US-CHINA RELATIONS IN SCIENCE AND TECHNOLOGY AND THE CHALLENGES AHEAD

A PROGRAM OF RESEARCH

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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 its 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.

Background

Not surprisingly, therefore, interest in China's scientific and technological capabilities has grown markedly in recent years, both within China and among foreign observers. Of 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. Cooperation between the 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 have 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.

This project on Science and Technology in Sino-American Relations 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.

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 main elements of the project include the following:

1. A Changing China. Over the past decade Chinese research and development expenditures have increased to the point where, in terms of purchasing power parity (PPP), China ranks third in the world after United States and Japan. 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 remains 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.

An important part of the study, therefore, is 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. It is also necessary to 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.

2. The Role of Government Programs in the US- China S&T Relationship. Over the past 25 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, although they have gotten attention on the Chinese side. 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, involves a 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.

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. 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. A third task, therefore, will be to attempt to clarify the baseline data necessary for understanding what is actually going on with these international corporate R&D activities, and examine their implications for U.S. economic and security interests as well as for their importance in knowledge production and technological innovation.

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 project involves an examination of 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 in 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.

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. International cooperative activities are multidimensional; 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. By exploring how these trends apply to the US-China case, we hope to be able to provide 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 and China as they deal with the increasingly complex military, economic, and environmental relationships. 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.