From Cold War Science Diplomacy to Partnering in a Networked World: 30 Years of Sino-US Relations in Science and Technology[1]

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Background.

January 31, 2009 marked the 30th anniversary of the signing of the *Agreement Between the Governments of the People's Republic of China and the United States of America on Cooperation in Science and Technology* (hereafter, the *Agreement*). The signing marked the formalization of reestablished ties in science and technology between the two countries which began following the signing of the *Shanghai Communique* in 1972. While sometimes dismissed as "scientific tourism" by the American side, the exchanges of scientific delegations which began after 1972 played a critical role in shaping what was to become a far more complex relationship. For the American technical community, these exchanges provided opportunities to bring Chinese talent back into world science, get access to distinctive natural and social phenomena and data, and learn of pockets of Chinese research excellence. But, more generally, they led to an appreciation of the great costs to Chinese science and higher education imposed by the Cultural Revolution years. For the Chinese technical community, the opportunities to travel to US facilities was a liberating chance to reestablish contact with international science, but also provided a new perspective on just how far behind China had fallen after years of radical politics.

For the two governments, the S&T relationship was an opportunity to build closer political ties - in spite of a highly asymmetrical nature of scientific development in the two countries - to

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counter Soviet influence. Six months prior to the January 1979 formal establishment of diplomatic ties, and on the heels of Zbigniew Brzezinski's important visit to China in May, 1978, which helped lay the political foundation for normalization, President Carter's science adviser, Dr. Frank Press, led a major delegation of representatives from US technical agencies to China to explore the expansion of relations in science and technology. This was then followed by the signing of agreements in the fall of 1978 for cooperation and exchange in agriculture, space, energy, earth sciences, and hydropower, and the important *Agreement on the Exchange of Students and Scholars* which opened the way for the 1 million plus Chinese who subsequently came to the US for training and advanced degrees. For the US, the S&T relationship was one more strand in the "web of relationships" it hoped to build with China, one that addressed both many of China's developmental concerns and US long-term interests in global issues. For the Chinese, the relationship offered invaluable access to intellectual resources needed to rebuild the research and higher education systems. Scientific, technological, and political factors were thus mixed together in what was an interesting new initiative in Cold War science diplomacy, and one that facilitated the reestablishment of diplomatic relations between the two countries.

Few would have imagined what the *Agreement* would have wrought 30 years later. The web of relationships that has been created in S&T is now characterized by multiple institutional strands, with multiple stakeholders having multiple objectives. Although the reforms and investments made in China's research institutes and universities have not entirely erased the asymmetries of the past, they have certainly made China an especially important partner in research and innovation for many constituencies in the US. In a number of fields of research, and on a number of pressing global problems, the S&T partnership between the United States and China will play a critical role in determining how the 21st-century future is invented. Revolutions in science-based technologies hold the potential for significant enhancements in national wealth and power in both countries, while shared interests in the management of such collective goods and bads as pollution, water and energy availability, food supplies and a broad range of issues involving risk and safety focus increased attention on knowledge-based approaches to these challenges.

The Drivers of Change.

In considering what has changed in the relationship over the course of 30 years, several factors stand out.

Geopolitical Realities. As noted above, Sino-American rapprochement in the 1970s was driven largely by shared concerns about Soviet power and its use. A concrete expression of these shared concerns was the Brzezinski visit to Beijing in May of 1978, which immediately preceded the Press delegation in July. The significance of the concerns about the Soviet Union was also evident during the 1980s when a Republican administration took power and gradually overcame its predispositions towards Taiwan to expand the science and technology relationship with the mainland, including importantly the relaxation of export control policies. Geopolitical realities, in short, were the ultimate justification for an expanding S&T relationship characterized by a growing number of Chinese science and engineering students coming to the United States, an expansion of government S&T programs, as well as liberalized export controls.

The events of 1989, of course, altered the geopolitical assumptions in fundamental ways. The collapse of the Soviet Union, the promises of democratization in the former Soviet empire, and the image altering events at Tiananment on June 4th combined to shake the political foundations of the S&T relationship. Following June 4th, government to government programs were suspended, high-level contacts between officials were cut, the US academic community expressed its outrage at the crackdown of the Tiananmen demonstrations, immigration regulations for Chinese students in the United States were relaxed, and embargoes were placed on technology transfer. The S&T *Agreement* was allowed to lapse and scheduled meetings of the JCM were not held. Nevertheless, some exchanges did continue and lower-level contacts between officials were maintained. Thus, in spite of the souring of political relations wrought by the Tiananmen events, the S&T relations survived and some observers would credit them for serving as an especially enduring element in Sino-US relations, even when the political relationship becomes deeply troubled. In April, 1991, the *Agreement* was renewed for another five years (adding new provisions for IPR protection), and the government to government relationship began to get back on track.[2] But, with the original political justification for the relationship no longer valid, a new one had to be found.

The US had emerged in the early 1990s as the sole superpower, a fact that was brought home to China in a political-military sense by the Gulf War and in an economic sense by Japanese decline and US economic revitalization. This had the effect of making China more attentive to the elements of US power while at the same time thinking about ways of balancing it.[3] The famous "southern tour"of Deng Xiaoping in 1992 represented a reaffirmation of the reform and open door policies of the pre-1989 era, and had the effect of overcoming Tiananmen-induced reluctance on the part of foreign corporations to invest in China. The Chinese foreign investment regime had by this time been liberalized to allow for wholly foreign owned enterprises, although the choicest foreign investment inducements offered by the Chinese - following China's "market for technology" strategy - were in return for technology transfer.

Foreign investment, and with it new forms of technology transfer, expanded rapidly after 1992 and increasingly involved investment in the information and computer technology (ICT) industries. US commercial interests became important in defining the political relationship, but had to contend with the negative legacy of the Tiananmen crackdown in the US, thus making the development of a new political justification on the US side an unfinished task. Hence, the often contradictory approaches to science and technology in the relationship throughout the 1990s - on one hand, accelerated technology transfer and investment in high technology industry in China; on the other, growing concerns about technology transfer, Chinese high tech espionage, and the S&T relationship more generally, which culminated in the 1999 Cox Committee report on U.S.

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[2] Jin Xiaoming. "The China-US Relationship in Science and Technology." Unpublished paper presented at the conference on "China's Emerging Technological Trajectory in the 21st-Century," Rensselaer Polytechnic Institute, September 4-6, 2003. Available at http://china-us.uoregon.edu/papers.php.

[3] Jin. "The China-US Relationship..."

National Security and Military/Commercial Concerns with the Peoples' Republic of China.

The 1990s was also a time of growing international concern over energy, environmental quality and climate change, with a rising awareness of the critical roles that China and the United States played in the global equation. These, of course, were Vice President Gore's issues. Taking advantage of some of the improvements in Sino US relations by the middle of the 1990s, the two sides initiated the US-China Environment and Development Forum in 1997, with Gore and the Li Peng chairing the first meeting in March of that year in Beijing. Subsequent meetings were held in 1999 and 2000, and had the effect of bringing high-level attention to the integration of energy, environment, S&T, trade, and development that transcended the work of the joint commissions (on S&T, economic relations, and commerce and trade) which had been established at the time of normalization.[4] The Forum did not survive the change of administration in 2000, but in some ways can be seen as a precursor of the Strategic Economic Dialogue (SED), discussed further below.

In spite of the jolts to Sino US relations resulting from the Belgrade bombing of the Chinese Embassy at the end of the Clinton administration, and the EP3 incident at the beginning of the Bush administration, the attack on the World Trade Center and the subsequent initiation of the "global war on terrorism" again changed the geopolitical situation in ways which strengthened US-China ties. Indeed, most observers of US foreign policy during the Bush years would argue that the US China relationship was the one bright spot of Bush foreign policy. In spite of the existence of serious trade problems, the Bush administration ended with a generally unambiguous endorsement of engagement, rather than containment, with China being treated increasingly as the "responsible stakeholder" called for by Robert Zoellick. The initiation of the Strategic Economic Dialogue (SED) and the exploration of new opportunities for military to military relations came to define new possibilities for a political foundation for S&T relations. The inclusion of energy, environmental, and technological innovation concerns in the agenda of

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[4] Jin. p. 9.

the SED also pointed to the growing importance of science and technology for the two countries and a maturation of the S&T relationship itself.

On the occasion of the 30th anniversary of normalization and of the signing of the S&T *Agreement,* the Obama administration thus begins in a radically transformed geopolitical context from the one that gave rise to the *Agreement* at the outset. The financial crisis, and the complex financial interdependence of the two countries, discussed further below, have altered the context even further. But, before considering where the Sino US S&T relationship might go under the Obama administration, let us consider some of the other drivers of change that have altered the context over the past 30 years. The remarkable transformation of China's research and innovation systems is a second obvious choice.

Changing Chinese Capabilities. China's systems for research and innovation in the late 1970s were close to broken. The Cultural Revolution had interrupted most areas of research and higher education, and China's socialist planned economy showed few signs of innovative potential. Science and technology, like the economy as a whole, had to be reformed and opened up. Thus began the fascinating story of the growth of Chinese scientific and technological capabilities over the past 30 years through a combination of domestic reforms and policy initiatives, and international collaboration and assistance. In retrospect, the story is especially remarkable in the ways in which human, material, and ideational resources from the international environment have been linked to domestic reforms efforts in ways which kept the growth of Chinese scientific and technological capabilities in rough synchronization with an increasingly globalized system of research and innovation. The relationship with the US was central to this process.

Unlike the governments of Europe and Japan, the US government has not provided direct foreign assistance in support of Chinese scientific and technological development, and from the beginning insisted that in the government to government S&T relationship, costs should be shared (even when, in the beginning, Chinese resources were quite limited) in proportion to the benefits received from collaboration. Indirectly, however, the contributions from the US side to

China's makeover have been substantial. These would range from US facilitation of World Bank projects in support of science and technology, to the support received by tens of thousands of Chinese graduate students in US universities through research grants to their mentors from US government agencies. The capacity and accessibility of the US university system - in spite of brain drain problems - has made the US university one of the most valuable assets in the international environment to be exploited by China.[5] This is especially true as a reverse brain drain begins to bring talented Chinese scientists and engineers back to academic leadership positions and high-tech entrepreneurial roles in China, and as China finds new ways to exploit its "scientific diaspora." The relationship with the US has also been important in providing ideational resources for China's domestic reform initiatives. This has been especially true with regard to institutional modeling, such as in the establishment of the National Natural Science Foundation China or the Chinese Center for Disease Control, and in approaches to intellectual property, venture capital, and foreign investment regimes. And, US-based multinational firms have been leaders in technology transfer and, more recently, R&D investments in China, as discussed further below.

Resources from the United States, and from the international environment more generally, would not have had as much influence as they have had were it not for domestic reforms and policy initiatives including, most recently, the initiation of China's Medium to Long Term Plan (MLP).[6] While these have certainly not been without problems (discussed further below), and are in many

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[5] The number of Chinese students studying in the United States increased from approximately 15,000 in 1985/86 to a record high of 67,723 in 2006/07. Institute of International Education. "Educational Exchanges between the United States and China." IIE Briefing Paper. July, 2008. p. 5.

[6] For a review of these, see, Richard P. Suttmeier and Cao Cong."China Faces the New Industrial Revolution: Research and Innovation Strategies for the 21st Century." *Asian Perspective* Vol. 23, # 3 (1999); Richard P. Suttmeier, Cao Cong, and Denis Simon. "China's Innovation Challenge and The Remaking of the Chinese Academy of Sciences." *Innovations: Technology, Governance, Globalization*, Vol. 1 Number 3 (Summer, 2006); Cong Cao, Richard P. Suttmeier and Denis Simon. "China's 15-Year Science Plan: Mapping Research and Innovation Strategies for the 21st Century." *Physics Today*. December, 2006.

ways incomplete, they can also be credited for turning what were largely moribund systems of research and innovation in the late 1970s into today's dynamic environment which attracts increasing international attention.

By a number of measures, China has now become an increasingly important player in world science and engineering. These would include manpower and expenditure indicators, as well as such measures of outputs as publications and patents. The record in international publications is especially impressive, in quantitative terms at least, with China's publication output now ranking second in the world behind the US.[7] In short, the researchers and institutions of China are increasingly attractive as partners in research and technological development. While the asymmetry which characterized the technical communities of China and the United States in 1970s has not entirely disappeared, there is no doubt that it has been sharply reduced and replaced by types of interdependencies which would have been inconceivable 30 years ago.

Changes in Science and Technology. Changes in science and technology have also been drivers for change in the Sino-US S&T relationship. These can be understood both in terms of intellectual content, or substance, and in the social relations of science and technology. When the *Agreement* was signed 30 years ago, the revolutions in computer science and information technology were only beginning. Molecular biology and biotechnology, likewise, were relatively immature as was modern materials science. Nanotechnology was largely a conceptual enterprise. Since then, of course, there has been remarkable progress in all these fields and with it the creation of new science-based industries. China, for the most part, was not a player in any of these fields at that time, but has now become highly active. The revolution in instrumentation through the application of ICT which was beginning 30 years ago, and about which China knew little, has now transformed the research environment and reinforces trends towards interdisciplinarity.

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[7] Loet Leydesdorff and Caroline Wagner. "Is the United States Losing Ground in Science? A Global Perspective on the World Science System." *Scientometrics*. V. 78, No. 1 (2009). 23-36.

30 years ago personal computing was only just beginning and there was no Internet. University-industry relations were nowhere near the intensity they are today, and intellectual property claims to new knowledge tended to be peripheral for academic researchers. Defense technologies and civilian technologies tended to be developed in separate realms, with the result that the management of dual use technologies was not a central national security issue.While science had always been characterized by international collaborations, the cost of international transportation and communications imposed limits on the extent of collaborations one might expect. With the reduction of transportation and communication costs as a result of new technologies, opportunities for international collaboration began to increase significantly. Relatedly, as a result of both reduced transport and communication costs *and* the spread of national policies to promote science and technology, research and innovation capabilities began to defuse to new parts of the world, especially to Asia. The widespread diffusion of digital technology, combined with growing numbers of technically trained individuals around the world facilitated the formation of global production networks, and more recently global innovation networks, in which China plays an increasingly important role.

In short, over the past 30 years, important new areas of science - supporting important new industries - have opened up, IPR issues are never far from the minds of researchers, dual use technologies complicate the reconciliation of trade and defense considerations in the making of national security policy. There has been an expansion in the numbers of centers of research and innovation around the world, and international collaborations have increased. Research and innovation increasingly require diverse competencies which, due to modern communications, can be drawn from around the world. The US remains a world leader in science and technology, but its leadership no longer remains unchallenged. Its share of the world's published papers, for instance, has declined, and the health of its research enterprise depends increasingly on foreign-born scientists and engineers, many of whom are from China. Thus, over the course of 30 years, we again see that the Sino-US S&T relationship has moved from one of manifest asymmetry to a far more complex pattern of interdependency.

Global Problems. Growing interdependency is also evident in a fourth driver - the rise of a series of global problems which have substantial technical content and in which China and the US have particular interests. These, of course, include climate change and environmental protection, energy, water quality and availability, and epidemics and infectious diseases. They also include terrorism, proliferation of weapons of mass destruction, information security and other national security related issues, and issues pertaining to the operation of the global economy such as the nature of international regimes for technical standards and intellectual property. These issues have all become considerably more pressing than they were 30 years ago due, in part, to China's economic growth and development. China and the US are both very sensitive to the ways in which these problems affect them and they clearly have special responsibilities for solving, or at least ameliorating, them. Most obviously, as the world's two leading consumers of energy and producers of greenhouse gases, the ways in which the two countries approach these issues have global implications. At the same time, they provide opportunities for - some might argue, they *demand* - intensified bilateral cooperation and coordinated leadership in multilateral settings.

But while the stakes are rising, questions about the modalities of relationships in science and technology are also becoming more complex. Research and innovation today is frequently characterized by the shortening of time between scientific discovery and technological application. Scientific research is therefore seldom far from commercial application and from the emergence of dual use technologies having both commercial and military applications. Concerns among business enterprises, universities, and governments for protecting proprietary knowledge, or knowledge of relevance to national security, have been heightened. Thus, the win-win, positive sum assumptions about cooperation in science have become complicated by the fact that the development of commercial and national security applications of new knowledge often introduce competitive pressures and the possibility of zero sum outcomes. National governments continue to adopt policies designed to capture value from scientific and technological advances and enhance national capabilities for research and innovation, even as they expand international cooperation. Both China and the United States exhibit these tensions - between "science and technology nationalism" and "science and technology globalism" - and the relationship between them is an especially rich case of how these tensions are managed.

Current Activities.

It useful to categorize the current relationship according to the main institutional channels through which it is conducted. These include government agencies, academic and professional channels, and corporations.[8] The existence of these channels, developed over the past 30 years, represents significant institutional resources for the kinds of strategic partnering on 21st-century scientific and technological development and global problems alluded to above. These challenges have basic research components, commercial components, and public goods components requiring a repertoire of organizational approaches, many of which now exist.

Government Programs.

The government to government relationship, conducted under the *Agreement* and some 26 subordinate agency to agency protocols (themselves having more than 60 annexes), covers a broad range of activities from basic research to technical assistance in domains ranging from agriculture to transportation. The implementation of the *Agreement* is the responsibility of the Joint Commission on S&T Cooperation (JCM), which meets roughly every two years and is co-chaired by the Chinese Minister of Science and Technology and by the President's Science Adviser. The S&T Executive Secretaries (ESM), led by the Director of the Office of Science and Technology Cooperation of the Department of State and by the Director of the International Cooperation Bureau of the Ministry of Science and Technology, meet during the years when the JCM does not meet. A sense of the government to government relationship can be seen in some

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[8] Contacts through the National Academy of Sciences, The American Association for the Advancement of Science, and a variety of NGOs constitute a fourth channel, but in the interest of space I will not discuss them here.

of the more prominent areas of cooperation:[9]

Agriculture. Agricultural agreements between the USDA and the Ministries of Agriculture and Science and Technology (MOST) call for the establishment of several working groups. A US-China High-Level Biotechnology Working Group (BWG) provides a forum for the two sides to exchange views on regulatory and biosafety issues associated with agricultural biotechnology, and involves not only the Chinese Ministry of Agriculture on the Chinese side but also the Administration of Quality Supervision and Inspection and Quarantine (AQSIQ), the Ministry of Commerce, and the Ministry of Public Health. The BWG also includes a Technical Working Group on the environmental and food safety implications of agricultural biotechnology which, in addition to the agencies above, also include representation from the Shanghai Academy of Agricultural Sciences, The Chinese Academy of Agricultural Sciences, The China Center for Disease Prevention and Control, The Chinese Academy of Sciences, Fudan University, and various provincial departments of agriculture. A variety of other activities in the area of food safety have occurred, including discussions of food safety regulatory systems with the National Development and Reform Commission (NDRC).

Other agriculture related activities include cooperation on ethanol and biofuels development, forestry management, soil and water conservation (including cooperation with The Chinese Ministry of Water Resources and the Chinese Academy of Sciences), plant and animal health, control of invasive species, agricultural economics and statistics, nutrition issues, and cooperation on research and management of individual plant and animal species. USDA has also cooperates with The Chinese Academy of Agricultural Sciences in the establishment and operation of a Sino-US Biological Control Lab in Beijing. Under its Scientific Cooperation and Exchange Program, USDA has supported the exchange of some 1500 US and Chinese scientists

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[9] The following information is drawn from Office of Science and Technology Cooperation, Bureau of Oceans and International Environmental and Scientific Affairs, Department of State. *United States-China Science and Technology Cooperation, 2008. Biennial Report to the US-China Economic and Security Review Commission.* Washington, 2009.

since the program was initiated in 1978.

Energy. DOE has also been engaged with China since 1978 but its involvement has intensified considerably in the face of global energy and climate change questions. A *Protocol For Cooperation in the Field of Fossil Energy Technology Development and Utilization* between DOE and MOST includes five annexes for cooperation: Power Systems (with China Power Investment Corporation); Clean Fuels (with NDRC); Oil and Gas (with China Petroleum and Chemical Industries Association); Energy and Environmental Control Technologies (with MOST), and Climate Science (with the Chinese Academy of Sciences and the China Meteorological Administration). Activities under these annexes involve training, R&D and demonstrations and capacity building in areas of high global salience, and are becoming increasingly central to Sino US relations as a result of the Strategic Economic Dialogue (SED) and the new "Ten Year Framework for Energy and Environment Cooperation"[10]

As China pushes ahead with measures intended to ameliorate the environmental effects of burning coal, and as the US struggles to develop a sound strategy for its own reliance on coal, opportunities for cooperation in clean coal technologies are especially notable. China is requiring that new coal burning plants be equipped with supercritical or ultra supercritical generation technology, and has redoubled its efforts to develop commercial scale facilities cold gasification and for CO2 capture and storage. The Ministry of Science and Technology, with the

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[10] The Framework provides for intensified cooperation in areas of electric power generation, transportation, clean water, clean air, wetland preservation. The recently completed Fifth SED added energy efficiency to the framework and enlists the US Trade and Development Agency and the US Export-Import Bank to support private sector activities in addressing "deficiencies in energy efficiency Chinese enterprises" and to assist in the implementation of the clean water program. TDA funding will also be used to support training programs for government officials at the national and provincial levels in pollution reduction and energy efficiency. Press releases. US Treasury Department Office of Public Affairs, December 4, 5, 2008.

Huaneng Group, set aside funds for participation in the DOE sponsored FutureGen project[11] which had been canceled by the Bush administration but now seems to be again funded by the new Economic Recovery Act. With China's increasing wealth, it has the wherewithal to build large facilities which are of considerable interest to the US.

Activities under the *Protocol For Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization* have also become especially salient. Again, under the protocol, there are a series of annexes - for rural energy development, wind energy, energy efficiency, renewable energy business development, development of electric drive and fuel cell vehicle technologies, and renewable energy policy and planning. With the increasing attention being given to energy efficiency in China and to renewable energy technologies, the technology sharing, technical assistance, training, and business development provided for under this protocol help link the two countries in highly important areas of technology and policy.

DOE is also involved with China in areas of basic research, most notably through agreements for cooperation in high-energy physics and nuclear fusion. The high-energy physics agreement was first signed in January, 1979 and has provided for close cooperation between high-energy physics communities in the two countries, especially in support of the establishment - and recent upgrading of - the Beijing Electron Positron Collider, an important facility which allows for world-class research in China. The largest current collaboration under this agreement is the construction of facilities for studying neutrino oscillations at the site of the Daya Bay nuclear power plant complex, scheduled for completion in 2011. The US is contributing half of the cost of the detectors, while the Chinese side is paying for the construction and civil engineering. DOE has also assisted in the design and construction of other major facilities including the new Shanghai Synchrotron Radiation Facility.

The *Protocol On Cooperation in the Fields of Nuclear Physics And Controlled Magnetic Fusion*

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[11] Deborah Seligsohn. "Can the US and China Cooperate on Coal?" *The Huffington Post.* Posted January 28, 2009.

Research was originally signed in 1983. Activities under the protocol have focused mainly on fusion and have involved training, cooperative research, and design assistance to China in the construction of its new EAST tokamak facility at the Institute of Plasma Physics of the Chinese Academy of Sciences in Hefei. This facility, which was tested and achieved its first plasma in September, 2006, has led to the increase of cooperative, mutually beneficial bilateral activities. With China joining ITER (International Thermonuclear Experimental Reactor), opportunities for bilateral cooperation on multilateral issues have also increased. In both the high-energy physics and nuclear fusion cases, we see that China's increasing ability and willingness to pay for large complex and expensive facilities is one of the reasons why it has become an increasingly attractive partner for international cooperation.[12]

Finally, in 1998, an agreement between DOE and NDRC on the peaceful uses of nuclear technologies was signed with the China Atomic Energy Authority being the implementing agency on the Chinese side. The agreement calls for cooperation in such areas as nuclear technology, export controls, materials protection, control and accountability, safeguards, emergency management, and high-level radioactive waste management. The DOE activities in the nuclear safety area augment activities under an agreement between the Nuclear Regulatory Commission and the Chinese National Nuclear Safety Administration (NNSA) which goes back to 1981 when NRC entered into an agreement with the State Science and Technology Commission (now the Ministry of Science and Technology). The NRC-NNSA agreement has taken on new life with China's decision to build Westinghouse AP 1000 power plants. Meanwhile, Chinese innovations in reactor design, especially its "pebble bed" reactor, are of considerable interest to the US side.

Medicine and Public Health. Cooperation in the areas of medicince and public health also goes back to 1979 with the signing of the *Protocol for Cooperation in Science and Technology of*

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[12] Although not discussed here, this is true in other fields as well, as seen, for instance, in astronomy with the construction of the LAMOST (Large Sky Area Multi-Object Fibre Spectroscopic Telescope) facility.

Medicine and Public Health which provided for cooperation in public health, biomedical research, health care, and health policy. But, the health area has expanded and become quite active in recent years in light of the AIDS epidemic, and in the wake of the SARS outbreak. In 2002, HHS and the Ministry of Health signed a memorandum of understanding for cooperation in fighting AIDS through prevention activities, treatment, and research. As part of the US Emergency Plan for AIDS Relief, activities include research on vaccines, the development of testing kits for rapid diagnosis, surveillance, and innovative treatments.

A second MOU, for collaboration on emerging and reemerging infectious diseases was signed by the two parties in 2005. It provides for a higher profile HHS presence in China with staffing from the Centers for Disease Prevention and Control (CDC), and supports Chinese capacity building through laboratory development, surveillance, enhanced epidemiology, and the establishment of China's own CDC.

The National Institutes of Health are also actively involved with China. Chinese researchers have been consistently the most numerous visiting scientists at NIH laboratories (in 2007, there were 630). NIH employs one scientist in Beijing who coordinates with the Chinese CDC, the Chinese Academy of Medical Sciences, and the Chinese Academy of Sciences in facilitating research on a variety of diseases, and plays an important role in the implementation of the agreement on emerging and reemerging infectious diseases; some $US 4 million has been spent by NIH on influenza research in China. In addition, NIH has also had its own long-standing MOU with the Chinese Academy of Sciences for cooperation in basic biomedical research. The MOU was first signed in 1983 and was amended in 2005. Among other things, it calls for jointly funded research training in the US, and continuing support for researchers once they return to China. It is also intended to encourage CAS scientists to collaborate more actively with Ministry of Health entities to raise the level of research capacity in the fields of medicine and public health.

<u>National Science Foundation</u>. NSF activities with China derive from two protocols. The Basic

Sciences protocol is with the Chinese Academy of Sciences, the Chinese Academy of Social Sciences, The Ministry of Education, and the National Natural Science Foundation of China (NSFC). A second protocol involving the US Geological Service as well as the NSF on the US side, and the NSFC, the China Earthquake Administration (formerly the State Seismological Bureau), and the Ministry of Construction on the Chinese side. Under these protocols, NSF has supported a broad range of collaborative research in basic science, engineering, and the social sciences which amounted to more than $16 million of spending during 2006-7. NSF has cooperated with China on projects dealing with disaster prediction and mitigation and structural engineering and the mitigation of hazards. Beyond the work under the protocols, however, there are a variety of other activities. In recent years, NSF has emphasized the importance of educational programs in its relations with China and has supported summer research opportunities for American graduate students in China. China also figures prominently in the NSF PIRE (Partnership for International Research and Education) program which provides for multi-year institutional support for international collaboration involving students and faculty, often on multilateral projects.

China participates as an associate member in the NSF Integrated Ocean Drilling Program, and this past year NSF and NSFC laid the foundations for a multidisciplinary project on climate change. The relationship between NSF and NSFC is especially cordial; as noted above, NSF inspired the establishment of NSFC and has provided ongoing counsel in the management and operation of a basic research-oriented funding agency. In 2004, the two agencies cooperated in convening a forum on basic science for the next 15 years in conjunction with the preparation of China's Medium to Long-term Plan for scientific and technological development. NSF also sponsors a variety of high level workshops and symposia in areas of cutting edge work of interest to the two countries, such as recent workshops on nano-scale standards and computer science. As a measure of China's growing importance to NSF, NSF established a representative office in Beijing in 2005.[13]

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[13] In addition to NSF, other agencies now maintain representatives in Beijing, including DOE, FAA, and units of HHS. These are in addition to seven officers in the Embassy's science

Atmospheric and Marine Science. The National Oceanic and Atmospheric Administration conducts activities with China under two protocols, one on atmospheric science and technology with the Chinese Meteorological Administration (CMA), and one on marine and fisheries science and technology with the State Oceanic Administration of China. A number of working groups have been established under each protocol. In the atmospheric science area, NOAA has played an important role in helping to modernize CMA through training, instrumentation, and software. Meanwhile China itself has significantly increased its capabilities with the acquisition of more advanced radars, satellites, high-performance computers, and increasingly sophisticated basic science. Areas of cooperation include numerical weather prediction, atmospheric chemistry, and the relationship between monsoons and climate. Under the Marine sciences protocol, there is also work on the role of oceans in climate change, and working groups on oceanographic data and information, living marine resources, integrated coastal management, and polar sciences.

Given its size, location, and topography, China figures prominently in earth observation activities of interest to NOAA, and NOAA's leadership in the science and technologies of earth observations makes it of considerable interest to China. China and the US are both important members of the World Meteorological Organization (WMO), and extend their bilateral cooperation into multilateral settings. China and the US also work together in the GEOSS (Global Earth Observation System Of Systems).

The cases, above, are intended to give a flavor to what has become a fairly extensive government to government S&T relationship. Clearly, there are a number of other interesting areas that could be examined including, for instance, active programs in metrology at the National Institute of Standards and Technology (NIST), and expanding programs in environmental protection, growing out of the energy and environment initiatives of the SED, involving the Environmental Protection Agency, and a new initiative between MOST and EPA on environmental technologies. The list could go on.

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counsellor's office.

Industry.

Cooperation through industrial channels began in the early 1980s with the transfer of technology. The initial forms of transfer involved licensing and equipment purchases, but as China's foreign investment regime came to be liberalized during the course of the 1980s, technology transfer increasingly became part of foreign investment projects. By the 1990s, China had developed increasingly sophisticated foreign investment regulations intended to extract as much technology as possible from foreign investors under its so-called "market for technology" strategy. Although US firms were not alone in transferring technology to China, in terms of scale and value of investments, levels of technology, and styles of corporate management, US companies arguably have been the major source of foreign technology for China since the early 1980s, in spite of US export control policies.

China's accession to WTO, has required that its foreign investment regime be liberalized, thus undercutting to some extent the policy tools used in the "market for technology" approach. It is in this context, of course, that China has redoubled its support for its own industrial R&D and made the development of its own technical standards and intellectual property central objectives of its MLP (Medium to Long-Term Plan). Interestingly, however, as China began to adjust its own industrial and technology policies in anticipation of WTO membership, foreign companies began to show an interest in performing R&D in China, thus facilitating new forms of knowledge transfer.

Interest in investing in R&D in China began slowly in the early 1990s, mainly with the initiation of contracts for research and technical services from Chinese universities and research institutes. Gradually, however, R&D activities were added to corporate investment strategies, and by the end of the 1990s, a number of companies had established R&D centers in China. By the end of 2007, this number had risen to some 1,160, the majority of which were American firms. It is thought that R&D expenditures by companies accounts for at least 15% of China's industrial R&D, and perhaps as much as 30%. Although a great deal of this R&D activity goes to support manufacturing and marketing in China, for a number of large firms - IBM, Microsoft, General Electric, etc. - China R&D operations have become critical components of global technology development efforts and have led to important basic and applied breakthroughs.

There is considerable debate about the impacts of these operations. On the Chinese side, government policy has been welcoming of these efforts in the belief that they provide China with critical experience in the management of R&D in the kinds of science-based industries China sees as the future of its industrial economy, and will lead to significant knowledge transfers as employees migrate out of the MNCs to start their own companies or join Chinese enterprises. Nevertheless, there are also critics who argue that most of the benefits from these R&D centers go to the MNCs, and their global operations. The benefits for China do not compensate for the costs in terms of the loss of some of China's best and brightest to employment in MNCs and in terms of policy privileges granted by the Chinese government, in this view.

Similarly, on the US side, critics argue that China-based R&D centers lead to technological leakage which will come back to haunt American companies, and result in the loss in high-paying professional jobs for American scientists and engineers. Defenders of R&D investments in China argue that US companies are forced to globalize their R&D in order to stay competitive, especially with regard to exploiting pools of science and engineering talent wherever it may be. In both the Chinese and US debates, we again see the playing out of tensions between science and technology nationalism in science and technology globalism.

Academic and Professional Contacts.

At the core of developments in Sino-US collaboration are the thousands of activities occurring at the scientist to scientist level. This, of course, is consistent with the traditional culture of academic science, as researchers seek out colleagues with common interests with whom they can share findings, collaborate or, perhaps, compete. Collaboration among individuals in China and the US, of course, has been powerfully influenced by the ties that have developed as a result of

Chinese students doing graduate work at US universities. Mentor-student relations involve research collaboration which over time evolves into senior colleague-junior colleague collaboration.

A high percentage of Chinese students who have come to the US over the 30 years have stayed and taken professional employment in US universities, companies and government laboratories.[14] At the same time, these individuals have often maintained ties with colleagues at institutions in China which has also fostered collaboration. Thus, there is also a strong co-ethnic dimension to Sino-US relations in S&T as well. The effects of both the US graduate school experience and the influence of common ethnicity is evident in co-authoring patterns of China- and US-based researchers. When one examines the international co-authoring of China-based researchers, collaborations with US colleagues clearly outnumber those with other countries.[15] Reportedly, nearly 40% of China's science and engineering publications in international journals had US-based co-authors. On the US side, some 8% had China-based co-authors.[16] Among China-US co-authored papers, the role of co-ethnicity is quite high.[17] While it may be premature to discuss the emergence of "Chimerican" science,[18] it is nevertheless evident that a deepening interdependency in academic science is developing between the two countries.

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[15] Bihui Jin, Ronald Rousseau, Richard P. Suttmeier, Cong Cao. "The Role of Ethnic Ties in International Collaboration: The Overseas Chinese Phenomenon." In D.Torres-Salinas and H.F. Moed (eds.) *Proceedings of the ISSI.* 2007, CSIC, Madrid, pp. 427-436. Available at http://china-us.uoregon.edu/papers.php.

[16] Norman P. Neureiter and Tom C. Wang. "US-China S&P at 30." *Science.* Vol. 323 (30 January, 2009). p. 687.

[17] Jin, *et. al.,* "The Role of Ethnic Ties..."; See, also. Richard P. Suttmeier. "State, Self-Organization, and Identity in the Building of Sin-US Cooperation in Science and Technology." *Asian Perspective* 32, 1, 2008.

[18] A term coined by Niall Ferguson and Moritz Schularick to describe the significance of the China-US financial interdependence for the world economy.

Further evidence of this trend is the growth of more institutionalized relations between US universities and Chinese counterparts. US universities have been somewhat slow in establishing formal research relationships with Chinese universities, but this is beginning to change. For example, Texas A&M has initiated its China-US Relations Conferences[19] and the UC Santa Barbara has launched a partnership with the CAS Dalian Institute for Chemical Physics (DICP), an internationally recognized center for research on catalysis.[20] The Harvard China Project of the Harvard School of Engineering and Applied Sciences and Harvard University Center for the Environment is connected with key Chinese universities in the field of environmental studies. An ambitious new initiative to build interinstitutional cooperation is the "10+10 Alliance" which calls for collaborative research and education between the10 campuses in the the University of California system, and ten leading Chinese universities.[21] Co-ethnic influences are also evident in these institutional initiatives, for example in the Peking-Yale Joint Research Center for Plant Molecular Genetics and Agro Biotechnology, a collaboration between the Department of Molecular, Cellular and Developmental Biology at Yale and the College of Life Sciences at Peking University. The center is led by Xing-wang Deng, a member of the Yale faculty who also holds an Changjiang Scholar appointment at Peking University.[22]

Science, Governance, and Modernity

Science and technology have been centrally associated with China's "search for wealth and power," since the 19th century, and enduring questions about China's political formula, capacity for governance, and modern identity are closely associated with its patterns of scientific and

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[19] See, http://china-us.tamu.edu/index.php.

[20] The UCSB-DICP relationship is one of several next-generation projects with China supported by the NSFs Partnership for International Research and Education (PIRE) program noted above.

[21] http://uoip.ucdavis.edu/documents/10+10_overview.pdf

[22] http://www.pyc.pku.edu.cn/index.html

technological development. The science and technology relationship with the United States therefore is never far from sensitive issues associated with what it means for China to be "modern." This was true in the pre-1949 era when US educators and Chinese scientists educated in US served as important agents for the introduction of modern science and technology at a time of great political uncertainty. While the political formula chosen in 1949 provided for a vision of science and modernity, by the early 1970s, that vision has lost its luster. Thus, as Sino-American S&T exchanges expanded during the 1970s, China could begin to appreciate how "unmodern" it had become relative to the dynamic capitalist world from which it had been cut off, and began to realize that its scientific and technological development would require profound changes in both its domestic institutions and foreign relations.

The US offered an alternative vision of science and modernity which became iconic for many Chinese in the post-Mao period. And yet, a deep-seated ambivalence about the US, grounded in assessments of the differences in Chinese conditions as well as in Chinese political and cultural nationalism, precludes any unqualified embrace of the American model. Chinese elites have therefore sought to guide China's reform experience by studying institutions and policies in a number of countries, and then attempting to reconcile them with Chinese realities. Yet, the US experience has gotten the most attention by virtue of US superpower status, its international leadership position in science and technology, US dominance as a destination for Chinese students and scholars, and the fact that as a large continental country, it faced many governance challenges of relevance to China in ways that other countries providing lessons to China didn't.

This somewhat contradictory set of attitudes towards the US provides both opportunities and challenges for the relationship. On one hand, there is a reservoir of positive expectations in China about the US and about what China can learn from the US. On the other hand, there is great sensitivity to Chinese pride and national identity which can readily lead to negative feelings about United States the US superiority complex manifests itself and leads to condescension towards China, and when the US itself fails to live up to the promise inherent in its institutions and wealth. Here, let us focus here on the opportunities.

These derive from the fact that China's problems of governance become more complex even as its capabilities in science and technology grow. The rapid expansion in Chinese expenditures on research and development over the past decade, for instance, has raised a whole series of questions about the effectiveness of funding mechanisms for promoting good science, the maintenance of the integrity of those mechanisms, and the means for ensuring accountability to political authority for expenditures. As spending has increased, increasing amounts of money are flowing not only to MOST, and it system of national projects, but also to the NDRC and other ministries charged with implementing the objectives of the MLP. However, the mechanisms for macro controls and accountability are not well developed with a result that bureaucratic machinations may trump national policy intent, and make possible corrupt practices which threaten both bureaucratic integrity and the integrity of science itself.

Governance issues are also evident in questions as to how science comes to serve government missions in the provision of public goods, a topic of increasing importance in China's changing policy priorities. Although Chinese government agencies charged with providing public goods have their own research facilities, China's institutional legacy is one in which the best science is usually done in the Chinese Academy of Sciences and universities, i.e. in institutions that are bureaucratically separate from users and service providers. The user agencies, on the other hand, have not in general had strong traditions of cutting edge research, focusing their scientific activities mainly on more immediate delivery of services; the CMA focuses on how to better predict weather, rather than on atmospheric physics even though fundamental research on atmospheric physics could improve weather forecasting. Thus, as China pumps money into ministries charged with using science to meet national needs, it faces interesting challenges as to whether these agencies have the capability to use the money wisely. On the other hand, supporting those centers of research excellence, which could be expected to produce important scientific advances, may also be disappointing since the latter are not well-connected to the actual problems and to those who need the science to support their missions. As noted above, in the discussion of activities in the medicine and public health area, US collaborators are aware of these problems. US concerns of this sort are evident in other areas of cooperation as well.

Finally, governance issues are evident in the realm of what might be called "regulatory science." As China's environmental and industrial safety problems illustrate, the development of regulatory capacity has clearly lagged behind the technological change which has accompanied China's economic development. While many of the problems of the regulatory regime have to do with law and enforcement, modern regulatory policy also requires high-quality scientific capabilities to assess risks and to set standards.[23]

In short, there are critical areas where science and governance intersect in the modern polity. As the discussion above illustrates, there are a series of issues of increasing importance for China where this intersection is troubled. China's experience with the reform of its science and technology system over the past 30 years has focused on building scientific and technological capacity and overcoming obstacles to commercial exploitation of knowledge - what might be called science and technology for development.[24] Considerably less attention has been given to these governance issues with the result that modernization is incomplete and further reforms are needed. While there are limits to what the United States can contribute to these further reforms, it is also true that the S&T relationship with United States has led to useful institutional innovations and suggestive exposures to US practices against which Chinese challenges can be benchmarked. From the discussion above we can see evidence of this in the establishment of NSFC and the Chinese CDC, and in cooperation and agricultural biotechnology in support of regulatory science in that area. A number of other examples could be cited ranging from experience in the management of big science facilities, to growing cooperation and environmental policy with EPA, from the expanded presence of the Food and Drug Administration in China, to the role that the FAA has played in promoting airline safety, etc.

As China struggles with its science and governance issues resulting from increasing expenditures

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[23] Cf., Richard P. Suttmeier. "'The Sixth Modernization?' China, Safety, and the Management of Risks." *Asia Policy* (July, 2008).

[24] Cf., G. Drori, J. W. Meyer, et al. (2003). *Science in the Modern World Polity.* Stanford, Stanford University Press.

on science and technology, it will have to consider whether there are other aspects of the US model to be emulated. These would include questions having to do with high-level science advice, stronger legislative oversight, mechanisms for tighter budget controls and the integration of budgeting and macro management, and sectoral questions about the roles which companies, universities, an academy of sciences and a ministry of science and technology should play in a modernized China. Since so much of the strengths of the US research and innovation systems is based on universities and private corporations, and multi-agency university research portfolios made possible by pluralistic funding sources, those Chinese who take inspiration from the US model would see China's science and technology future in strengthened university and enterprise R&D, and strengthened R&D capabilities in mission agencies. But, the relative weaknesses of the university, corporate and mission agency sectors in China argues, in the view of others, for central roles for government leadership for industrial research (through MOST and NDRC), and the maintenance of a strong and capable Chinese Academy of Sciences.

The Changing Politics of Cooperation.

From the discussion above, we can see that there have been vast changes in the bilateral S&T relationship over the past 30 years. We can discern a growing interdependency between the two countries as 21st-century realities bring the issues of S&T cooperation closer to their vital national interests. As we have seen, however, cooperation in science and technology is viewed on both sides as carrying risks as well a substantial benefits. To enhance the chances that the benefits will be realized, and to minimize the risks, the two countries will have to steer through a number of issues which have affected cooperation in the past. These include the following:

Finding Common Understandings on Security Issues. Although security issues have not precluded active programs of collaboration, they have often been irritants and in recent years have become more problematic. A central issue that has affected the relationship since 1979 has been US export controls which, although liberalized over the course of the past 30 years, nevertheless still elicit complaints from China and from many American exporters. More troubling is the growing concern over "deemed exports,"and the implications that policy in this area have for the movement of persons and for the administrative burdens placed upon institutions - universities, corporations, government laboratories - hosting Chinese students and scholars. Post-9/11, security driven immigration policies, as noted above, have also been a problem. Although progress has been made in the visa granting process for students coming to the United States, delays in granting visas continue to frustrate scientific communication and often prompt organizers of scientific meetings to convene meetings outside of the United States in order to avoid cumbersome and often demeaning visa problems.[25] The recently released report from the National Academy of Sciences, *Beyond "Fortress America,"* though not explicitly focused on China, calls for a major overhaul of US approaches to export controls and visas for professionals, and offers the Obama administration an agenda of choices of relevance to the relationship with China.[26] On the Chinese side, restrictions on the sharing of data for security reasons has been a problem, especially in NOAA's relations with the SOA.

In several areas, national security considerations have precluded cooperation. Space has been a prominent example as have communication and cooperation in defense related areas, although the time may be right or movement in these. From a US point of view, progress towards better understanding on security issues is also closely related to problems of Chinese espionage. Although it is unlikely that S&T related espionage will be thoroughly purged from the relationship, there is a need for China to better understand that reports of Chinese espionage in the United States sours the relationship and enhances the position of constituencies in the United States who would radically reduce professional contacts with China.

Funding. The funding of S&T cooperation with China has also long been an issue. In spite of the fact that tens of thousands of Chinese students in the US have benefitted from US

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[25] The most recent case coming to the author's attention was the inability of MIT educated Academician Chen Hesheng, director of the CAS Institute of High Energy Physics to obtain a visa in time to attend a professional meeting in Washington in November, 2008.

[26] Available at www.nap.edu/catalog.php?record_id=12567.

government research funding at universities, as noted above, the funding of government to government projects has often been uncertain. Whereas China has long had dedicated funding for international cooperation, and has recently seen a dramatic increase in budgets for this purpose, US agencies, in general, do not. Instead, they operate on the principle that international activities must be justified in terms of agency missions - which historically have been understood in domestic terms. Increasingly, of course, the missions of US technical agencies are defined in terms of global responsibilities, as seen for instance in the health area, in earth observations and energy and climate change, and these do offer new opportunities for funding cooperative activities with China - increasingly in multilateral fora. Nevertheless, a variety of useful projects often have not gotten off the ground due to funding constraints, with the result that China is often looking to Europe and Japan for more reliable and forthcoming partners. As noted above, China has been prepared to participate in the FutureGen project only to see the US withdraw. The dynamics of funding the relationship are undoubtedly changing, however, as the interdependencies increase and as China comes to spend more on its science, including large facilities. The global financial crisis is likely to have consequences as well, although it is too early to discern what these may be.

Governance and Coordination. These two large countries with their extensive research systems and technical communities both face problems of governance and national coordination. With its centralized Ministry of Science and Technology, China seemingly coordinates its relations with the United States better than the US does with China. On the other hand, MOST’s ability to overcome China’s serious domestic “stovepiping” is limited; thus, in spite of what appears to be a more centralized system in China, it often lacks effective national leadership and coordination in science. This not only affects the performance of the research system domestically, but also means that foreign partners may be having sub optimal interactions with China by missing out on relations with key individuals and institutions who are not part of the organization with whom a formal agreement exists. Thus, some of the better work of interest to an American agency in a given field might very well be done in the Chinese Academy of Sciences, or in universities, but these may fall outside of the purview of the counterpart agency with which the American organization has an agreement or protocol.

In the US, by contrast, in spite of its more decentralized tradition of institutions, national coordination often works reasonably well through formal and informal mechanisms. Facing China, however, coordinating mechanisms are generally weak and usually perform at a minimalist level. Staffing at both the State Department and the Office of Science and Technology Policy is weak. For a limited number of high priority areas, such as energy and environment, the SED mechanism has brought greater coordination and national coherence to both countries, but it is still too early to tell whether these are sustainable in the face of a new administration. There are those on the US side who would argue that more high-level attention to the relationship inevitably makes for greater political visibility and, perhaps, political vulnerability. Nevertheless, in both countries the research and innovation enterprises are huge and increasingly differentiated. Both countries therefore need fora at which the views of multiple stakeholders in the S&T relationship can be represented.

Doubts have also been raised about the adequacy of the JCM mechanism. First, given the growing importance of the relationship, some have suggested that a meeting every other year does not provide sufficient opportunity for high-level exchange of views and the development of plans; the meeting should therefore occur annually, in this view.[27] Others would argue that the JCM mechanism deals only with activities occurring under the *Agreement* and subordinate protocols, whereas S&T relations between the two countries, as seen above, are now multichanneled, involving multiple stakeholders, both public and private. In this view, there is a need for a broader, more inclusive mechanism for guiding the relationship that would reflect academic, industrial, as well as governmental interests. Finally, some have wondered whether the SED mechanism, at least for energy and environment, was superseding the S&T relationship under the *Agreement*. As the Obama administration develops its policies towards China, it has an opportunity to propose innovative set of arrangements which more fully reflect the growing

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[27] Neureiter and Wang.

importance of science and technology in China US relations.

Managing the Contradictions of Globalization. As suggested above, concerns over capturing the benefits of the knowledge economy have prompted governments around the world to support policies to advance national competitiveness through the promotion of innovation. At the same time, international cooperation in science and technological development has been growing, leading some to speak in terms of the globalization of research and innovation. China and the United States have both responded to these developments with a mixture of scientific and technological cosmopolitanism and economic or techno-nationalism. In recent years, China has clearly become concerned about its dependency on MNCs for commercial technology and a clear objective of its new MLP is more effectively to secure its technological sovereignty. The approaches it has used to do so, as seen for instance in some of its efforts to promote its own technology standards, reflect a troubling techno-nationalism. In the US, despite its strong traditions of internationalism in science and innovation, disturbing signs of economic nationalism in the face of economic vulnerabilities and new national security concerns are evident in immigration and export control policies and in responses to Chinese technology-related investment initiatives in US assets. As two countries who have benefitted disproportionately from globalization, China and the US have a special calling to curb their inward looking impulses and build on their cosmopolitan traditions and resources.

Conclusion - Partnering in a Networked World.

The science and technology relationship between China and the United States in 2008 is a very different one from that of 1978. Today, both sides have the opportunity of building a genuine partnership in ways which were not true 30 years ago. At the same time, they also face the likelihood of becoming competitors in ways which were not true before - competitors for talent, for market share in high-technology markets, for technologies relevant to national security, and for prestige. The bilateral relationship, furthermore, is increasingly embedded in a series of multilateral interactions - whether in basic research, commercial R&D, or public sector technologies. These are a reflection of the globalization of research and innovation and the emergence of what might be referred to "post-nationalist science." But, while the trends towards globalism continue, so too do the pulls of science and technology in support of national security and national economic well-being. The challenges for the two countries moving forward are to ensure that techno-nationalist forces do not excessively interfere with what is becoming an especially valuable relationship, understood in both bilateral and multilateral terms.

At the outset, the relationship of the late 1970s was described as a new departure in Cold War science diplomacy in which both the scientific and political values were at play. Scientific and political values are no less at play in the relationship today, but the formula for integrating them has clearly changed as the world has changed. Cold War concerns no longer drive the relationship, the distribution of scientific and technological capabilities around the world has changed, and science-based technologies affecting competitiveness and national security are never far from political agendas in ways that were not true 30 years ago. Science diplomacy still involves negotiation and mutual adjustment among nation states; in our case, between an established scientific superpower and a rising one. But, it also involves the development of strategies for managing multiple interactions in a world of internationalized research and innovation networks. Hence, while the concept of "Chimerican" science has appeal, it is ultimately misleading precisely because of the multiple interactions both China and the US have with other countries in the networks.

In these networks, the US can still be thought of as a "supernode," whose science and technology assets attract collaborators from around the world. But, while this status in the networks continues, it also faces challenges from other nodes of activity - "emerging supernodes" if you will - whose status is being enhanced by virtue of successful collaboration with other active nodes and by successfully exploiting network externalities. China clearly qualifies as an emerging supernode which has not only build up its domestic science and technology assets by its own ambitious policy and investment decisions, but has also shrewdly devised strategies for international cooperation to exploit network effects. Within the networks, though, its bilateral relationship with US remains by far the most important.

For the US, the bilateral relationship with China 30 years ago was of little significance for the well being of its science and technology. This is no longer the case; and trends suggest that cooperation with China will become increasingly important for the health of the US science enterprise and for maintaining its network position. While understood by many in the business, academic, and government technical communities, this insight has not been widely recognized by the political community in the US, but this is beginning to change.

Thirty years of cooperative relations between the two countries leave both in good positions to exploit these S&T ties to enhance their positions as "supernode" and "rising supernode" in global research and innovation networks. Enhanced cooperation between them will have the effects not only of strengthening the networks, but will also help determine how 21st-century global problems will be approached and how 21st-century technological future is to be invented.