental considerations are driving the cultural encounter, and that when disappointments occur, they are seen as betrayals, and when conflicts arise, they are difficult to manage.

U.S.–China S&T relations since 1979 have produced numerous new bridges between the two societies that did not exist at the time of the establishment of diplomatic relations. Yet, in odd but understandable ways, U.S.–China relations have resisted "normalization" and have remained "fragile," as Harry Harding has argued. S&T ties, in their broader cultural manifestation, have certainly contributed to processes of normalization, but they may be as much a force for fragility as for normalization for the reasons noted above.

On the other hand, what has transpired in the name of U.S.–China S&T relations since the end of the 1970s can also be viewed as the creation of significant assets for further cooperation as the two countries begin to confront the problems of the twenty-first century. China and the United States will be two of the world's largest economies, two of the world's largest international traders, two of the world's largest producers of greenhouse gases, two of the world's nuclear powers, two of the world's major arms exporters, and they will be in possession of two of the world's largest pools of scientists and engineers. Science and technology will be increasingly important to both countries domestically and in their encounters with the problems of international society. It follows that S&T will also be of increasing importance in the bilateral relationship as well. Without unwarranted optimism, it is fair to assume that S&T relations will become more of an integrative force in the future. If so, the ability of S&T relations to play that role will be very much a result of the network of ties and the many achievements that have come about from the encounter during last two decades.

ENDNOTES

1. Interview, Chinese Academy of Sciences, July 1996.
2. *China News Digest* [electronic], January 25, 1997.
3. Wendy Frieman, "Asian Winds, American Chills," in Todd M. Davis (ed.), *Open Doors, 1995/96* (New York: Institute of International Education, 1997), pp. 110–111.
4. Press, of course, has been a major figure in the development of the S&T relationship in his roles as Science Adviser, and later, President of the National Academy of Sciences. It is important to recall, however, that his involvement with China began earlier in the 1970s, when as a professor of geophysics at MIT, he led an earthquake-prediction delegation to China and served for two years as chair of the CSCPRC.
5. As Kathlin Smith's chapter notes, the English translation of the Association's name had in the past been abbreviated as "STAPRC," the Science and Technology Association of the PRC.
6. For a discussion of these early government-to-government contacts, see Richard P. Suttmeier, *Science, Technology and China's Drive for Modernization* (Stanford, CA: The Hoover Institution Press, 1980), pp. 84 ff.
7. Misunderstandings and disagreements over research charges continue to create bad feelings among investigators on the two sides. See, for instance, "Both Sides Point Finger in Tiff Over China Dig," *Science* 274 (1 November 1996): 715–716.
8. At the meeting of the Joint Commission in October 1996, the two sides entered into a new agreement (via a new annex to an existing protocol) for cooperation in civil industrial technology.
9. Other problems, such as the defection of tennis star Hu Nan in 1982, and the initiation of China's campaign against "spiritual pollution," which appear rather insignificant in retrospect, were seen as unwanted developments for the relationship at the time.
10. Harry Harding, *A Fragile Relationship: The United States and China since 1972* (Washington: The Brookings Institution, 1992), pp. 138 ff.

11. U.S. support for Chinese students from various sources was estimated to be approximately 80 million U.S. dollars a year in the mid-1980s. Apart from commercial investments, this was the largest single source of support for China's modernization efforts. Harding, *A Fragile Relationship*, p. 151. Cf. footnote 14, below.
12. Harding, *A Fragile Relationship,* p. 174.
13. Of the roughly 220,000 students and scholars who have gone abroad (all countries) from 1979 to 1995, only 75,000 had returned. The rates of returns among those sponsored by the government (37,000/44,000) or by work units in China (48,000/86,000) was notably higher than "self-sponsored" students (which includes those who received support from U.S. universities and other U.S. institutional sources. *China News Digest* [electronic], January 25, 1997.
14. Harding, *A Fragile Relationship*, p. 195.
15. See, for example, Yu Guangyuan, "On the Emancipation of the Mind," and Xu Lianying, "Essay on the Role of Science and Democracy in Society," in Fan Dainian and Robert S. Cohen (eds.), *Chinese Studies in the History and Philosophy of Science and Technology* (Dordrecht/Boston/London: Kluwer Academic Publishers, 1996), pp. 1–12. Both of these essays appeared originally in 1981 in the journal, *Dialectics of Nature*.
16. Lyman Miller, *Science and Dissent in Post Mao-China* (Seattle: University of Washington Press, 1995), p. 213.
17. "Soul-Searching After China Crackdown," *Science* 245 (August 4, 1989): 461.
18. *China Exchange News* 17, 3 (September 1989): 2.
19. It is interesting to note that Britain's Royal Society reacted in a somewhat more discriminating manner to the June 4 events. In a press release of August 7, 1989, the Royal Society announced that it would continue its activities with nominally nongovernmental institutions in China—CAS, CAST, and the Academy of Medical Sciences—but would suspend programs with governmental bodies, or those "under the direct control of the State Council" (including the Ministry of Geology and the National Natural Science Foundation of China).
20. "Soul-Searching after the China Crackdown," op. cit.
21. Author's conversations, Beijing and Tianjin, August, 1989.
22. The extent of participation in the events of the Spring of 1989 by personnel of the CAS is not known. At least one CAS researcher who did participate was killed in the crackdown.
23. *China Exchange News* 18, 3 (September 1990): 2.
24. High costs and other problems with the Chinese research environment—especially for social scientists—are also factors in the decline.
25. It should be noted that the U.S. technical agencies, in general, had a more relaxed view of the IPR issue than did commercially oriented agencies such as the U.S. Trade Representative.
26. As of 1995, 239 of the 432 "academicians" (*yuan shi*) in CAS who had foreign training had received that training in the U.S. Of the 432, 345 had doctorates, 181 of which were earned in the United States. I am indebted to Cao Cong for this information.
27. The worst of the cutbacks were in the 1980s. In the 1990s, budgets have gone up, but not as rapidly as costs. In addition, the Chinese yuan was devalued relative to the dollar. Among other things, these conditions have forced Chinese universities and research institutes to cut back on their subscriptions to foreign journals. Tsinghua University, for instance, has reduced its subscriptions to foreign journals from 1,012 in 1986 to 472 in 1996; at Peking University during the same period, the numbers are 1,949 and 972, respectively. *China Focus* (January 1, 1997).

28. U.S. firms that have established R&D facilities in China include General Motors, Ford, General Electric, IBM, Motorola, and Texaco. *The China Business Review* (January–February 1997): 48.
29. Kyna Rubin, "Go West, Look East," *Far Eastern Economic Review* (October 10, 1996): 60-62.
30. See, Congressman Peter DeFazio "China Deal Costly to U.S. Workers," *The Register Guard*, Eugene, Oregon (July 3, 1996).
31. These include a new agreement on industrial technology between the Chinese SSTC and the U.S. Department of Commerce and plans to implement a new program on sustainable development initiated by Vice-President Gore and Vice-Premier Li Peng.
32. *The China Daily* (January 18, 1997). This agreements were reached during a high level NAS mission to China led by Academy president Bruce Alberts. This was the most important visit of its kind since Tiananmen.
33. Alastair Iain Johnston, "Learning Versus Adaptation: Explaining Changes in Chinese Arms Control Policy in the 1980s and 1990s," *The China Journal* 35 (January 1996): 44-45. See also Banning N. Garrett and Bonnie S. Glaser, "Chinese Perspectives on Nuclear Arms Control," *International Security* 20, 3 (Winter 1995/96): 43-78; and Wendy Frieman, "New Members of the Club: Chinese Participation in Arms Control Regimes, 1980-1995," *The Nonproliferation Review* (Spring–Summer 1996): 15-30.
34. Cf. assessments offered by Johnston, Garrett and Glaser. Johnston (pp. 49–51), for instance, finds evidence that the work of China's arms-control community contributed to changes in Chinese thinking about joining the NPT, which it did in 1992.
35. Cf., Harding. p. 212.
36. As Shambaugh points out, this literal translation of "American imperialism" "… nicely captures the ambivalence—admiration and denigration—that distinguishes Chinese perceptions of the United States." David Shambaugh, *Beautiful Imperialist. China Perceives America, 1972–1990* (Princeton, NJ: Princeton University Press, 1991), p. 3.