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U.S.- CHINA RELATIONS IN SCIENCE AND TECHNOLOGY AND THE CHALLENGES AHEAD: A PROPOSAL

As the technical dimensions of international problems, ranging from national security to global struggles to control disease, acquire greater salience, science and technology are playing an increasingly important role in US foreign policy. At the same time, scientific research and technological innovation are becoming increasingly globalized as important centers of scientific and engineering competence emerge in new parts of the world, with unsettling implications for national economies, employment patterns for scientists and engineers, and the distribution of capabilities of importance to national security. Globalization, in short, is changing the playing field for research and innovation, and it is becoming increasingly important for the US to incorporate these changes in their visions of what foreign policy for the 21st-century should entail. An especially important part of this new reality is China's emergence as a great economic power and, through the efforts of China's own research institutions and a growing number of MNCs attracted by the human and institutional resources available for original research and creative innovation in China, a critical site for knowledge creation, utilization, and diffusion as well.

Not surprisingly, therefore, interest in China's scientific and technological capabilities has grown markedly in recent years, both within China and among foreign observers. China's rapid economic growth over the past two decades has prompted questions about its longer term sustainability and the role of technology-based productivity gains in future growth. China's rise as a great trading nation raises questions about the changing composition of China's foreign trade and the extent to which China is competing in international markets with knowledge-intensive, high value-added products. China is becoming especially interested in the establishment of its own technical standards, raising the question of whether this will lead to increasing conflicts over trade and investment. The high environmental costs associated with Chinese economic growth make the need for new, environmentally friendly technologies in support of sustainable development most pressing. The interest in technological capabilities is also prominent in the context of China's national security strategies and prospects for military power. Chinese political leaders and defense planners have become more concerned about the capacity for innovation in technologies of relevance to national security, as the nature and implications of high technology warfare have

become evident. For foreign governments and foreign military analysts who are concerned about China's rising power, the increasing attention given to technological capabilities among Chinese defense planners makes the issues of Chinese scientific and technological development matters of new strategic importance, and China's recent successful entry into the world of manned spaceflight points to a series of intriguing questions about the changing relationships between commercial high technology industrialization in China and national security missions. Thus, on the cardinal issues facing China in the early 21st century - security, economic, and environmental - China's ability to create and use new knowledge has acquired a special importance in our assessments of the kind of society China will become in the coming decades and the terms by which China will interact with the rest of the world. US-China relations in science and technology figure prominently in these issues.

Cooperation between United States and China in science and technology has both contributed in significant ways to the enhancement of Chinese scientific and technological capabilities and has been an important part of the bilateral relationship since the reestablishment of diplomatic relations in 1979. S&T relations have continued through the highs and lows of the political relationship and have succeeded in building a "web of relationships" on a range of issues - in commerce, education, environmental protection, national security and in knowledge creation itself - of importance to both countries. In the course of this relationship, the terms of cooperation have evolved and the relative contributions of each side have changed. Over time, the great asymmetry which characterized the relationship in the early years has gradually faded as China's scientific and technological development has progressed. But, political and economic complications in the overall US-China relationship has also paralleled this S&T development. As a result, there is considerably less consensus in the US than there was at the time of normalization as to whether China's progress in science and technology - and the critical role which US-China S&T cooperation plays in that progress - is in the US interest. For some American observers, China's scientific and technological development contributes to China's overall national strength which challenges US interests in both economic and security terms. For others, the developing scientific and technological capabilities in China should be welcomed since they offer new opportunities for solving common problems and spur contributions from China's talented technical community to

the world's store of scientific knowledge. US-China S&T cooperation should therefore be supported and promoted, in this view, for serving both US interests and those of the international community.

The New Landscape

The project being proposed does not pretend to resolve the value differences reflected in these two interpretations, but we believe that coming to a *better understanding of the factual basis for them* is important for the ongoing policy discourse. We believe that a careful analysis of the scope and dimensions of the S&T relationship needed for the establishment of this factual foundation is long overdue and that the development of an integrated assessment of the dynamics of the relationship will help clarify policy choices. The need for analysis and assessment of the sort being proposed is especially timely in light of 1) the many significant changes which have occurred in China over the past decade; 2) the radically different security environment faced by the United States in the aftermath of the attacks on the World Trade Center; and, 3) the prospects for a new bio/nano/materials/IT technological revolution in which the US and China will be significant players.

Over the past decade, a number of significant developments in China, and in the broader context in which the S&T relationship is conducted, have occurred. Among these,

- China is emerging as a far more important player in international S&T, has become an important participant in the global ICT revolution, and shares with the US a series of common interests in science-related global problems, including those relating to public health, the environment, and energy.

- Both the United States and China have seen significant changes in the ways in which government, industry, and universities interact domestically in knowledge production, and these changes have significant implications for international cooperation.

- China's accession to WTO has led to important new initiatives in its research and innovation strategies, especially with regard to the setting of technical standards, which are having disturbing consequences for US trade and investment objectives.

- China's S&T progress has become a source of concern to those interested in the national

security implications of the S&T relationship as seen, for instance, in the 1999 Cox Committee Report, the reports of the U.S.-China Security Review Commission (USCC), and the annual Defense Department reports to Congress on China's military power.

- In the wake of changes in US immigration policy and practices following 9/11, new restrictions on the movement of Chinese scientists and engineers has resulted in serious problems in implementing programs of research cooperation and professional exchange.

- China has shown a much greater interest in diversifying its S&T relationships, building much closer cooperative ties with some of its Asian neighbors, such as South Korea, and working with the European Union for a much deeper relationship involving participation in each other's high priority projects.

- China is now completing a long-term science and technology development plan for the coming 15 years which will significantly shape the structure and priorities of its research enterprise.

- Finally, China, like the US, has begun to wrestle with the ethical problems and social policy implications emerging from work in the biomedical sciences, nanotechnology, ICT and other scientific discoveries and technological advances.

Project Outline

In light of these developments, we believe that it is appropriate to reexamine the conditions under which the S&T relationship is conducted, review its achievements and problems, and examine the policy issues which may affect its future development. The study proposed would have the following main elements.

1. A Changing China. Over the past decade Chinese research and development expenditures have increased to the point where China ranks third in the world, after United States and Japan, in terms of purchasing power parity (PPP) terms. As noted, China is in the process of launching an ambitious long-term planning process to prepare for the development of science and technology, and its social impacts, up to the year 2020 which will target new fields of research, establish new administrative mechanisms for science, and increase the flow of resources going to R&D. It has continued to reform the policies and institutions which constitute its national system of

innovation, it has risen notably in the ranks of contributors to the world's science and engineering literatures, has expanded international cooperation in S&T, it has expanded its higher education system and is seeking to create "world-class" universities from among its more accomplished institutions of higher education, and has sought to position itself to benefit from the globalization of research and innovation. Among the more important changes which have occurred are the significant increases in R&D being performed in China's corporate sector and the notable growth of R&D activities in China sponsored by multinational corporations. A whole new pattern of government-industry relations is emerging in which voices from industry will become far more important in determining national priorities and directions. In addition, while China's brain drain remain serious, it has also shown some signs of reversal, and various programs in China to build active relationships with Chinese scientists and engineers abroad have shown success.

A first task of the study proposed, therefore, would be to document these developments more fully than they have been by reviewing the changes in the three main sectors of China's research system (universities, the Chinese Academy of Sciences, and industry), examine the statistical indicators used by China for measuring its progress and the efficacy of its policies (with particular attention given to R&D expenditures, scientific and engineering manpower, and output indicators) and put these in the proper institutional context, review the important national R&D programs which China has used to focus resources on high-priority policy objectives, and investigate reforms in higher education which will impact the production of a new generation of scientists and engineers. The completion of this task will involve reviewing extant studies in the secondary literature, and Chinese statistical materials and policy documents, and would result in an updated report on changes in the Chinese national innovation system, and what these mean for the US.

The report would:

a) review and analyze China's long-term science and technology development plan with an eye towards identifying the implications for the US, and for US-China S&T cooperation;

b) assess the ways in which institutional reforms in China are creating institutional symmetries with the US which work to facilitate, or hinder, S&T cooperation with the US;

c) identify the policy mechanisms, the human resource base, and institutional arrangements

for Chinese initiatives in the bio/nano/materials/ICT technologies areas;

d) provide more a detailed account of the policy and institutional contexts for interpreting quantitative S&T indicators of scientific and technological development in China than what is found in the current literature (cf., Hsiung, 2002).

2. The Role of Government Programs in the US- China S&T Relationship. Over the past 35 years, government to government S&T programs have played an important role in fostering bilateral S&T cooperation. These programs began at a time of great asymmetry in the capabilities of the two countries, and when United States seemed to offer unique opportunities for cooperation. Over the years, Chinese capabilities have improved, as we have noted above, and China now sees many opportunities for cooperation with other partners, especially (as noted above) in Europe where European leaders see S&T cooperation with China as critical to a range of other issues, where China has begun to participate in EU Framework Programs, and where European researchers have begun to participate in China's national programs. Yet, US-China government to government programs continue to be an important part of the overall fabric of the relationship especially in basic science, health and biomedical sciences, and energy and environmental affairs. They have not, however, been subject to a systematic review and evaluation by investigators outside of government for a number of years, except for a recent paper by the Science Counselor at the Chinese Embassy (Jin, 2003). The need for a fresh review of government programs is especially timely in light of the changed international political and security environments and trends towards globalization. A second part of the study, therefore, would be to review the nature of government to government relations, including bilateral agency to agency relationships, with a view towards identifying trends, problems, and new opportunities with reference to the commercial, security, environmental as well as the purely scientific interests of the two sides. This task would involve a review of available government documents and interviews with officials involved in both countries, examine failures and successes in cooperation, and would attempt to assess the important policy issues at stake in light of the changing circumstances noted above.

3. The Role of the Corporate Sector in S&T Cooperation. A major development in the

overall picture of US-China S&T relationships over the past decade has been the expanding presence of R&D activities in China sponsored by US-based multinational corporations. The past decade or so has been characterized by the globalization of corporate research, and China has become an important site for these activities. At the same time, Chinese firms are beginning to show an interest in investing in R&D in the United States. Governments in both China and United States have been keenly interested in these developments and have been somewhat divided as to their desirability (Walsh, 2003). It would seem that research cooperation in the corporate sector is increasing, but we don't know by how much, or how large a share of the total bilateral activities fall within this category. We also don't know what special problems and opportunities cooperation through corporate channels present; arguably, the Chinese government has paid considerably more attention to the importance of these ties, and has sought to facilitate them. This third task would attempt to clarify the baseline data necessary for understanding what is actually going on with these international corporate R&D activities, and would examine their implications for U.S. economic and security interests as well as for their importance in knowledge production and technological innovation. We would rely on published and web-based corporate information, a web-based survey of corporate activities, and telephone interviews with corporate research managers. In addition, we would attempt to develop cooperative relations with the Industrial Research Institute in the sharing of data.

4. Patterns of Academic Cooperation. As indicated, in the 25 years since normalization of diplomatic relations, S&T cooperation has been broadened and deepened between the two sides, and the primary realm of this cooperation has been the extensive web of contacts and relationships among universities and research scientists and engineers themselves. A fourth task in the study proposed would be to examine the patterns and dimensions of these relationships, including the nature of the growing interdependence between United States and China in science and engineering education, by analyzing data on inter-university relationships, and patterns of co-authorship. Particular focus will be given to what we have elsewhere called China's "extended scientific community," a term we use to refer to Chinese scientists and engineers from the PRC now working in United States. In this fourth part of the study, we will attempt to come up with a more

precise estimate of the size of this community, its geographic locations, disciplinary distributions, and employment patterns. We will also investigate the patterns of interactions between this extended community and the domestic scientific community China. There is a common understanding that members of the "extended community" play an important role in bridging scientific and technological activities in China and in United States, but there has yet to be any systematic study of this group. Meanwhile, a series of emerging issues involving IPR, research ethics, and security and immigration concerns have arisen which are likely to affect patterns of cooperation. For this part of the study, we will examine Chinese and American data sources, conduct interviews among scientists, and conduct an online survey.

5. Integrated Analysis. As international cooperation in science and technology has increased over the past fifteen years, advances have also been made in the analysis of international cooperation. We are developing concepts and tools which permit much more discriminating analysis of the various types of international cooperation, the motivations for it, the nature of national and international specialization in research and development, and the different types of resources needed for, and committed to, different modes of cooperation. As recent work on US-Korea S&T cooperation has illustrated, cooperative activities are multidimensional (Wagner, *et. al.*, 2003). Some are characterized by the relatively spontaneous pursuit of new research opportunities, while others reflect careful planning in more formally organized settings. Some forms of cooperative activity are characterized by centralization, while others are "distributed." International cooperation can result from initiatives from scientists (as individuals or as teams), it can be driven by a variety of governmental policy concerns, and, increasingly perhaps, it is motivated by corporate interests in commercially viable innovations and in building a globally relevant knowledge base for corporate operations.

The final tasks of the project proposed will involve the application of these new concepts and tools to the US-China case, with the aim of providing a far more textured analysis of the relationship than has been available to date. The finer grained, more discriminating analysis we expect to offer will help clarify the policy choices facing the US as it deals with its increasingly complex relationship with a China whose military, economic, and environmental significance is

inescapably tied to its progress in science and technology. Among these policy choices, are those relating to multilateral as opposed to bilateral forms of cooperation, modes for facilitating communication and travel in support of S&T cooperation, the changing context for export controls, harmonizing regulatory approaches with regard to the environmental and ethical implications of new technologies, and finding the basis for US-China cooperation to facilitate the development of science and technology in the Third World.

Timetable.

The project envisioned would involve work over the course at 18 months, beginning July 1, 2004. During the first three months, both investigators will focus on the first task of assembling baseline data on the many changes which have occurred in the Chinese national system of innovation, will prepare a report to NSF on this work, and will prepare an article for publication. During the next three months (October-December, 2004), the focus will be on government to government programs and will involve analysis of extant data and interviews with officials in both countries. We would hope to produce a preliminary report on this work by early 2005 which could be of use to a new administration at that time.

During the first half of 2005 (January-June), Cao will work full-time on academic exchanges and interactions and the definition and activities of the extended community. In the July-September, 2005, period, we will focus on the corporate research sector, with the remainder of the project period given to an integration of the different components of the study and an assessment of what the findings imply for policy choices.

Products and Significance.

We have little doubt that the growing interest in Chinese scientific and technological capabilities, noted above, will create an increasing demand for good data and analysis of Chinese policies, plans, and performance in the areas of research and innovation. We therefore expect that there will be substantial interest within government policy circles and business groups, as well as within the academic community, in this project. It has been quite some time since a comprehensive review of the US-China relationship in science and technology has been conducted, and we believe

the study will add a much-needed empirical base for policy discussions. It will also contribute to academic studies of contemporary China and US-China relations.

The more specific products we see emerging from the project include the following:

a) An interim report, to be finished in time to be of use to a new administration, that would explain the rapidly changing environment for science and technology in China, and point to implications for the US. Particular attention would be given to a discussion of China's long-term plan for S&T, the growing importance of industrial R&D, the prospects for basic research, and new initiatives in China to participate in the bio/nano/materials/ICT technological revolution;

b) A series of published articles in academic and popular media which will contribute both to the academic study of China and to broader public understanding of the role of science and technology in US-China relations;

c) A project web site on which relevant research materials will be posted along with the reports and papers coming from the study. We will also use the web site as a forum for soliciting opinions and exchanges of views among other academic experts, key people from the corporate world, and government officials;

d) A major final report to NSF of our findings (with NSF approval, we would also seek to publish this report as a book).

The Investigators.

Both investigators have had extensive experience studying developments in Chinese science and technology, as the attached biographies indicate. Both have also followed the development of US-China S&T relations in some detail. Suttmeier authored the first major review of the S&T relationship, *U.S.-P.R.C. Scientific Cooperation: An Assessment of the First Two Years*, done for the Department of State in 1981, and he was also a senior member of the Office of Technology Assessment team which authored the1987 OTA report, *Technology Transfer to China*. His "Scientific Cooperation and Conflict Management in US-China Relations, 1978-Present," appeared in Vol. 866 (1998) of *The Annals of the New York Academy of Sciences.* Both investigators have extensive experience of fieldwork in China and long-standing contacts with Chinese officials and researchers whose cooperation for the completion of the study would be

important.