CHINA-US S&T COOPERATION:
PAST ACHIEVEMENTS AND FUTURE CHALLENGES[1]

Richard P. Suttmeier
University of Oregon
Cao Cong
University of Oregon and the Levin Institute of the State University of New York

Presented at the U.S.-China Forum on Science and Technology Policy
Oct. 15-17, 2006
Beijing, China

Background.

At the time that science and technology (S&T) relations between China and the US were initiated in 1978, there was much interest in the US in having the S&T relationship contribute to the building of a broad "web of relationships" between the two countries. In many ways, this goal has been met. We have seen science and technology make notable contributions to the economic relationships between the two countries, to new approaches to technological development and to the expansion of research collaboration. What started out as a government to government relationship has truly led to the creation of a web in which a wide variety of individuals and organizations on both sides of the Pacific are collaborating in research, innovation, policy discourse, and the building of institutions providing the infrastructure for further scientific and technological development. In all of this, the political relationship between the two countries has been served; the S&T relationship has been an enduring tie even in periods when the political relationship had reached its nadir.

As we consider the web of relationships in science and technology itself, the activities under the official government to government science and technology agreement continues to provide an important framework for activities outside of the agreement. The latter now include a whole variety of programs and relationships involving corporations, universities, NGOs, as well as individual researchers. On a variety of measures, S&T cooperation with the United States is the most extensive S&T relationship China maintains with any country, and much the same could be said for the role of China in the international S&T activities of the United States.

Conditioning Factors.

While the S&T relationship worked to support the political relationship, it is also the case that the achievements in the S&T relationship were made possible by a convergence of political interests between the two countries. Cooperation with United States has been an essential ingredient in China's modernization drive and quest to become scientifically and technologically developed. For the United States, the development of a strong and stable China has been a consistent objective since the normalization of relations in 1979, although the rationales for pursuing this objective have changed from Cold War geo-strategic considerations to economic and commercial interests, and are increasingly becoming tied to concerns over energy and the environment.

In addition to the conditioning effects of the political relationship, the S&T relationship has also been facilitated by gradually overcoming the asymmetries in capabilities and institutions which characterized the relationship at the outset. The China of the late 1970s was a long way from becoming an international leader in science and technology and, as a result, the bilateral relationship in S&T in the early years was highly asymmetrical - with US interests in cooperation being driven not by the quality of research in China, but largely by opportunities for new kinds of data and access to new ecosystems.[2] **Through two decades of efforts, this asymmetry in capabilities is fading as China becomes an important contributor to the world's scientific literature and one of the world's leading educators - in quantitative terms - of scientists and engineers. This diminishing asymmetry opens up broad new avenues for bilateral cooperation, especially in light of the enhancement of China's new Medium and Long-Term Plan, discussed further below.**

Also diminished with time, and again facilitating the achievements that have been made over the past 2 ½ decades is the declining asymmetry in institutions. Again, we should recall how much China has changed since the S&T relationship was initiated. At that time, China's research system was dominated by government research institutes operating under a central planning system. University research was weak, research in industrial enterprises was minimal, and notions of competitive, peer-reviewed grant-making were very underdeveloped. There was no patent office, and understandings of science-based regulation - and the role of science in policy making more generally - were embryonic. China's reform program in science and technology over the past 25 years has altered this landscape dramatically and, one can reasonably assume, it has taken considerable inspiration from what has been learned from S&T cooperation with the US. While China's research and innovation systems still remain quite different from those of the US in important respects, it is nevertheless true that the "US model" has been - and, indeed, continues to be - an especially important source of ideas and practices for China to study and emulate selectively. It would not be an overstatement to observe that the reconfiguration of China's institutions for science and technology over the past 25 years is itself a major achievement of the S&T relationship.

The Nature of Cooperation.

As noted above, the bases for cooperation in the early years of asymmetrical capabilities often turned on the desire of US-based researchers to gain access to distinctive natural phenomena in China and unique data. In addition, many American scientists felt a special calling to aid China's scientific development and bring talented human resources from China into active participation in international science. On the Chinese side, there were a range of objectives associated with strengthening and modernizing Chinese science, ranging from exposure to new instrumentation and the technologies of modern research, to access to the leading centers of advanced professional training.

As the asymmetries in capabilities and institutions faded, and as hundreds of thousands of Chinese students came to receive education in the United States, we have seen the growth of active research collaboration. This can be measured, however imperfectly, by the growth of co-authoring of scientific papers by researchers in the two countries. Let us briefly review some of the data which describe trends in this co-authoring.

Figure 1 illustrates both the rapid growth of China's SCI papers over the past decade as well as the growth of internationally co-authored papers which have also continued to increase, albeit not quite as fast as the former during the past few years.[3] **Figure 2 identifies the main countries with whom Chinese scientists collaborate internationally, and illustrates that during the past 10 years, the strength of collaborative ties with the U. S. have increased considerably more rapidly than those with the other leading countries. The importance of this trend if further illustrated when we look at collaboration in selected fields. The diagrams in figures 3-18 illustrate the changing patterns of international cooperation for both the U. S. and for China between 1996 and 2005 in cell biology, genetics, chemistry, and nanotechnology. It is clear that the strength of the China-US relationship has increased in all the fields studied, and is especially striking in nanotechnology.**

These data on international co-authoring are especially interesting in light of the political and policy environments from which they arose. The 1996-2005 period, was one of often tense relations - marked by US concerns over strategic technology transfers, the release of the Cox report which was received very badly in China, the US bombing of the Chinese Embassy in Belgrade, the EP-3 spy plane incident, and a series of diplomatic and security initiatives from the Bush administration which reflected the views of those who believe a rising China is likely to be a threatening China.

These experiences with the US convinced many Chinese that in China's science and technology relationships, there was a need for greater diversification and less reliance on relations with the US. Chinese policy during this period thus came to be characterized by various efforts to promote much more active ties with Europe, Russia, and China's East Asian neighbors. As figures 3-18 illustrate, these efforts at diversification have had some success; China is more engaged with more countries on a more substantial basis than it was 1996. Nevertheless, as we have seen, the data also points to a strengthening of ties with the US at a more rapid rate. Why might this be so?

Brain Drains, Gains, and "Circulation."

As noted above, one of the striking features of the S&T over the past 25 years has been the large number of Chinese students and scholars who have come to the United States for advanced study. As a result of political considerations, professional and economic opportunities, and lifestyle choices, a large number of these individuals have remained in the United States. Of these there are now some 62,500 China-born (excluding Taiwan-born) Ph.D.'s in science and engineering pursuing professional careers in United States.[4] **74% of these are between the ages of 30 and 49, with roughly 37% of the total employed in educational institutions with another 49% employed in industry. Approximately half are now US citizens.**

This population of China-born doctorates in science and engineering has become established in careers in United States and is at an average age where its members are highly productive and/or at a point in their careers where they are building or expanding their institutional bases. Many have maintained ties with institutions in China, and have a variety of incentives for continuing to do so. These range from instrumental concerns for the recruitment of good graduate students and access to low-cost research services, concerns for reputations in China, access to Chinese financial resources, to non-instrumental orientations characterized by enduring emotional attachments and desires to see China succeed. At the same time, researchers in China have incentives for identifying collaborators in the U. S., and building relationships with leading US institutions and researchers. Under these circumstances, we might hypothesize that ethnic ties might facilitate professional collaboration; collaboration of this sort might then be reflected in patterns of international co-authoring.

Bibliometric analysis of co-authored articles supports this hypothesis and indicates the importance of China-born scientists and engineers working in United States for the strength of Sino-US S&T cooperation. In a review of some 345,000 papers covering the 2001-5 period, Jin Bihui and her colleagues at the Chinese Academy of Sciences found that well over 50% of China's internationally co-authored papers involving a US-based researcher involved co-ethnic collaboration.[5] By field, the percentages were as follows:

MATH - 70.8%
PHYSICS - 78.9%
CHEMISTRY - 72.4%
EARTH SCIENCES - 59.4%
BIOLOGY - 73%
GENERAL - 62.3%

Clearly, investments made in the training of large numbers of Chinese students and scientists over the past 25 years are paying off in terms of the bridging of the technical communities in the two countries.

Looking to the Future.

Much has changed in the context in which the US-China S&T relationship is now evolving, and understanding the implications of this changing context will be important if future achievements from the relationship are to be realized. Among the more important factors requiring attention are the following:

1. The Central Importance of China's Medium to Long-term Plan (MLP). China's new MLP represents a fascinating and ambitious effort to bring Chinese science and technology into a leading international position by the year 2020, while also harnessing S&T for the solution or amelioration of pressing national problems.[6] **While it is sure to have false starts and disappointments, it nevertheless involves major commitments of resources and intellectual and administrator energies which will shape Chinese research and innovation experiences over the next 15 years. As such, it also offers a template for international cooperation, as discussed further below.**

2. The Bridging Role of the Scientific Diaspora. **Large numbers of Chinese students and scholars, as we know, have gone abroad for advanced training and are remaining abroad. While constituting a brain drain, increasingly the brain drain is less a zero-sum phenomenon and more of a positive sum experience, as suggested by the concept of brain circulation. As noted above, the diaspora plays an important role in the bilateral cooperation.**

3. Globalization. **The processes of globalization add new dimensions to the bilateral relationship in at least three ways. First, the Internet facilitates the initiation of globally distributed research projects in which both countries have active interests; bilateral cooperation, thus, will increasingly often involve greater attention to multilateral possibilities and implications. Second, globalization creates a whole series of new problems - energy, environment, public health, etc. - of great importance to the two countries and which pose new opportunities for research cooperation. Third, the globalization of commercial research and development has led to increasing attention to the global talent pool, making China an attractive site for commercial R&D activities, but at the same time, introducing new forms of competition for talent.**

4. *National Security.* National security concerns have clearly become much more important in shaping the context for the bilateral S&T relationship. In the past, export control issues have been a constant irritant in the relationship, but in light of the asymmetries in power, have been manageable. As differences in the power positions of the two countries narrow, export control questions have become more complex and daunting. The post-9/11 security environment in the United States has produced important changes in immigration policy and implementation, changes which have been irritating to China and have helped sour the attitudes of many members of the Chinese technical community towards the United States. Changes in US immigration policies have had parallels in the export control area as export control policies are being extended to cover the movement of people ("person embodied

technology") under the rubric of "deemed exports." While the US has declared that it seeks to find the right balance between national security and scientific freedom, post-9/11 policies have been tilted towards the former and have the potential to undermine the further development of the S&T relations with China. This is especially the case if deemed export policy is allowed to discriminate against foreign-born scientists on the basis of their country of origin. As seen above, a great deal of bilateral cooperation is built upon the research collaboration between ethnic Chinese in the United States and their counterparts in China.

5. *Scientific Progress*. World science is at an especially dynamic and exciting time at the moment with new research technologies, new interdisciplinary opportunities and patterns of research collaboration, and exciting challenges in information technology, nano-science and technology, and the biological sciences. At the same time, a host of new social problems challenge scientific communities to discover new knowledge and apply it to meet societal needs. China and the US are emerging as leaders in many of these areas of research and have special opportunities and responsibilities to work together in building agendas for progress.

6. *Demographic Changes*. Lurking in the background of the bilateral relationship are significant demographic issues which could shape the relationship in the coming years. The US is seeing the aging of its US-born technical community and is increasingly reliant on foreign-born scientists and engineers for its rejuvenation. S&Es from China have become an important source of this rejuvenation, as we have seen, but new opportunities in improving living and working conditions in China could dampen the supply of Chinese technical personnel for work in the US research environment. At the same time, China is facing its own demographic changes. Its population is aging, and its ability to educate large numbers of highly qualified scientists and engineers in the future is not certain.

The Importance of the MLP.

Each of the six factors noted above will require careful attention by the two sides. Each has potential for generating conflict within the relationship, but also opportunities for new forms of cooperation. In this context, the development and implementation of the MLP can be seen as offering a framework for cooperative initiatives especially if the priorities of the plan - public goods, basic research and high technology - are seen as offering particular avenues of collaboration.

For instance, the MLP places strong emphasis on science and technology in support of the supply of *public goods* - energy, environment, agriculture, public health, etc. These are matters of great concern for the United States as well, and how these two big countries manage these problems has obvious global significance. While not exclusively matters of government concern, these all call for the active involvement of public agencies. Fortunately, the existing government to government agreement has led to a tradition of cooperation in these areas and provides a framework for new initiatives. The recently signed agreement for the supply of nuclear power plants to China illustrates the potential usefulness of this framework.

The MLP also targets the expansion of *basic research* into exciting new areas of science. Again, a good framework for cooperation here exists in intergovernmental and inter-institutional agreements, but also in the critical role played by the scientific diaspora in collaborative research. In this area, governments have a role in facilitating easy travel and communication and, in this context, some of the security inspired policy initiatives of the US side are cause for worry. Successful collaboration in basic research also requires a serious regard for scientific integrity and a system of research administration which maximizes the chances that outstanding work will be supported.

The third area of priority found in the MLP is *high technology* development. Here again, something of a framework exists, although the potential problems in this third area could become more difficult. We can anticipate that a great deal of bilateral cooperation in the areas of high technology will be conducted through commercial channels involving Chinese and American companies. The rapid growth of corporate research in China (and the anticipated growth of Chinese corporate research in United States), the expanding dialogue on technical standards, and signs of joint R&D on new products and processes all point to a broadening agenda of collaboration.

Of course, the context for commercial cooperation in high technology is strongly influenced by government policies, and a number of issues of policy will influence collaborative prospects. By all accounts, the problems of intellectual property rights protection in China has been a significant deterrent for expanded cooperation, especially in certain industries such as pharmaceuticals. In addition, US export control and immigration policies have limited the expansion of cooperation.

With the introduction of the MLP, China is committing itself to accelerated high technology development, with much emphasis placed upon the acquisition of intellectual property rights over new technologies and control over technical standards for their development and deployment. The implementation of policies in support of the MLP have the potential for causing bilateral conflict and limiting the development of cooperation, as seen for instance already in misunderstandings over technical standards strategies and government procurement. The search for effective technology and industrial policies in support of the MLP which serve China's interests, are consistent with WTO commitments, and foster international cooperation, is one in which international dialogue could be helpful.

An additional potential source of irritation in the area of high-technology stems from remaining institutional asymmetries and asymmetries in capabilities. In particular, the persistence of weaknesses in Chinese industry for developing effective research strategies and managing innovation should be recognized. The more accomplished sectors of China's research system in universities and in the institutes of the Chinese Academy of Sciences are often doing work which is more appropriate to the technological needs of foreign companies, including US companies, than they are to those of Chinese companies. Bilateral cooperation in high technology, therefore, could begin to take the form of cooperation between US companies and Chinese research entities, a pattern already in evidence. Relationships of this sort can be mutually beneficial but they also run the risk of appearing to be exploitative, in the sense that foreign companies may be able to take advantage of research and human resource development paid for out of public funds in China while reaping commercial benefits that the Chinese side is institutionally incapable of capturing.

A New Stage.

The discussion above suggest that Sino-American cooperation in science and technology is about to enter a new stage, one in which the imperatives for - and payoffs from - collaboration are increasing dramatically. At the same time, there are new elements of competitiveness in the relationship which must be recognized, and a new context of multilateral possibilities in which the bilateral relationship is nested. The patterns of bilateral interaction have become more complex and the number of stakeholders in the relationship has increased. These are all good reasons for the two sides to rethink whether the existing mechanisms for coordinating the range of science and technology activities, to achieve mutual benefits, are adequate.

The implications of the new stage for the US include a heightened recognition of the strategic importance China attaches to its science and technology development over the coming 15 years. This would involve an appreciation of the historical context in which the MLP has been launched, and the current realities affecting its implementation, including balanced assessments of China's strengths and weaknesses. By extension, this implies the need for higher-level attention to the relationship within the US government. The US also should become more sensitive to the increasing complexity of the relationship, the need to make more discretionary resources available to it, and the need to find new mechanisms to accommodate the mix of public and private interests in scientific and technological cooperation with China. The US needs to reexamine its thinking about export controls, especially the accuracy of the risk assessments on which they are based and whether the benefits form greater liberalization are not currently underestimated.

The new stage also carries implications for China. While the progress of institutional reform in the S&T system has been impressive, the continuation of reforms will be necessary. There is clearly a need for a more credible IPR regime, and the disturbing incidence of scientific misconduct needs to be addressed. Since much of the reluctance on the US side to expand cooperation in high-technology areas is related to security concerns, China should take steps to make its military-related and dual use technology projects more transparent. Finally, China's introduction of the concept of *zizhu chuangxin* - variously translated as autonomous or independent innovation - as a guiding idea for the MLP has generated much discussion about its meaning and implications for the direction of technological development. Because of the confusion associated with this concept, China should try to further clarify the term and reassure the US and China's other international partners that *zizhu chuangxin* does not signal a drift towards a more "beggar thy neighbor" techno-nationalism.

In the years since China and the US began scientific and technological cooperation, the S&T

relationship has contributed to the building of strong ties between the technical communities of the two countries, and has facilitated the maturation of political and commercial relationships as well. Over the years the asymmetries in capabilities and in institutional structures have been reduced, and the scientific opportunities and challenges to use science and technology to serve social needs have increased. The need to move the bilateral relationship to a new level of cooperation is becoming more compelling. At the same time, the potential for friction and conflict in the relationship may also be increasing as a result of national security concerns and techno-nationalist sentiments on both sides. It would be terribly unfortunate if the latter came to trump the remarkable challenges and opportunities which characterize the S&T relationship at the new stage.