Proceedings of the China-U.S. Forum on Science and Technology Policy

Section II – Invited Presentations

Proceedings of the China-U.S. Forum on Science and Technology Policy

Section IIA – Presentations by Distinguished Speakers

Research Universities and the Wealth of Nations

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October 16, 2006

It is a great pleasure to be back in China. I first came here in 1978 as director of the National Science Foundation (NSF) to explore the possibility of an exchange of students, scholars and scientists between our two countries. The Chinese government had expressed an interest in such an exchange; the White House was taken by surprise but quickly agreed to talks with one proviso — that such an exchange would require a formal "memorandum of understanding" signed by the two governments. What has been called the Nixon-Kissinger ping-pong diplomacy occurred earlier, but had not lead to a normalization of relations. The Chinese initially insisted on an informal arrangement for an exchange, but eventually agreed to a government-to-government program. I wish I had time today to give you an account of our negotiations. Suffice it to say that each side had a great deal to learn from the other. I signed the exchange memorandum for the United States; it was the first document ever signed by the two governments. Soon thereafter, our exchange program became part of a more comprehensive agreement on science and technology that Chairman Deng and President Carter signed on the chairman's historic visit to the United States in January 1979.

One of the changes I have observed in China over the years is an increasing commitment among government and education officials alike in building a strong foundation of basic research. I believe this approach has considerable wisdom. It is one that the United States has used since World War II with great success. How this approach evolved, and the role universities play in spurring American economic growth, is the theme of my remarks today; thus the reference in the title to the 1776 *magnum opus* of Adam Smith.

The economic evidence about the relationship between research and development (R&D) and economic growth is overwhelming. As late as the mid-1970s, there was very little economic theory or data about investments in R&D and economic development. When I served as director of the NSF in the late 1970s, we were well aware of the lack of such economic analysis when making the case to the Congress for federal support of research. Accordingly, we initiated a special research program at NSF focused on just that issue — the relationship between investments in R&D and the growth of the American economy. In the intervening years, a substantial body of research has been conducted. This work was nicely summarized several years ago in a recent report of the President's Council of Economic Advisers: 50% of the growth in the American economy in the last 40 years has been due to investments in research and development. The private sector is a major driver of R&D, but federally funded research at universities plays a key role. The report points out that when federal investments in university research increase, there is — with an expected time lag—a corresponding increase in private-sector investments. There is now a well-researched link between university-based research and industries' R&D efforts.

The State of California provides an excellent example of this linkage. In the early 1990s, the state endured one of the worst recessions in its history. In prior periods, California had entered recessions later and came out earlier than the rest of the nation. But this traditional pattern broke down. California suffered a major economic downturn fueled by cutbacks in defense and aerospace — a huge loss of jobs that resulted in a dramatic drop in the tax revenues of the state.

What has happened in the intervening years? California is once again a thriving economy, recently becoming the fifth largest in the world. It is an economy that has remade itself with a diverse set of companies, heavily focused on knowledge-intensive products. An increasing number of companies are entrepreneurial in origin and high-tech in character. These companies (and their technologies) can be traced to the research universities of the United States — but particularly, the ten campuses of the University of California, the California Institute of Technology, Stanford University, and the University of Southern California.

Biotechnology, for example, a booming industry in California, traces its success — in fact its very existence — to research programs that came out of the state's universities. Digital telecommunications is another case in point. It could not exist at its current scale and scope without the California universities that produce the research and educate the engineers and scientists essential to keeping this industry on the cutting edge. The internet, multimedia, computers, and software are yet other examples.

The principal role of the research university is in the area of basic research and the training of the next generation of scientific and technical talent; nothing in my remarks today should be interpreted as contradicting that statement. Nevertheless, starting in the 1970s it became increasingly evident that research universities needed to establish greater linkages with industry to ensure that research findings were effectively transferred into the commercial sector. The University of California (UC) is very much aware of its responsibility in this regard. For example, the university regularly holds statewide conferences on technology transfer, bringing people from the university together with colleagues in industry to examine how we can do more to facilitate technology transfer. We have also established a program at the university — the Industry University Cooperative Research (IUCR) program — which seeks to identify the most promising research areas for new products that, in turn, create new jobs. Let me explain briefly how the IUCR works. UC researchers join with scientists or engineers from a private company to formulate a research proposal. A panel of experts drawn from industry and academia selects the best projects for funding. At least half of the funding for each project comes from industry, with the remainder from the university.

There are many benefits of the IUCR to California companies. One benefit is the involvement of graduate students in every aspect of the research the company sponsors. Industry gets the benefit of some of the world's brightest young minds while graduate students learn firsthand about industry's needs. And because the program targets specific, next-generation research in areas of California's greatest strengths and opportunities, it is a significant element in the state's strategy for maintaining its economic leadership.

Another example is an initiative by the California state government several years ago to establish four institutes on campuses of the University of California to foster industry-university collaboration. The four institutes are:

- *California Institute for Telecommunications and Information Technology* (Cal-IT2), based at UC San Diego in collaboration with UC Irvine, focuses on digital wireless telecommunication.
- *California NanoSystems Institute* (CNSI), based at UCLA in collaboration with UC Santa Barbara. Its purpose is to promote the transfer of nanosystems innovation to the marketplace.
- *Institute for Bioengineering, Biotechnology and Quantitative Biomedical Research* (QB3), based at University of California-San Francisco in collaboration with UC Berkeley and UC Santa Cruz. Its purpose is to develop mathematical and computer models to integrate our understanding of biological systems, from atoms and molecules to cells, tissues, organs, and the entire organism.
- *Center for Information Technology Research in the Interest of Society* (CITRIS), based at UC Berkeley, which sponsors research on information systems that have a direct impact on the economy and quality of life; for example, boosting transportation efficiency; advancing diagnosis of disease; and expanding business growth through richer personalized information services.

These institutes are now up and running and are supported by a combination of industry, state, and federal funds. They already are yielding examples of the benefits of cooperative research between industry and universities.

My examples are from the University of California, but other American universities are pursuing similar agendas. The incentive for industrial firms to enter into cooperative research agreements with universities was significantly enhanced by passage of the Bayh-Dole Act of 1980. Prior to passage of this legislation, rights to results from research supported by the federal government had been vested with the government itself. However, the government rarely if ever sought to exploit or license research results that do not emerge from its own laboratories. Therefore, potentially useful products and processes that might have been derived from the results of federally-funded research never emerged. The Bayh-Dole Act changed that situation significantly. The terms of that legislation granted rights to federally-funded research results to the organization that had conducted that research, most prominently universities. Thenceforth, private firms could negotiate to share the rights to research results with potential university partners, providing a strong incentive which did not previously exist. It is worth noting that the idea and impetus for the Bayh-Dole Act evolved out of the NSF economics research program mentioned earlier.

As research universities began to grow accustomed to working in research partnerships with private industry — and to appreciate the tangible and intangible returns on such research partnerships — they instituted additional mechanisms to exploit promising research results of their faculties. Many individual faculty members conducting research in US universities have started their own companies to develop and market their results. Between 1988 and 2003, US patents awarded to university faculty increased from 800 to 3200. Research universities themselves have created Technology Licensing Organizations (TLOs) to patent the research results of their faculties and to license those results to private firms. Because the Bayh-Dole Act vests rights to federally funded research results in universities rather than individual investigators, universities have instituted their own criteria for sharing financial returns from such research results with the responsible faculty members. TLOs provide a ready means to get university research results off the shelf and into the productive, commercial sector.

The United States is unusual in the degree to which it relies on universities to perform basic research. The roots of this phenomenon date back to World War II. Near the end of the war, President Roosevelt turned to his science advisor, Vannevar Bush, for advice about the future of American science. Vannevar Bush (no relation to George W. Bush) is one of the great individuals in U.S. history, known for his contributions as a statesman of science. His report, which appeared shortly after President Roosevelt's death, was entitled "Science: The Endless Frontier." As the title suggests, Bush viewed science as a vast frontier of opportunities to serve virtually every aspect of the national welfare. His report set the stage for the modern era of science and technology in the United States.

What were the arguments that Vannevar Bush put forward? First, he asked "Who should fund the research and development effort of the United States?" Bush argued that applied research and development should be done by the private sector, by industry. But he also argued that the private sector would not ensure an adequate investment of funds in basic research. In essence, he believed that private market mechanisms ensured that industry would invest in applied research and development, but those same market mechanisms would not ensure adequate investment in basic research. His argument — well supported by subsequent economic research — was that a company's investment in basic research could often generate results that were just as valuable to a competitor company as to the company making the investment. Further, the eventual payoff for basic research might well be too far into the future. There was no question about the societal returns for basic research, but there was not the same return to the specific company making the investment. Thus, he proposed that the funding of basic research was an obligation of the federal government.

The second question he asked was "Who should perform R&D activities?" Applied research and development, he said, is a private sector responsibility and should be performed by the private sector. Who should perform basic research? The former Soviet Union carried out research in institutes run by the central government. The French have the centrally administered CNRS programs. The Bush concept, based on the experiences of World War II, was that American universities should be the principal performers of basic research; and that the federal government should provide the funds for that work.

There was a third part to Bush's analysis. Namely, that basic research should be funded through a peer review process. Individual scientists would make proposals for work they thought was valuable. Peers — scientists from around the country — would evaluate these proposals and the evaluations would determine which to fund and which not to fund. Federal science agencies in the United States do not provide unrestricted block-grant funding to universities. Rather, individual scientists (or groups of scientists) submit proposals that request funding for specific research projects. A scientist's proposal is then sent to other scientists for their evaluation. This evaluation — the peer review — is the critical factor in ensuring that the best science is funded.

There were other aspects to Bush's proposal regarding military research and federal research laboratories. But the core ideas were: the federal government should fund basic research, while applied research and development were the responsibility of the private sector; basic research should be performed in universities and decisions about funding made via a peer-review process. The Bush model created a sea-change for American universities. Before World War II, universities received virtually no funding for research from the federal government and were peripheral to the R&D enterprise. Today they are at the core of the American research system, thanks in large measure to an extraordinarily successful partnership with the federal government. As a result, both the research enterprise itself and the U.S. economy have prospered. When the history of the last half of the twentieth century is written, the vital role research universities have played in the American economy will be regarded as one of our greatest accomplishments.

Research universities in the United States include private universities and those supported by state and local governments. The best of these institutions compete with one another for faculty, for students, and for research funds. The country's top universities usually have funds to support the research of newly-attracted faculty for perhaps one or two years. However, the bulk of their research support is from grants awarded to individual faculty members or research groups most often from the federal government, but also from private foundations. In the American system, federal grants are awarded to individual faculty members within universities rather than to the universities themselves. The competition among faculty members for research funding is an important factor in fostering the quality of university research.

Could industry take the place of research universities in the American research enterprise? The evidence suggests not. As recently as the 1970s, several large U.S. firms performed significant basic research in their own corporate laboratories. Today, virtually all industrial research focuses on the solution of specific problems. In the United States we are relying more than ever on universities for the basic research that will fuel our economy. A recent statistic sums it up: seventy-three percent of the papers cited by U.S. industry patents are based on publicly supported science, authored principally by academic scientists; only 27 percent are authored by industrial scientists.

In its simplicity and flexibility, Bush's report remains a model for science policy. But does Bush's model have any relevance for contemporary China? I believe it does. Obviously, no model can be imported wholesale from one country into another. China is finding its own way and its own solutions to the challenge of putting knowledge to work in the economy. But however solutions differ, the evidence is overwhelming that research universities are priceless sources of ideas that create jobs, give birth to new industries, and stimulate economic growth.

We are living in an incredible era of intellectual discovery. From agriculture to medicine, from aerospace to computing, science is experiencing a series of revolutions that are remaking our ideas of what is possible. These revolutions are occurring on the campuses and laboratories of research universities every day. We have only just begun to tap the possibilities of this knowledge explosion, and the effort to link intellectual discovery more closely to applications has major implications for economies around the world. Research universities are key to this effort.

Roles of the National Natural Science Foundation of China in Fostering International Cooperation

Zhu Zuoyan

Vice President
National Natural Science Foundation of China

October 16, 2006

Allow me, on behalf of the National Natural Science Foundation of China (NSFC) and myself, to congratulate you on the opening of the Sino-US Forum on Science and Technology Policy, and extend my heartfelt appreciation to the fruitful work of the experts attending the forum from both China and the United States.

At the dawn of the new millennium, public expectations of science are high, and public support for science is strong. Science policy needs to reflect the actual state of science, and its capacity for addressing the needs of society. One requires continual contact with the scientists who lead the work and upon the processes of government to frame key social issues, which I believe, is the momentum behind this Forum and all those efforts we have made in the past as science policy makers and managers.

Here please let me give a quick retrospect to the joint efforts of the US National Science Foundation (NSF) and NSFC on the *Decade Series of Sino-US Science Policy Dialogue,* which were first established in 1999, and have since been annually organized and held alternatively in China and the United States. Over the past eight years, a series of themes have been addressed during these bilateral workshops organized by NSF and NSFC with the enthusiastic participation of scientists and science managers from the two countries. From *R&D and the Knowledge Society*, to *Biomedicine and Biotechnology*, *Technology Innovation*, *Engineering Education for a Global Economy, Science, Society and the Internet, Basic Science in the Next Fifteen Years*, to *R&D Policies Related to Emerging Infectious Diseases,* we have been trying hard to identify and resolve issues which could be described as the "intrinsic imperative of science". We believe this continuing dialogue has been and will keep serving as a bridge between science policy makers and science communities of our two countries.

The Chinese government attaches great significance to the development of basic research. The *National Middle and Long Term Science and Technology Development Plan (2006-2020)* defined basic research as an important source for the development of high new technology, the cradle for the fostering of innovative talents, the foundation for the construction of advanced culture and the internal dynamics of future science and technology development. *The Plan* stresses the importance of giving play of the leading role of basic research. The National Natural Science Foundation of China, together with the Ministry of Science and Technology, the Ministry of Education, and the Chinese

Academy of Sciences, assume the sacred responsibilities of supporting and planning for basic research.

Since its foundation in 1986, NSFC has committed itself to international cooperation and exchange, providing various collaborative channels and relevant support to cooperative activities between Chinese and overseas researchers. NSFC has so far signed 64 agreements and memoranda of understanding for scientific cooperation and exchange with 35 countries and regions across the world. NSFC's participation in the China-US Protocol on Basic Research dated in 1995, under the framework of which, our cooperation with the National Science Foundation of the United States has been very fruitful.

In recent years the two science foundations in China and in the United States have conducted extensive and beneficial cooperation, and played important role in promoting the science and technology cooperation and development between our two countries.

NSFC and NSF have maintained a sound working relationship, which progresses with the times. Since 2004, cooperation and exchanges at working levels between the two organizations see very good achievements. Personnel exchanges and bilateral workshops with diversified topics have further strengthened mutual understanding, enhanced cooperation at administrative levels, as well as promoting further collaboration and communication between the science communities of the two countries. Those sharing and communicating at the administrative levels, in the areas such as funding system supervision, financial management, electronic proposal processing and evaluation system, and policy discussions on perfecting financial management systems, have brought the relationship into a mature and fruitful state with great achievements. An effective channel of information exchange is well maintained. In May 2006, on the occasion of NSFC's 20^{th} anniversary held in Beijing, NSF Director Dr. Arden Bement, made speech at NSFC's invitation and expressed his desire to strengthen further the existing relationship between the two organizations. We are also very pleased to see that NSF has chosen Beijing as the place for its third overseas office besides Paris and Tokyo, which shows NSF's great interests and strong commitment to cooperation with China in science and technology.

The period of the 11^{th} Five Year Plan and the following few years is a key strategic stage for China to develop basic research and enhance her innovative capabilities. The governments of China and the United States, facing common scientific challenges in the 21^{st} century, realize and pay increasing attention to the exchanges of policies in science and technology at the government level. I believe, with joint efforts of the governments and science communities of our two countries, we will see an even more exciting Sino-US science and technology cooperation in the future.

To conclude, I wish the Forum a great success!

Adding Value through Innovation

Deng Zhonghan

Chairman
The Vimicro Corporation

October 17, 2006

I'm honored to be here and present some thoughts about cooperation between China and the United States, as well as how to do innovation in China and what we have learned from Silicon Valley. We hope that our experience and our thoughts about innovation in China will be beneficiary to both our academic and industrial leaders here as well as our US partners across the Pacific.

I believe that I certainly benefited from my education in the United States. But in a sense that actually started in 1979 when the United States and China signed a cooperation agreement in science and technology. In 2006, we extended that agreement for another five years. This year in China we start a 15 year plan on how to build an innovation country, and also innovative industrial and market economy where our country can benefit from technology development instead from environmentally polluting industry.

So we believe that this is a new era for our country and that we can really focus on developing our country's economy based on a new model driven by the market. Corporations and enterprises are going to be the leading innovation powerhouses. Also, intellectual property development as well as intellectual property protection will be keys to the success of how to build an economy based on innovation.

My background in the United States began with a PhD from the University of California, Berkeley. Then I started my first business in Silicon Valley. I also worked at IBM and as a teaching assistant at a research lab in New York. I learned a lot from my experience in Silicon Valley. I found out that to do innovation is not only about technology development or how much time you spend in the lab; it is also not about how many dollars are invested in the university or institutional research. There should be some mechanism to make sure that the dollars that are invested and the time people spend on those research projects will be used by industry and the market. Our president Hu Jintao promoted a slogan called market-driven innovation and noted that that would be done primarily by corporations or enterprises instead of research facilities in universities or in research organizations.

This is also something that I learned a lot from Silicon Valley where most of the new technology developed in the startups where people who are professors from universities work together with industry scientists and engineers to develop very advanced technology. In such a startup environment, technology can be utilized and can be adopted by the industry very quickly.

So I believe because China was a planned economy and is moving toward a market or open economy market-driven innovation is really the key point. We have now a lot of reports for cases where lots of dollars were invested but technology stayed in a lab and has never been used by industry. So market-driven is really the key slogan.

Many new technologies in the United States are developed by leading corporations, like IBM, Intel and Microsoft, but in China we always look into some research labs or universities for technology, so I think that market-driven innovation is something very new.

In market-driven innovation, intellectual property protection becomes a key issue not only in the commercial and trading areas, but also in the R&D and innovation areas, where we want to protect intellectual property as well as to develop more intellectual property through cooperation.

I'd like to give you a brief introduction about to our company. I'm going to use this company and my own experience in growing this business to share with you a new business model or a new innovation model happening in China.

Vimicro was founded in 1999 in Beijing in the Zhongguancun area with seed money from the Ministry of Information. We have many US, Taiwanese, Hong Kong, and Japanese investors. Today it has become the largest multimedia semiconductor technology company in China. We don't do fabrication; we only design chips for multimedia applications in cell phones, over the Internet, through computers, as well for home entertainment and set-top boxes. In 2004, our company and our team won the National Science and Technology 1st Class Award in China. This was the first time the award was given to a semiconductor company. It was presented by our president, Hu Jintao.

We have more than 400 patent applications filed and many of them have been already been granted. We have also more than 1000 patents in the process of being filed. We have cutting-edge products and solutions offered to both the PC and mobile phone markets. We are also entering the security market and also home entertainment and game box areas. We are now the #1 PC camera processor supplier with over 60 percent market share globally and are now #1 in the mobile camera processor market in China. We are now selling chips to Korea, Japan, and Europe. We also sold some of our products in the United States working with companies including Dell and Hewlett Packard, Logitech and other companies in the North American market. We're an active member of leading global and domestic multimedia standard groups. In the past, China was famous for and is still famous for manufacturing goods in China. We believe that in the new era of innovation design will become a part of the economy and we are moving from manufacturing to design. But how to do that or how to do develop an innovative business is an important question.

We believe that moving from innovation to value creation is not that simple. It is not just doing your work in the lab. It is about how to create value through a mechanism that is going to help your technology development by it to commercial products. Here are three questions we're going to ask:

1. What is innovation?
2. How does innovation lead to value creation?
3. What roles will China play in the innovation and value creation process?

So what is innovation? Here is a definition by Clayton Christensen, a professor from Harvard Business School, published two year ago in his book entitled, *The Innovator's Dilemma*. He defines technology as "the processes by which an organization transforms labor, capital, materials, and information into products and services of greater value …the concept of technology extends beyond engineering and manufacturing to encompass a range of marketing, investment, and managerial processes." Innovation occurs "when there is a change in one of these technologies."

How does innovation from technology result in products and lead to value creation? I believe there are two aspects that we need to look into. One is the supply side and the other one is the demand side. Elements on the supply side are those elements which convert technology or innovation into a real product or real business, including technology, management team, and capital, investment, and employment involvement. On the demand side, you need to look into how your innovation is going to impact the market, what kind of market scope it will have. So research organizations and even manufacturing organizations needs to have all those elements embodied into this process, then innovation can become a value creation process.

We're going to address how China is going to create value through innovation. Innovation is a method. I'm going to use Vimicro as a case study on how to add value through innovation.

On the supply side, we just talked about technology. Vimicro has more than 400 patents filed on a new architecture called adaptable or reconfigurable processor architecture. This architecture fits into a technology regime where microprocessors, digital signal processors as well as ASIC larger hardware processors reside. Our architecture has a unique advantage by providing programmability to multimedia processors.

On the supply side, we also look at what kind of management team we have. We have about seven people trained in the United States who have worked in Silicon Valley.

We formed our company gradually. Some people joined our company over the last seven years, including my co-founder David Yang who graduated from Stanford 11 years ago He has his bachelors, masters, and PhD degrees in electric engineering and is the chief technical officer of the company. We also have several other people both on the finance, accounting, engineering, and marketing side of the company. We have about 70 people who have returned from Silicon Valley.

Also on the supply side, we're talking about corporate governance of the leadership in technology. The company's management spends its money based on a budget, so we believe that globally-savvy board members and advisors are a key to the success of any innovative organizations. Including are our board are: Don Lucas, former chairman of Oracle, Cadence and a board member of many companies; Ted Van Duzer, professor at UC Berkeley and also a member of the National Academy of Engineering and IEEE; Joe Grundfest, former SEC Commissioner, provided us with a lot of good insight on how to build strong corporate governance and to do right by shareholder investment in technology development; Richard Newton; Chenming Hu; Robert Brodersen; Jan Rabaey; and also the deceased Chancellor of UC Berkeley Chang-Lin Tien helped to form a board and also advised our company on innovation for the past seven years.

Also on the supply side, you need a global base of shareholders and investors. Our first seed money investment came from the Ministry of Information, which is China's governing body on the information technology industry, and the seed money has been returned more than 100 times. (Our company is listed on the NASDAQ). We not only have great returns financially. Additionally, our company helped to develop the first chip exported from China to the global market and won the 2005 National 1st Class Science & Technology Award.

We also have General Atlantic Partners from Connecticut, and we have several others, like Doll Capital, Power Pacific from the United States, as well as Fujitsu from Japan and Foxconn from Taiwan. What I want to present here is a business model where you have your shareholders with a global base. They will maintain a requirement, probably the highest standard by the shareholder for the company to conduct a business Board members representing the shareholder are also global base, a global presence. Our board has technology leadership through Ted Van Duzer as well as Don Lucas who is a pioneer in setting up venture investments in Silicon Valley. So with these kinds of investors and board members you make sure your company has the highest standard to conduct a business particularly in the innovation and R&D areas.

Here's another supply side element. We have benefit from low cost engineering per employee in China as well as returnees from Silicon Valley who are well paid and have much better skills in design. Among our approximately 600 employees we have about 10 percent from Silicon Valley.

So now let's talk about the demand side. Innovation means market-driven. Innovation doesn't happen just in the lab for purely technology or scientific interest. It happens when you see market demand. China has a huge activity on the market side. We have a rapid growth in the economy and have the largest base of consumers, 1.3 billion, and we have the world largest mobile population, over 350 million subscribers, and largest potential wireless data market. We have a very advanced network infrastructure that allows computers and many other equipment to talk to each other. All this helps people to develop a new lifestyle over the Internet. We also have government's commitment in promoting the multimedia industry in China. So I think that innovation in China is going to happen be driven by the market because of such tremendous activity in the market side.

Also on the demand side, the company's core technology is, as I've mentioned, reconfigurable adaptable computer architecture. This is used for multimedia and multimedia can be developed in different segments, including personal computers, mobile handsets, home entertainment, and also security. Multimedia applications are growing rapidly in several different industries, and particularly in the mobile phone market. This market is the segment that we leveraged and penetrated over the last three years. We succeeded in developing the first PC camera in the world to power systems like Skype, Microsoft, and Yahoo and a kind of video communication over the Internet. The whole system was pioneered at the Bell Lab 50 years ago but it was too expensive and so only became feasible in recent years when Vimicro launched a new single chip product that dramatically reduced the cost of the chip and the cost of system and the power. So now with the chip and PC camera embedded into notebooks, cell phones, and computers, more and more people can enjoy video communication remotely.

On the mobile phone side, people know what is happening everywhere. So to do that on the demand side you need to form a partnership with leaders in the industry. What we have done in the past successfully is to have achieved partnerships with Microsoft, Intel, TI, Fujitsu, Logitech, and all those leading industry organizations where a lot of new applications, new technology development and new thoughts were created. We worked together to implement ideas, implement standards, and implement protocols to make this industry possible.

Innovation doesn't just happen in the lab. It happens everywhere. It happens with global partners and with global markets. Otherwise a company's technology development will be just localized. It will be just local and it won't become a real state-of-art technology development. So we also participate in global standards developments like MMTA, MIPI, and AVS.

We believe that through these elements we put together on the supply side and on the demand side, the new Chinese innovation powerhouse is going to have a new business model that has global shareholders, global board members, global partnerships, global supply chains, global end customers, global end markets, and also different government bodies participating together to make innovation happen. This is the real example which I have been developing for the past seven years.

Innovation adds value to the economy, to trade, to global development of a new lifestyle and civilization. We believe that innovation is not just technology, it has many other meanings.

We are making a transition from simply manufactured in China and to designed in China. **Made in China** means manufactured plus designed. What I believe is that what we are doing here is not going to create a threat to the United States or to any of our global partners. We actually win together, we manufacture and design together. We develop standards, we develop and industry together, and that helps us to preserve energy, avoid pollution, grow a more balanced economy, and eventually better trade, better commerce conditions for each country and for all the people on Earth.

Lessons from the Past; Challenges of the Present; Opportunities for the Future

John Gibbons

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Figure 1 exhibits data on the carbon dioxide concentration found in Antarctic ice cores over the past 400,000 years (and more recently by atmospheric sampling), and average temperature changes during that same period of time. While both fluctuate considerably, those fluctuations track closely (Figure 1). Until about 20 years ago, the peak level of carbon dioxide concentration of approximately 280 parts per million (ppm) occurred in 1800, at the beginning of the Industrial Revolution in Europe. That level has now been surpassed and is currently approximately 370 ppm. It is projected to grow rapidly unless deliberate steps are taken to stabilize carbon emissions, mostly from combustion of fossil fuels.

Figure 1. Atmospheric Carbon Dioxide Concentration and Temperature Change

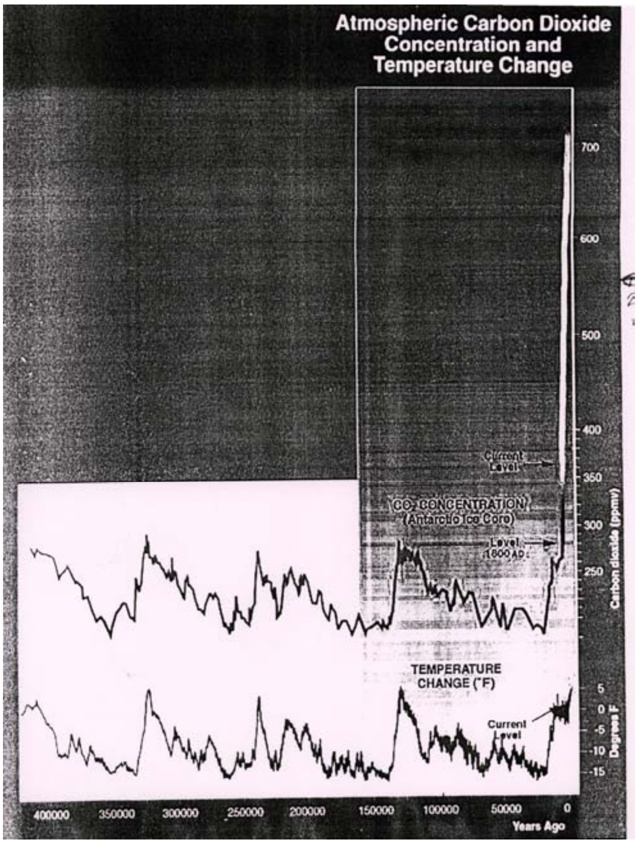
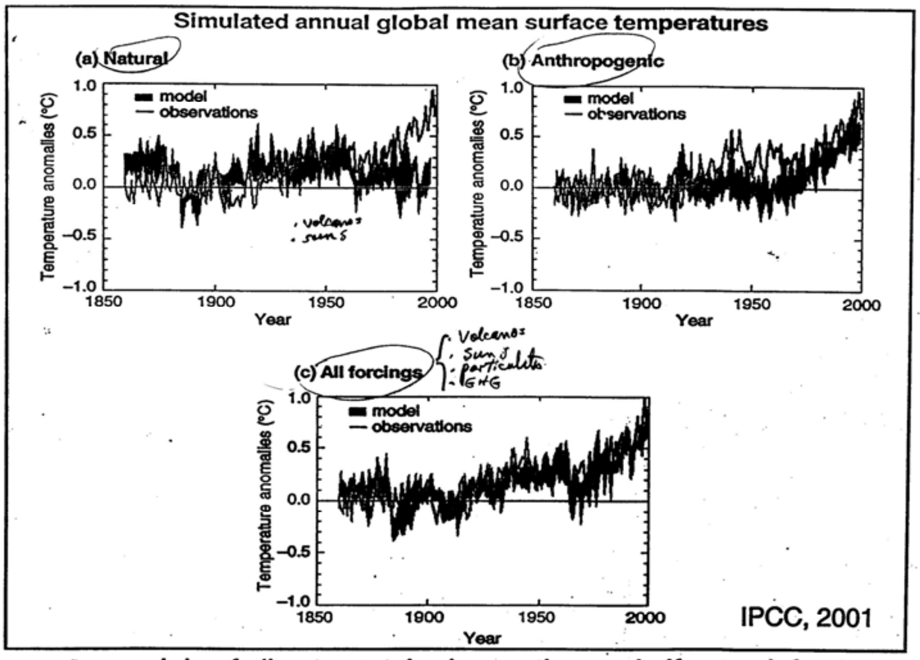


Figure 2 shows the results of computer models of the earth's annual mean surface temperatures from 1850 to the present. Note that these models match observations only if natural forcings (e.g., volcanoes and solar fluctuations) and forcings due to human activitiesare taken into account. The latter account for most of the rapid warming since 1970.

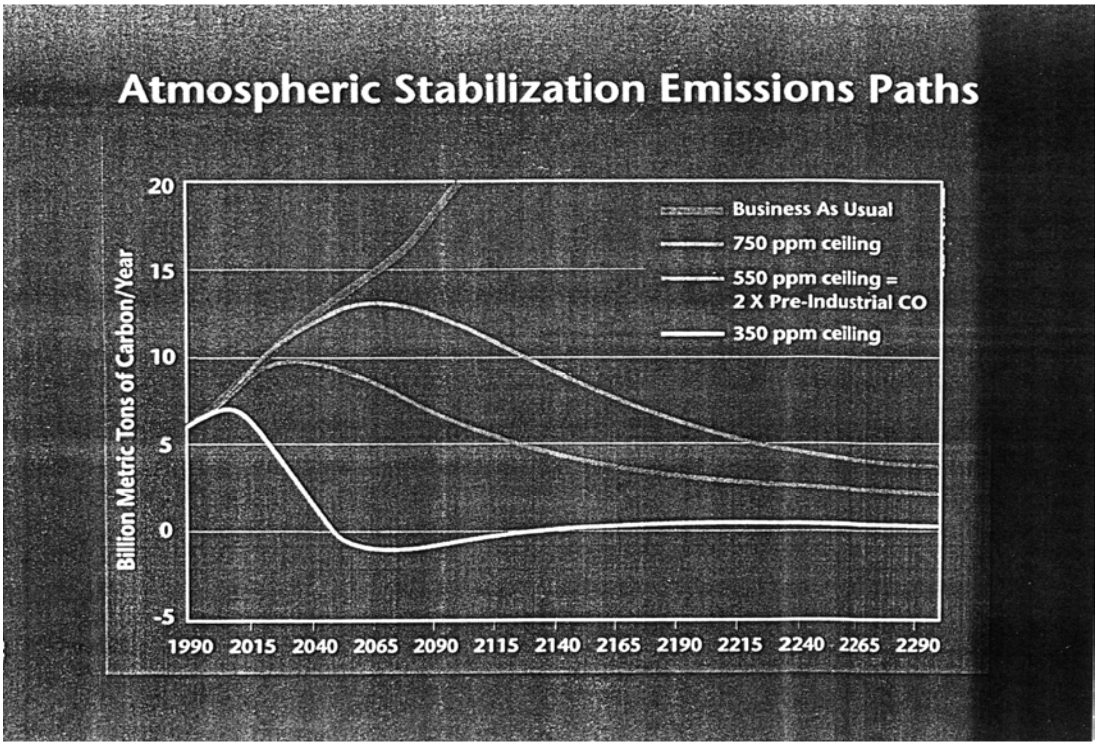
Figure 2. Computer models of climate



Computer models of climate match observations only if natural forcings (sun, volcanoes) and human ones (GHG, particulates) are included. The human forcings are responsible for most of the rapid warming 1970-2000.

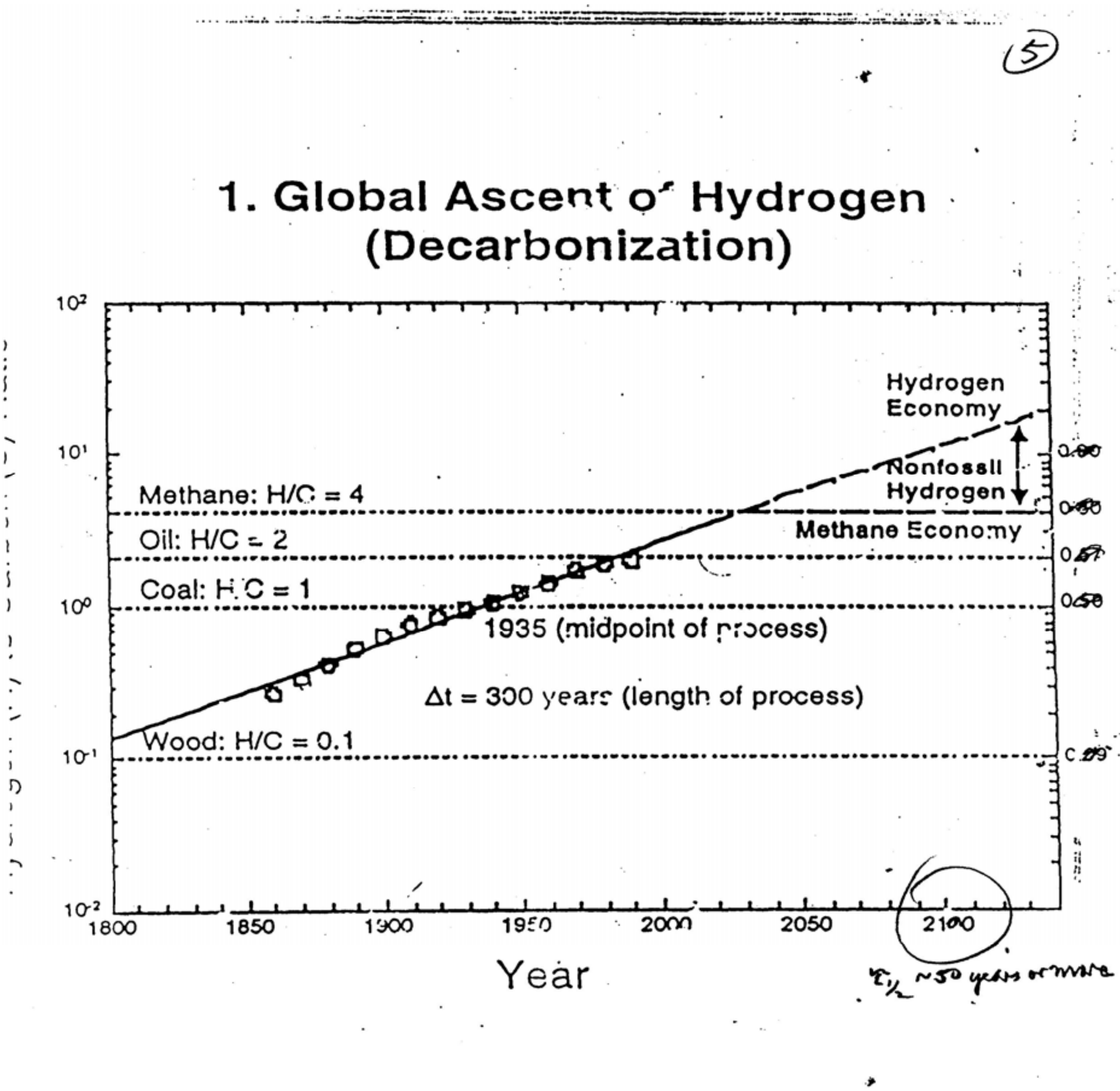
Climatologists sometimes speak in terms of three atmospheric stabilization emission paths: the first envisions a limit to the atmospheric concentration of carbon dioxide at 750 ppm, the second at 550 ppm or twice the pre-industrial level, and the third at 350 ppm (Figure 3). According to the first of these scenarios, the number of metric tons of carbon emitted into the atmosphere annually would continue to increase until about 2065 when it would be approximately 13 billion metric tons, after which it would slowly decline. The second and third scenario would result in more drastic reductions of atmospheric carbon. Following either scenario – particularly the third – could result in severe damage to the world's economy as a result of such rapid changes in, for example, fossil fuel combustion and rapid abandonment of energy-intensive capital stocks such as automobiles and housing.

Figure 3. Atmospheric Stabilization Emission Paths



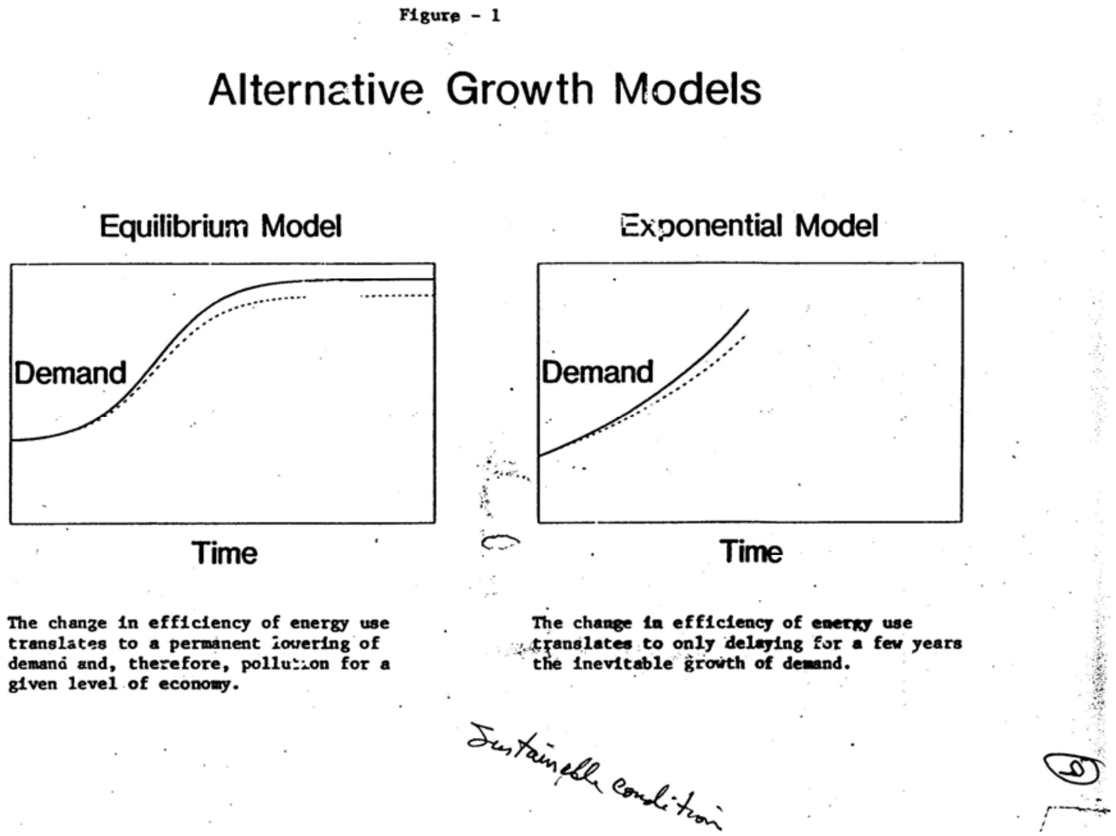
One way to reduce atmospheric carbon emissions would be to increase the ratio of hydrogen to carbon in the principal fuels used throughout the world. The hydrogen to carbon ratio for coal is one and for petroleum is two, while the ratio for methane is four (Figure 4). It is possible to envision increased use of methane as a fuel during a transition to an economy in which non-fossil hydrogen would serve as the world's principal fuel. A hydrogen economy by the early years of the 22nd century is conceivable if action toward that end were undertaken soon.

Figure 4. Global Ascent of Hydrogen



However, it will be difficult to achieve sustainable growth absent a leveling of the world's population growth which increases the demand for energy. According to the current, exponential growth model of development, any change in the efficacy of energy use translates to only delaying for a few years the inevitable growth of demand. On the other hand, in an equilibrium growth model, the change in efficiency of energy use translates to a permanent lowering of demand, and therefore, pollution for a given level of economy (Figure 5).

Figure 5. Alternative Growth Models



There are at least three imperatives that will be essential if the world is to achieve sustainable growth by the 22nd century: first, stabilize human population growth; second, transform production from “open” to “closed” systems; third, make available the necessary resources to support research and development (R&D) aimed at achieving sustainable growth, such as making the transition to a hydrogen economy as rapidly as possible. All three imperatives, but particularly the third, would benefit from increased international cooperation.

Achieving sustainable development represents a related set of long-term challenges. Several successive new generations of well trained, highly motivated, and adequately equipped scientists and engineers in China, the United States, and in other countries will be called upon to continue to address those challenges for the balance of this century.

Proceedings of the China-U.S. Forum on Science and Technology Policy

Section IIB – Inaugural (Keynote) Presentations

Keynote Address

Huang Qitao

Former Vice Minister of Science and Technology

October 16, 2006

I am very pleased to attend this Forum on Sino-U.S Science and Technology Policy. Please note that today I am representing Mr. Xu Guanhua, Minister of Science and Technology, as well as myself. Both of us deliver a very warm welcome to government officials, entrepreneurs, and experts from the United States, as well as our domestic guests.

We have made great strides in science and technology cooperation since the signing of the Sino-U.S. Scientific and Technological Cooperation Agreement in January, 1979. In November, 2005, President Hu Jintao urged a further development of the Sino-U.S Joint Commission on Cooperation in Science and Technology and encouraged closer cooperation among the government departments in charge, research institutions, and industries in the two countries. During President Hu Jintao's visit to the United States in April, 2006, he renewed the Sino-U.S. Scientific and Technological Cooperation Agreement for another five-year extension. At that time, planning for the 12th Meeting of the Sino-U.S. Joint Committee on Scientific and Technological Cooperation were actively underway. That meeting will be held October 18 and 19 in Beijing.

At present, the Sino-U.S S&T cooperation has several aspects: cooperation between the two governments, research institutes, universities, and enterprises, as well as technical personnel exchanges. So far, both countries have implemented thousands of scientific and technological cooperation projects, while tens of thousands of scientists have participated in bilateral exchanges. Cooperation in a wide range of fields has produced remarkable results which cover various kinds of fields such as basic research, high technology, and civilian technology.

After China's reform and opening 20 years ago, the country's economic achievements have attracted worldwide attention. However, these developments were achieved at a heavy cost to resources, energy and the environment. Of course, the problems we encountered are also the common problems around the world. To promote sustainable economic and social development, China has proposed to enhance our capability for independent innovation and to build an innovation-oriented country as our new technology development strategy.

Earlier this year, China held a National Conference on Science and Technology, releasing the outline of Medium- and Long-Term Plan for Science and Technology Development from 2006 to 2020. The development of this plan was launched during June, 2003 with Premier Wen Jiabao assigned as head of the leading group. The whole process required two years, involving more than 20 government departments and 2000 experts. A distinctive feature of the plan is that we have determined to enter the ranks of innovative countries in 2020, and have established independent innovation as a new national strategy. This will not only have a significant influence on China's scientific and technological progress, but also will have a far-reaching impact on economic and social development.

To ensure that China could grow into an innovative country, in the coming 15 years, China’s S&T development will center on significant issues related to economic and social development, and will shoulder the responsibilities of sustaining and leading economic and social development. First of all, energy development and protection of water resources and environment must take priority. Through scientific and technological progress, we shall greatly improve the productivity of energy and resources and promote comprehensive utilization of energy and resources. We shall increase the research and application of biomass, wind, solar energy and other renewable energy. We are determined to resolve the major bottlenecks, such as energy resources, which hold back economic and social development.

Second, we shall adhere to a people-centered policy, and put the improvement of people's life and health as an important mission of technological innovation. We shall rely on the application of biotechnology and information technology to improve people’s food structure. We shall strengthen R&D on innovative drugs. We shall strengthen the technical support in prevention, early warning and emergency in case of production security and public security incidents.

Third, we shall support the development and application of generic technologies, especially the integrated innovation of information technology, new material technology, and advanced manufacturing technology, so as to create a new industrial structure, thus “putting high-tech industries in the leading place while upgrading the whole traditional industries sector, and promoting the rapid development of the modern service industry.”

Fourth, we shall strengthen basic research and research on advanced technology, which provides for the sustainable development of technology.

The Chinese government attaches great importance to indigenous innovation and, through institutional innovations, the promotion of technological innovation. Since China's reform and opening, we have relied on institutional innovation to liberate and developed productivity, and to provide a strong impetus for sustained and rapid economic growth. In the coming 15 years, we will strengthen the national innovation system to secure the institutional and technological innovation by means of several initiatives:

First, we should give full play to the role of enterprises as a mainstay in technological innovation. We should not only focus on enhancing the ability of technological innovation in large-size enterprise, and promote them to be the principal body of R&D, as well as principle sites for the creation of intellectual property, but we must also promote the development of the small and medium sized enterprises (SMEs) which are filled with creativity by means of building a favorable policy environment Last year, within China's 53 state-level high-tech industrial development zones there were more than 45,000 enterprises. And their R&D expenditures were 80.62 billion Yuan, amounting to 2.8 percent of the income from product sales. About one-third of China's investment in R&D activities went into various innovative projects in the state's high-tech enterprises. From 1999 when the Chinese government set up a "small and medium-sized technological innovation fund" to now, a total of 4.4 billion Yuan has been allocated to support nearly 8,000 programs, effectively supporting the development of technological innovation capability of small and medium-sized enterprise.

Second, we should create a favorable environment for enterprises to innovate. We shall focus on the coalition of fields of industry, academy and research; unite the strengths of universities and research institutions to satisfy the innovation needs by enterprises, so as to accelerate the transfer of scientific and technological achievements to enterprise products. Meanwhile, we shall accelerate the establishment of financial systems and intermediary services to provide financial and advisory support to enterprise innovation. The establishment of innovative partnerships between governments and enterprises is to be regarded as an important task to support enterprises. To provide a rich source of knowledge to enterprise innovation, the government is setting up scientific and technological program and promoting the coalition of fields of industry, academy and research. Meanwhile, we shall increase the supply of generic scientific equipment and the sharing of information to provide an effective platform of innovation for enterprises and the whole society.

Third, we shall strengthen researches on the generic and leading-edge technology to support and guide the development of industrial technology.

Fourth, we shall establish an effective system of public policies to promote innovation. The government will strengthen the coordination of economic, technological and personnel policies make the policies harmonious with each other to promote the innovation, and share the risks of innovation. Of even more importance is that the government should create favorable legal and social environments for enterprise innovation. In particular, we must pay close attention to the protection of intellectual

property, strengthen the relevant legislation and enforcement, emphasize the combined functions of administrative enforcement and the judiciary to enhance the protection of intellectual property, and safeguard the interests of innovators as well as their enthusiasm for innovation.
China, as a developing country, had attached great importance developing science and technology. With the development of the S&T, China has successfully solved the problem of 1.3 billion people's eating, has brought most people out of the poverty, and increased the average life-span has to 73 years old. China has reached the level of a middle developed country. With the development of S&T, China is accelerating the process of industrialization, and at the same time, the pace of its utilization of information technology has picked up. China has become the biggest communication country in the world. The number of cyber-users has broken through the 100 million mark. More and more people are enjoying the unprecedented convenience for production, life and learning from information technology. With the development of S&T, China has had great success in the construction of fundamental infrastructures and urbanization, while the country's ability to coordinate economic development with environmental protection is also improved unceasingly. The development of China's S&T is proceeding at a very fast speed, which has not only sustained China's economic prosperity so as to make China's 1.3 billion people enjoy the felicity of modern S&T civilization. The country's S&T development has also provided other developing countries with the experience that a nation's prosperity is dependent on S&T development, and has also made great contribution to the world's development and human civilization.

The core of constructing an innovative country is to regard the strengthening of the ability for indigenous innovation as the strategic base point of developing S&T, to regard it as the center piece in adjusting our industrial framework and changing the mode of economic development, and to regard it as a national strategy. This means that in 2020, China's input in the R&D will take up more than 2.5 percent of GDP, the contribution rate of S&T development to the economy will exceed 60 percent, the degree of the dependence on the foreign technology will fall below 30 percent, and the number of domestic patents and international SCI (science citation index) papers will put China among the top five nations in the world.

Indigenous innovation is anything but closed innovation. It is innovation which depends on maintaining foreign cooperation and communication. Indigenous innovation has three meanings: 1) strengthen the original innovation and creation to go for more science discovery and technical invention; 2) enhance the integration of innovations to make all kinds of interrelated techniques to provide a basis for more competitive products and industries; 3) reinforce the ability to digest and assimilation advanced techniques. The core of indigenous innovation is to strengthen the ability to create more property right on the base of extensively making use of the world's innovation resources. Although China, as a developing country, has made a great success in the S&T development, there is still a big gap between China and the developed countries. Therefore, China has to strengthen comprehensive international cooperation from basic research to technical innovation and on that basis, of make the best use of the international S&T resources.

Sino-US S&T cooperation is based on significant common interests, strong mutual complementarities, and great potential of future cooperation. For the sake of future developing Sino-U.S S&T cooperation, I put forward some proposals:

1. Initiate strategic research on Sino-U.S S&T cooperation; enhance the top design and the whole plan; look for the new cooperation fields, projects and modes which are in the common interests of both sides; develop and formulate a Sino-U.S cooperation plan with definite goals and evident emphases.

2. Continue to insist on and strengthen the meeting mechanism of the Joint Committee of Sino-U.S S&T; impel the understanding of the S&T development strategies and priority development fields; integrate resources; steer the Sino-U.S S&T cooperation into multi-sided and harmonious development.

3. Drive with great force the keystone fields of S&T cooperation, and assign priority to big cooperation projects, especially to the development of high-tech fields, including energy sources (the reproducible sources and new sources), information technology, biotechnology, nanotechnology, aeronautics, and space, as well as to health, the environment, resources, and other global problems. Meanwhile, I once again call on America to relax the control of high-tech exports to China.

4. Build up a good platform and environment for the Sino-U.S S&T cooperation; encourage scientific communication and mutual visiting. The U.S government should pay attention to and solve as soon as possible the problem of Chinese technicians' visa. Initiate a special plan for Sino-U.S technicians' cooperative training to further strengthen Sino-U.S cooperation in protection of property rights in order to pragmatically and effectively protect those rights.

5. Adopt policy measures to encourage enterprises in both countries, including the medium-small sized enterprises to participate in Sino-U.S S&T cooperation, and support the building of R&D centers to promote the S&T cooperation at the levels of industry and enterprises.

6. Discuss a Chinese S&T Year in the United States to further enhance the friendship underlying Sino-U.S S&T cooperation. By means of exhibitions, meetings, symposia, visiting communication, training, and education we will bring forth

recent fruits of China’s S&T development to increase the American people’s comprehensive understanding to China’s S&T and promote China’s high-tech enterprises in America. We also welcome the United States to come to China to hold such activities.

Let us hand in hand, with the reciprocal purpose and a sincere attitude, carry out positive and effective actions to drive the Sino-U.S S&T cooperation to another new height!

Thank you very much!

Keynote Address

Edward E. David, Jr.

Former Science Adviser to President Richard Nixon and Former Director of the Office of Science and Technology

October 16, 2006

Ladies and Gentlemen. I am privileged to keynote this China-U.S. Forum on Science and Technology (S&T) Policy. I join the other Forum organizers on both sides in hoping the results of the Forum are useful to decision-makers in China and the United States, and specifically to the 12th U.S.-China Joint Commission Meeting (JCM) which follows later this week. Suffice it to say, the origins of these meetings and the relationship between China and the United States go back many years. The JCM began in 1979 about the time of my first visit to this country and has been successful in activating joint activities and joint research continuously over the intervening years. These activities have led to deepening relations between the two societies. It is the intent of this Forum to open the cooperation further and to provide policy makers in both countries with advice on ways to extend the relationship and thereby improve our countries' research, development, and cooperation.

This Forum addresses science and technology policy. Beyond policy, understanding the science is a necessary but not sufficient condition for a successful research system. The Forum has endorsed adopting "best practices" in research and in innovation. That has encouraged and continues to encourage best practices in research and innovation in both countries.

The U.S.-China S&T relationship is also subject to influence from the policy environment. Alex DeAngelis, in his excellent background paper prepared for this Forum, discusses a number of policies validated from the last thirty or more years of the bilateral S&T relationship. There are four of his points that I would like to mention:

- We should invigorate the relationship by advocating mutual interests
- This relationship underpins the economic well being and security of both countries
- The private sector is the primary source of new ideas and creativity in this relationship and should be emphasized, and
- The benefits from S&T cooperation are large and worthy of efforts to expand the cooperation.

Enlightened bilateral policies for S&T relations are important not just for scientists and engineers. Policies affect many if not most of our fundamental relationships in trade, environmental protection, and security. It is important for all of us to support this bilateral relationship, to work to improve it, and to seek out the best ideas and knowledge from our universities, companies, and other institutions. Too, we must address the "three mountains" for societies to climb – these are medical services, education, and housing. We must rely on public financial support and technological support by private sources.

Over the many years since science and technology matured, there have been significant changes in ways these activities have grown and progressed. After World War II, the U.S. federal government became the principal funder of research in the United States, much of it done in federal laboratories, U.S. universities, and in contract industrial labs. However, times have changed and today the major support for research and development (R&D) in the United States comes from private industry, augmented by venture capital, private foundations, and other private sources. Meanwhile, the total funding for R&D has grown by seventy-five percent since 1990 and is now over $300 billion. The causes behind this transformation are diverse, but one major influence has been the recognition that the research enterprise drives economic growth. Governments worldwide now recognize that research is a key to economic prosperity. China has been in the forefront with its outstanding academic institutions and traditional inventiveness and entrepreneurship. But "relevant research" as it is often called today, now occupies the attention of all nations, though with different emphases.

China's president Hu Jintao, has used the phrase "making China an innovation-driven nation". This phrase encompasses both fundamental research and economic-driven development. This current merging of two vastly different reasons for supporting science and technology was foreseen by the U.S. intellectual leader, J. Robert Oppenheimer, when he observed that science is both <u>enabling</u> and <u>useful</u>. The distinction lies in the motivations behind research. Science is driven often by curiosity and the desire for understanding. Engineering and technology are driven by the effort to commercialize new devices and systems benefiting publics and nations. The modern viewpoint is that both understanding and engineering are required to accomplish the goals of societies and nations.

The complete innovation picture includes such diverse activities as education, research and testing, intellectual property rights, the rule of law, and operating a world society that fosters innovation and attracts talent to research across many different countries and cultures including, for the purposes of this Forum, both China and the United States Also the private sector has to be granted ownership of proprietary developments funded by public sources as is done by the so-called Bayh-Dole legislation in the United States

So far I have been emphasizing that engineering and applied science occupy the frontier for economic development. But there is another vital contributor to innovation; namely, basic or fundamental research. Many people are concerned that such research, that is research for satisfying personal curiosity and which is not purposeful, is less likely to be useful and so not worth the cost of a research effort, nor is it aligned with corporate or national needs. Industries and political factions tend to be less sympathetic to curiosity seekers than to researchers who have a purpose or use in mind.

Yet a closer examination of this logic leads to another view. An example is the invention of the laser many years ago. At the time, there was no accepted use for this source of coherent light. In fact, many people said that the laser was “a solution looking for a problem.” In the interim between then and now, the laser has become widely used in applications from recording and reading microscopic tracks on compact discs to precise measurement of distances and surgery on people and animals.

During the development of a new system or device, progress is often blocked by a lack of knowledge. This familiar situation can lead researchers to either a trial and error approach (attempts to try “everything”) or to experiments to create the knowledge or know-how to overcome the barriers to progress. The latter can lead to research which is indistinguishable from basic research in its methodology – only the objectives or purposes of the performers distinguish basic from applied.

There are cases where careful research for problem solving has led to new science and knowledge. For instance, in optics of the eye, a precise way of intervening using microsurgery was needed. Surgery with lasers of adequate power turn out to be preferred to scalpels to reshape the cornea in the eye. Laser surgery is now common for cataract removal and other eye diseases and conditions. Such examples show that instincts of scientists as to what is important in research often lead to the opening of new fields of great eventual utility, not predicted initially.

These generalities are vital for this occasion since we are often concerned with research priorities and policies addressing funding and its distribution among research fields. But content and substance of research is important also. A startling feature of the changing research scene is the increasing worldwide emphasis on biology and life sciences as somewhat distinct from the physical sciences. In the United States, the growth of life sciences has outpaced that of the physical sciences in recent years. The National Institutes of Health (NIH) have been leaders in this transformation. They have been the favorites of the Congressional budgeteers, so they have not lacked funds to do exploratory research.

Significantly, this distinction between the physical and life sciences does not translate into engineering. Engineering has a foot in both camps. It is true that engineering has been associated with physical science traditionally, but today bioengineering is outpacing other fields of engineering and promises to become the leading engineering field. All the preeminent engineering universities in the United States now have biology departments as well as ones devoted to medical subjects and the corresponding medical instrumentation. New buildings and laboratories devoted to bioengineering and related disciplines are proliferating. Critics of the scene point to the danger of overbuilding without a corresponding increase in research funding. However, biology and related disciplines are attracting a large influx of students just as computing and computer sciences did in a previous era. Also, women are joining the parade and are at least equal in numbers to males. So overbuilding seems unlikely.

Engineering looks upon biology as a new subject to exploit, leading to expanded engineering fields such as tissue engineering, genetic engineering, and proteomics. It would be fair to say that these developments stem from findings about the structure of the

DNA molecule and the impact of subsequent discoveries such as recombinant DNA; and RNA which can be a template for duplicating DNA and can act also as a genetic switch to turn off gene function: that is, suppressing gene function. Of course, such revolutionary possibilities have created disputes in food and related technologies, from genetically modified organisms (GMO's) and cloning, to stem cell technologies, and gene therapy. Such conflicts lead us to look carefully at what technology is bringing forth. We know that scientific advances in nuclear matters have created conflicts and hazards for the world, as well as promising opportunities for sustainable energy. Caution is the right policy, but it is clear that frightening hazards seem to come with advances in technology application for societies. Suppression of promising uses of technology can't be a final answer to the obvious hazards. *Wisdom aimed at avoiding misuse and violence must prevail.*

We must look, too, at the way we handle new technologies and the way we make use of new knowledge. Education remains one of the most important, some people say most difficult, tasks for societies. President Hu Jintao in his recent speech to the Chinese Academies of Sciences and Engineering emphasized education to build teams of innovative technical talents for China. He devoted a large part of his speech to various aspects of this subject. It is clear that education and encouragement for technological innovators are high on his list of objectives for China. His obvious conviction that technical talents are essential for China mirrors that held by many people in the United States who have expressed their conviction that science and engineering education are the key to economic well being as well as health. Related is the discipline of economics, especially as it applies to commercialization and emergence of products, services, and technical applications. A recent proposal and project addressing major educational barriers stimulated the idea and development of a $100 laptop computer aimed at universal student use (one laptop per child). This project comes from the Massachusetts Institute of Technology (MIT) Media Lab. In November this year, these computers will be in students' hands in several African countries for testing.

Educators have long recognized that technology can provide assistance to education. Several universities have initiated efforts to make instructional materials available on the Internet featuring unrestricted and free access. Sophisticated but low cost technologies appear to be a preferred way to spread knowledge and skills. This path is being practiced in many institutions of learning from primary schools to colleges and graduate schools. Computing and the Internet provide opportunity for modern education to extend its reach beyond the borders of continents and nations.

Innovation is another emerging way to improve humanity's lot. Innovation includes manufacturing and marketing newly invented devices and systems. Countries are exploring ways to commercialize and protect inventions. The United States and China are familiar with the pitfalls encountered when bringing new products forward to augment economic development. Both countries have learned well that attention must be given to subjects beyond technical. Some of these are design, manufacturing, distribution, sales, and training of both users and technicians to make contributions to successful innovation. Manufacturing costs and natural resources availability require attention for successful innovation.

Also revolutions in the transport of goods and information are redefining business practices and personal relationships around the world. Components manufactured in one country can be available the next day to a manufacturer in another country. In telephony, call centers serve customers half a world away. Joint enterprises such as these are coordinated by shared databases and messages which cross the world in milliseconds. Indeed as Tom Friedman has said "The modern world is flat"!

The Internet is a critical aspect of the shared infrastructure which links China and the United States. Not only does it benefit scientific research and commercial development but also it increasingly supports education and cultural exchange. It is widely anticipated that universal broadband service, based upon fiber and wireless technologies, will become available for all people, businesses and public institutions. Even as this expansion takes place, it is vital that the shared communication infrastructure support our agreed interests.

In the United States, the project to bring "100 Mb/sec to 100 million homes" sponsored by the National Science Foundation is investigating alternative futures for the Internet's architecture. That project envisages a regional design for the United States that is particularly suitable for large scale deployment and reliable operation. This research may be of interest to China given that China and the United cover approximately the same land area and China has a population that is four to five times larger.

Many universities in the United States have started technology parks to incubate and support startup companies. I am also aware that China has used high tech development zones to encourage innovation and new companies. Such parks in the United States are providing effective paths to economic development. A recent study by a U.S.-German economics group showed that a high percentage of scientists and engineers who receive patents for their work become involved in startup companies.

In reciting these changing frontiers, we should not leave out the human factor. In the United States today, there is a fear that the country will be facing a shortage of well trained and motivated scientists and engineers. It is true that fewer and fewer young people are enrolling in schools and universities that could train and educate them for careers in science and engineering. As a consequence, the United States may be facing a shortage and a decline in its standing among nations.

The author acknowledges and appreciates contributions of many people to this speech with special thanks to Dr. J. Thomas Ratchford, Director, Science & Trade Policy Program, George Mason University, and Distinguished Visiting Professor, George Mason University School of Law and Dr. Alexander Fraser, Founder and President of Fraser Research, Princeton, NJ.

Proceedings of the China-U.S. Forum on Science and Technology Policy

Section IIC – Roundtable 1: Lessons Learned During the Evolution of China-U.S. Relations Since Normalization

Successes and Challenges of Industrial R&D in China

Xiangli Chen
GE Healthcare

Oct. 16, 2006

imagination at work

R&D Investment in China

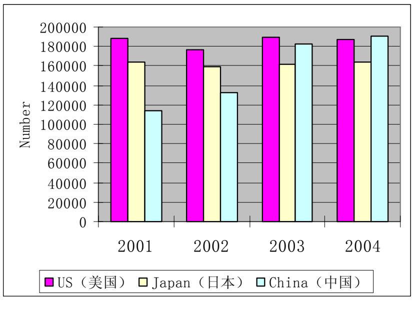
R&D Spending as Percent of GDP

- Developed Countries: 3%
- China: about 1% at present
  2.5% by 2020

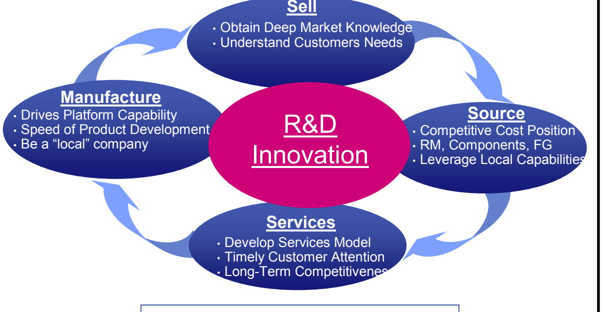
750 MNC R&D Centers in China

- Spend about $2B/Year
- 11% of total R&D Spending in China
- Important in China's Innovation eco-system

Patents Issued in China, US and Japan



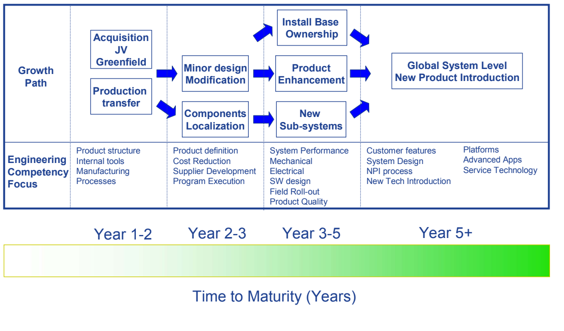
R&D: Key to China Business Strategy



Focused on Capability & Capacity…
Self-Sufficient & Local Feeling

GE in China – 12,000 Employees, $2B+ Investment $5B/Yr Revenue

R&D Skills Development Process



Example: GE's CT Development in China

Y2000
CT/e
CT/e Twin

510 units

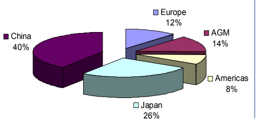
Y2003
CT/Be-1
CT/e Twin Linux

Y2004
CT/Be-2
LS China

Y2005/2006
RT 4/16
BrightSpeed 4/8/16
CT/e Optimization

>800 units

CT/e: >3000 Installed Units

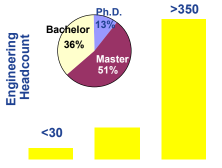


Key achievements

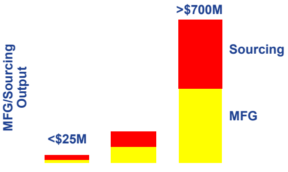
- High Tech at Affordable Cost :
  - Significant Cost Down while Improving Performance
  - Best-selling Value CT in the World
- Grow NPI Competency with Program Success
  - Win more Opportunities … Performance & Premium

R&D… Driving Growth

GE Healthcare China R&D



Manufacturing/Sourcing



- Multiple Technologies: CT, X-ray, MRI, Ultrasound, Healthcare Information Tech…
- Product Leadership – Value & Performance segments

- Sustainable Productivity Growth.
- Comprehensive Product Coverage for Global Supply Chain

Rapidly Developing Ability to Win in China and Globally

Managing R&D Growth in China

- Grow R&D Competency One Step at a Time
  - Production Transfer
  - Localize and Develop Supplier Base
  - Value Engineering / Re-design
  - Sub-system Ownership
  - System-level New Product Introduction… Global COE
- Start "Local"… Develop into "Global"
  - In China for China… In China for the World

Building Effective R&D Organization

- Plan Strategically, and Stay the Course
  - Set up realistic expectations, and meet / exceed them
  - Start with expatriate leaders… strong ties with HQ, act as role models and bring corporate culture
  - Be culturally sensitive: organization, career path, and retention
- Invest in People
  - Hire only the best, and fully leverage "returnees"
  - Bridge assignments: send org. leaders overseas, and bring tech experts to China
  - Training: soft skills, project management, design processes, IP protection...
  - Provide challenging opportunities, build for long term success.

The Evolution and Experiences of Sino-American Scientific and Technological Cooperation

中美科技合作的历程和经验教训

Wu Yikang

吴贻康

Adviser

China Association for International

Science and Technology Cooperation

中国国际科学技术合作协会顾问

Oct. 2006

1. Evolution of Sino-American Scientific and Technological (S&T) Cooperation

（一）中美科技合作的历程：

(1) Period of S&T Exchange at Non-governmental Level (1972 -- 1978)

（1）民间科技交流时期（**1972-1978**）

(2) Period of Vigorous Development of Governmental Cooperation (1979 -- the first half of 1989)

（2）官方科技合作蓬勃发展时期（**1979** 年**-1989** 年上半年）

(3) Period from Depression to Recovery (the second half of 1989 -- 2001)

（3）低潮至复苏时期（**1989** 年下半年**-2001** 年）

(4) Period of New Development (2002-present)

（4）科技合作新发展时期（**2002** 年至今）

2. The Development of Sino-American S&T Cooperation

（二）中美科技合作的发展

The present Sino-American S&T cooperation are composed of four major parts:

(1) S&T Cooperation between the Two Governments.

(1)政府间官方科技合作。

(2) Enterprises-related Cooperation.

(2)与企业的合作。

(3) Cooperation at Local and Non-governmental Level.

(3) 地方上和民间的合作。

(4) Cooperation with both Returned Scientists and Visiting Scientists in the USA.

（**4**）与留美学人的合作。

3. Evaluation on Sino-American S&T Cooperation

(三)中美科技合作的评价

(1) Chinese Evaluation (mainly based on the benefits for China)

1、中方评价（主要从中方受益评价）：

(2) American Evaluation (mainly based on the evaluations of US-China Science and Technology Cooperation Agreement made by the US-China Economic & Security Review Commission under the US Congress in 2004 and by US Department of State in 2003)

2、美方的评价（主要根据 2004 年美国国会美中经济与安全评审委员会和 2003 年美国国务院对美中科技合作协定执行评估）：

4. Experiences of Sino-American S&T Cooperation

（四）中美科技合作的基本经验

(1) Sino-American S&T Cooperation Is of Mutual Benefits and Can Achieve Win-Win Results.

（**1**）中美科技合作是互利的，可以取得双赢。

(2) Sino-American S&T Cooperation Should Not Necessarily Coincide with Diplomacy.

（2）中美科技合作不必时时与外交同步。

(3) Attention and Support from the Leaders of the Two Countries Are Needed for the Smooth Implementation of the Cooperation.

（3）中美科技合作需要双方领导重视。

(4) Efforts from the S&T Communities of the Two Countries Should Be Encouraged for Promoting Sino-American S&T Cooperation.

（4）中美科技合作要调动科技学术界力量促进合作。

5. Problems with and Ways Forward for Sino-American S&T Cooperation

（五）中美科技合作存在问题与展望

(1) Problems with Major cooperative projects

（1）重大合作项目问题。

(2) Visa problem

（2）签证问题

(3) Problems from technology control

（3）技术控制问题。

The Technology Transfer Issue in Sino-US Relations, 1981-2006: Some Reflections, Thoughts, and Perspectives

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Introduction

The issue of technology transfer in Sino-US relations has been one of the most controversial and contentious in the recent history of the bilateral relationship. The source of the tensions and stresses has stemmed from a number of factors, foremost of which have been on-going American restrictions on the sale of advanced technology and equipment to the PRC as manifested in US export controls and the non-defunct COCOM regime. In spite of the demise of the COCOM regime in 1994 and the substantial relaxation of export controls since the early 1980s, the fact remains that China continues to be dissatisfied regarding selected US-government export controls that continue to limit Chinese access to American technology. Moreover, China also views with great unease the intermittent use of technology transfer controls by various US administrations as a form of political leverage designed to reward or punish Chinese behavior, whether it be for alleged human rights violations, PRC behavior over Taiwan, or other actions the US considers inconsistent with its own foreign policy goals and objectives.

This brief paper examines the historical evolution of US-China technology transfer relations since the 1980s, with an aim towards identifying the changing drivers of behavior for each of the respective countries. It attempts to provide some critical reflection, some focused thoughts, and some historical perspective on the experience of Sino-US technology transfer. As will be shown, it highlights three main salient features about the nature and thrust of these relations: 1) the steadily enhanced understanding and sophistication of China with respect to the operation and dynamics of the international market for advanced technology and equipment; 2) the growing divergence and lag between the strategic goals and objectives between the American business community and the US government, most clearly manifested in the apparent lack of coherence between the pursuit of American commercial interests and the pursuit of our other foreign policy aims; and 3) the increasing impact of globalization on the bilateral relationship, which in many ways, has radically altered the environment in which the two countries interact and define their individual as well as joint interests.

China's Perspectives on Technology Transfer

China has placed a great deal of emphasis on the use of foreign technology as a means to drive its economic growth and close the prevailing technological gap between itself and the rest of the world. The decision by China's leaders to eschew the self-reliance policies of the 1960s and 1970s in favor of a more open set of cooperative policies with the West and Japan has had an important shaping effect on the nature of China's modernization drive. Foreign investment, because of its ability to serve as a mechanism for bringing in advanced equipment and know-how into China, has been welcomed, leading the PRC to become one of the top recipients of foreign capital in the world over the last two decades. It also has become the primary vehicle for bringing in advanced management knowledge to China since the onset of the open policy in the early 1980s. Policies have been put in place encourage foreign firms to bring higher and higher levels of technology to China in return for access to the growing Chinese market. While the value proposition for this quid pro quo did not hold much attraction for many foreign firms in the late 1970s and 1980s, their perspective has changed as the consumer and industrial markets have developed and China has become an important importer of everything from major commodities to cutting edge consumer products and state-of-the-art high technology equipment. Of course, the problem has been that even while China has engaged the global market as a major source of both exports and imports, its buying activities, while a substantial complement to its growing export capabilities, has resulted in a huge trade deficit in the Sino-US trade relationship.

Several features stand out as characteristic of US business views of China in the first period of interaction and engagement. Numerous American firms found themselves confounded by the seeming complexities of the Chinese bureaucracy and administrative system for dealing with potential technology suppliers and foreign investors. The difficulty of doing business in China was most clearly manifested in the multiple players and multiple layers of approval foreign firms encountered when they attempted to make a business deal. At the national level, it was hard to work across ministries and commissions because of the highly vertical, often rigid nature of the Chinese system. Similar problems were encountered when trying to decipher the relationships between central and local authorities. The lack of transparency often made matters worse, especially when it came time to flush out the decision-making and approval processes inside the government and Party organizations. Interestingly, time delays on the Chinese side in responding to business offers, often misconstrued as some Machiavellian form of Chinese negotiation strategy, actually were no more than a function of the poor coordination inside the PRC system itself.

Other problems and issues that emerged during this period derived from the incomplete nature of the Chinese regulatory system, the absence of the rule of law in many areas of commercial affairs, and the rather cumbersome nature of the rules and regulations that did exist, such as the technology import legislation that was in effect for most of the 1980s and early 1990s. American firms also were daunted by the Chinese penchant for carrying on multiple negotiations simultaneously for the same project. There was sense that foreign firms were being played off against one another as the

Chinese side used the process as a form of learning to enhance their own knowledge and thus increase their ability to extract a better deal for the PRC side. Besides being extremely lengthy and at times unclear, the process left many US firms feeling squeezed, exposed, and somehow naked as they left Beijing or Shanghai after a typical session with MOFERT/MOFTEC or the State Planning Commission. Many US firms lacked an understanding of the impact of the Sino-Soviet legacy on China, especially in terms of the Chinese desire and policy intent to a) avoid excessive dependence on any one country and b) develop a rather diversified series of technology partners and sources.

Of course, Chinese behavior regarding technology transfer was influenced by a range of factors at the time, including a relative lack of foreign exchange to pay for all the equipment and license all the technology that the country needed to foster more sustained economic growth. In addition, Chinese behavior was heavily influenced not just by its experiences with the former Soviet Union, but also by the experiences of many Third World countries in their interactions with multinational corporations. China imposed a series of technology import rules and approval processes that were designed to avoid being taken advantage of by more experienced, more knowledgeable corporate executives from these companies. Having come to China as a consultant for both the UN and World Bank during this period to lecture on international technology transfer issues, it was clear that the Chinese system lacked the knowledge and confidence to allow for a more open ended, liberal policy package to address technology import issues, and thus it probably was not unwise to adopt an approach that was more cautious and perhaps restrictive — even though it produced frustrations among US and other foreign firms.

In many ways, I would suggest that what American firms frequently mistook for diabolical behavior and thinking on the part of the Chinese side was really a PRC system that was trying to find its way with respect to the level of acceptable/necessary reliance on foreign investment and imported technology. The Chinese system during the 1980s and even today continues to debate the merits of the traditional "make or buy" choice many companies as well as countries face. At that time, the principal debate was over "hens versus eggs," or we might say hardware versus software. And, you might imagine, at one end of the spectrum was the State Science and Technology Commission (now called MoST) arguing in favor of more indigenous development of know-how <u>and</u> at the other end were the economists in the State Planning Commission and perhaps even State Economic Commission arguing in favor of acquisition of more equipment purchases from abroad so that economic output could be more readily and quickly increased. These debates were made further complicated by the fact that Chinese performance regarding technology acquisition and absorption was highly uneven and problematic in some cases. The country's limited infrastructure at the time plus the lack of adequate managerial expertise and systems integration capabilities often led to problems of indigestion.

Yet, in the eyes of US industry, Chinese behavior was viewed as sub-optimizing because of the tendency to talk quality, but to buy on the basis of price. China was viewed as a country willing to pay for hardware and equipment, but not the software needed to make the imported equipment work. Very expensive machinery often sat idle or was mis-used because of a perceived unwillingness to pay for the training programs, support services, and related items that were required for effective implementation and utilization. At stake, from the American corporate perspective, was not loading on a bunch of expensive, highly profitable services, but rather, in the final analysis, their ability to engage in a successful project in China. No one wanted to be stuck with a failed project and the bad press that might ensue, and so even without adequate payments, many US firms found themselves supplying the necessary engineering and management expertise without appropriate compensation. This obviously had a deleterious impact on their so-called "bottom line" — which helps to explain why so many US firms complained about the absence of profits from their China business during these early years.

Obviously, the problems encountered on the Chinese side were not without their equivalents on the US side. American companies, like their other foreign counterparts in Europe and Japan, experienced problems regarding technology transfer because 1) they tried to do too much too fast; 2) came to China not fully understanding or appreciating the strategic importance the Chinese had attached to technology transfer—and thus often did not have a complete technology transfer strategy as part of their business thinking; 3) did not do their homework in general, esp. in terms of more fully understanding the prevailing shortcomings in China with regard to management skills; and 4) selected the wrong partner in the wrong location. A popular phrase that emerged during this period when discussing cooperation with China was "sleeping in the same bed, but with different dreams." The emergence of this phrase reflected the tendency of many US companies to get caught up in so-called "China fever," which left them willing to engage in business behaviors in China that they would not have repeated in any other country. Many American firms paid inadequate attention to the Chinese policies and pronouncements regarding their goals and motivations for technology transfer, which eventually left them feeling unduly pressured by the PRC authorities to up their quotient of technology transfer. These complaints increasingly made their way to the US Commercial Officers in the American Embassy in Beijing and the US Consulates throughout China. Given the fact that Chinese intentions regarding the centrality of technology import actually were widely publicized and could be easily tracked in the official, public pronouncements of the PRC government, it probably would have benefited US firms and the American government to have paid more attention to China's stated objectives, even if they sounded more like hyperbole and highly aspirational at the time.

If the 1980s were a period of adjustment and learning for China, the policy environment and operating situation regarding technology transfer in the 1990s was one of steady normalization and improvement. These improvements occurred in several key areas. First, the existing legislation regarding technology import transitioned from its highly restrictive flavor to a series of processes and procedures that are more facilitative, more flexible, and more focused on a very limited number of less-encouraged sectors. In addition, new legislation, initiated by the former MOFTEC and now by the Ministry of Commerce, designed to encourage and support the establishment of foreign R&D centers in China, has gone into effect. Second, with a decade or more of moving up the learning curve in terms of technology acquisition practices and an understanding of the international technology market, China has become more proficient and more sophisticated in targeting the right types of know-how and negotiating the appropriate terms and conditions. The negotiations that took place between Shanghai Auto (SAIC) and Ford versus General Motors over the initial GM joint venture in the early 1990s highlights the enhanced ability of China to understand the rules of the game and how to gain strategic advantage. From the perspective of American companies, the decentralization of the decision-making and approval procedures and deal-making authority has placed the interests of the supplier and buyer of technology closer to one another, which steadily, albeit gradually in some cases, has allowed for a smoother, less problematic implementation experience. None of this is meant to suggest that the Chinese are any less tough as negotiators, but rather that the higher levels of transparency and more direct involvement of end-users upfront has caused less frustration and put commercial considerations, as opposed simply to political factors, at the center of the majority of discussions and negotiations.

Generally speaking, China's membership in the WTO in 2001 has further led to improvements in the business environment that American firms have found to their satisfaction. In essence, Chinese participation in WTO has helped to lead to greater convergence between PRC and US commercial interests in the area of technology transfer. The old adage of "sleeping in the same bed, but with different dreams" seems to be much less meaningful today as a more open, less conservative Chinese approach to technology transfer has made for greater efficiency in developing and engaging in international technology cooperation and collaboration. In addition, Chinese understanding of the technology transfer process — the so-called "key success factors" has led to much less waste and much more effective utilization of the acquired know-how, esp. with the higher priority being given to the role of management as well as the emphasis on such skills as project management and systems integration. Of course, difficulties and unmet expectations regarding such problems as "intellectual property protection" have not erased all areas of disagreement. Many American firms, while willing to bring more and more advanced technologies and know-how to China, report that their principal uneasiness about doing business sin China stems from continued concerns about IPR violations. This is ironic in view of some recent research by the French investment firm CLSA in Shanghai that suggests that while these expressions of concern are real, the number of foreign firms that actually have experienced a serious problem in the high technology sectors, for example, is limited.

Last, but perhaps most important, even with the significant changes that have occurred in the level of control over technology exports to the PRC, China still continues to be dissatisfied with remaining restrictions imposed by the US Government on the sale of high technology. This has led to a growing sensitivity in China about the role of the US as perhaps the principal supplier of technology and know-how to the PRC. One important consequence of these reservations among different groups in the PRC government is the growing tendency of Chinese enterprises and various government agencies to look to Europe, Korea, Israel, and increasingly Russia as an alternative source of key technologies. The growing closeness of Russia and China, for example, in the area of commercial technology transfer is a point of interest to American industry and government officials, if only because of the on-going huge Sino-US bilateral trade deficit and the huge opportunities that exist for much broader and deeper commercial technology collaboration between the two countries. One of the true tests for the future will derive from the experiences of US firms with regard to their growing R&D operations in China. Motorola has set up 16 R&D facilities in China, with other US companies such as Microsoft, Intel, GE, etc. not far behind in terms of the steadily increasing size and level of their commitment to being in China. If these operations grow and prosper without major problems in areas such as IPR protection and operational freedom, then the future looks very bright for taking the Sino-American technology transfer relationship moving to the next level.

US Government Role in Sino-US Technology Transfer

Perhaps one of the most complex and least understood facets of US tech transfer policy towards China has been the efforts by Washington DC to balance its commercial interests with its national security concerns. Granted, US government policies regarding technology transfer to China have been evolving, but it often is unclear about how one element of American policy towards China meshes (or not) with several other aspects. Seven strategic considerations represent the main drivers for US government technology transfer policy towards the PRC:

1) restrict and control the transfer of technologies, esp. in the dual-use category, to moderate the pace of Chinese military modernization in the context of a potential Sino-US clash over Taiwan;
2) limit the sale and transfer of technologies that would contribute to the enhancement of PRC's military power projection capabilities in Asia and around the world;
3) restrict and control the transfer of technologies, esp. in the dual use category, that would make or might make a demonstrable contribution to China's nuclear weapons systems and delivery capabilities;
4) utilize government policy and restrictions through end-user controls to limit or prevent the unauthorized "internal" diversion of dual use technologies sold by US firms from civilian to military applications in China;
5) to limit and intercede where appropriate to prevent industrial and military spying by China in the US regarding so-called "restricted" technologies, know-how and equipment;
6) promote US commercial interests in developing expanded US business ties with China and even assisting in those cases where technology transfer can be used as an asset or a form of leverage in negotiations and deal-making; and
7) support steady Chinese economic growth to promote a stable and secure China as well as the increased integration of China into the world economy.

While each of these provisions seems clear enough and one could argue that they steadfastly have been at the center of US government thinking about technology transfer to China, it also is the case that the emergence of tensions over non-technology related issues or the intrusion of new external factors into the atmospherics of the bilateral relationship frequently have led to less clarity about the precise meaning of several of them.

The crux of Sino-US stresses and strains in the technology transfer field have had less to do with the restrictions on the overt sale of munitions and weapons systems, and much more to do with the handling and disposition of so-called "dual use" technologies, especially with respect to technologies and equipment in such fields as semiconductors and integrated circuit technology, information and advanced communications/ tele-communications technologies, nuclear energy, aerospace and space technologies, etc. While American industry, driven by commercial opportunity and a desire for expanded economic bridge-building with China, increasingly has been willing to share advanced know-how with their Chinese counterparts, the US government frequently has sought to moderate these flows in the interests of US national security. The US Department of Commerce, which has played the primary role in overseeing the export control legislation, has been faced with a seemingly contradictory mission—to promote US commercial interests with China while at the same time imposing controls where US defense interests may be at risk.

The complexities of the Chinese system, of course, have not made their job any easier. Throughout the 1980s and into the 1990s, the close interactions between China's defense and civilian industrial and technology base was clear to US government and intelligence officials as well as scholarly observers of the Chinese situation. The designation of actual end-users was further complicated by the seemingly complex numerical naming system that the Chinese government used to obscure the precise activities of military-linked factories and R&D institutes. Close cooperation between ostensibly civilian organizations such as the Chinese Academy of Sciences and the Chinese defense establishment did not help matters from the perspective of the US government officials charged with protecting American interests. While common strategic concerns about the intentions and behavior of the former Soviet Union may have led to a forging of cooperation between the two countries in the early 1970s, the precise meaning of phrases such as "support the steady economic growth of China" or "encourage China's increased integration with the world economy" were not easily translated into actual policy decisions when American companies submitted requests for licenses to sell certain types of equipment and technology to the PRC. The situation was made further messy by the intermittent appearance of high-level discussions in public and private between the two countries about the possibilities for explicit cooperation in the defense area, including the transfer of technologies to remedy a range of deficiencies in China's defense-industrial sector.

Underlying the government-to-government problems regarding technology transfer was a rather explicit fact, namely that the level of political understanding and trust between China and the US had not reached a sufficient level to enable both Chinese and US foreign policy goals to be met. In 1984, while an assistant professor on the faculty at MIT, I wrote an article in MIT magazine "Technology Review" suggesting this state-of-affairs entitled, "Technology Transfer to China: Too Far Too Fast?" Rather than simply a statement, the addition of the "question-mark" in the title was meant to raise questions about the respective goals and expectations of the two countries regarding technology transfer. Simply stated, for the US, the technology transfer aspects of the relationship were generally seen as “the icing on the cake” in the context of larger international political and strategic military issues, e.g. the Soviet invasion of Afghanistan. For China, however, access to US advanced technologies was the cake itself! In many ways, one could argue that this underlying problem continues to confront both countries today as they seek to evolve their relationship to a new level in the 21st century.

Yet, US government policy aims and intentions still lack a degree of coherence that would allow the two countries to use the technology transfer relationship as a vehicle for forging closer ties and collaboration in commercial and political terms. The notion of US support for advancing Chinese economic growth has now taken on a sort of distorted twist. When this notion was first introduced, few in Washington DC could have imagined how fast and how extensive Chinese economic and technological development might be in just two-plus decades. However, it has never been the case that the US government or even US industry sought to or could control the pace and extent of China’s economic modernization; there are no valves or switches nor a giant control panel that the US government can implement, even in the area of export controls, that can very likely substantially moderate or alter the course of Chinese technological and economic development. This is especially true in a world of globalization, where there are more alternative sources of technology, more potential and actual business partners, and the degree of alignment among even OECD governments regarding tech transfer policies towards China is weak at best. My point is not that any US administration ever intended to adopt such a heavy handed approach, but rather that once the proverbial genie was let out of the bottle, the degree of American leverage was always going to be modest at best. Yet, with the rapid rise of China over the last 5-6 years, there seems to be a degree of surprise and awe as to how far and how fast the Chinese economy has come.

One of the key watershed events in the Sino-US technology transfer relationship was the publication in 1998 of the now infamous Cox Report, which laid out in great detail, though often with very specious evidence, a number of rather damning accusations about China’s behavior in illicitly acquiring American advanced technologies and know-how to support its nuclear and related military modernization efforts. The issue is relevant for this discussion because at the heart of the debate over the accuracy of the analysis and the finger-pointing were two US companies, Hughes and Loral, that in the pursuit of closer commercial ties with the PRC explicitly were identified as having violated, in a substantial fashion, US laws and restrictions on technology transfer to China. A third company, the now defunct McDonnell Douglas, also was later accused of similar kinds of alleged misconduct re: the transfer of advanced machine tools to China. The appearance of the Cox Report also occurred in the midst of the growing perception in the US government and in some quarters of US industry, that China was pressuring American firms to engage in technology transfer practices that were far more extensive than they were willing to entertain on their own. Boeing engineers, worried that their jobs might be jeopardized by extensive offset requirements for the sale of Boeing airplanes to the PRC, threatened to bring suit to the International Trade Commission in the US over China's alleged heavy handed business practices.

What made the Cox Report so ominous were the rather explicit statements about Chinese acquisition of US classified and controlled know-how to support their advanced nuclear weapons and delivery programs, and that the so-called "gap" between China and the US in these strategic weapons areas had been closed by the concerted efforts of the PRC to access targeted technologies by legal and illegal means. The report claimed that China has been engaged in a program of "systematic espionage" targeted against America's most advanced nuclear weapons facilities. To make matters even worse, China also was singled out for engaging in behaviors that facilitated the proliferation of weapons systems and components re: nuclear weapons to countries such as Iran, North Korea, Pakistan, Syria, and Libya. Moreover, the report suggested that the relaxation of US export controls towards China, combined with the demise of the COCOM control regime in 1994, had contributed to enhanced Chinese access to the US technology stockpile. The report also suggested that in view of the behavior of Hughes and Loral as well as McDonnell Douglas, it was clear that the decision to rely increasingly on self-policing corporate programs and systems to monitor the sale of controlled items was not working.

In raising these sensitive issues, it is not my purpose to prove or disapprove their veracity; nor is it my purpose to re-visit the highly charged atmospherics that surrounded US-China technology transfer relations as recently as 6-8 years ago. Rather, my point is to highlight the centrality of technology transfer matters in the bilateral relationship and the need to recognize that in the midst of the evolving Sino-US relationship, the need for building greater fundamental trust and understanding remains an on-going challenge. The appearance of the Cox Report apparently sent reverberations throughout the US Congress and intelligence community, raising all sorts of questions about whether American policy towards China had been naïve and mis-directed. It also sent some shockwaves throughout the Chinese political and S&T system as well — as senior Chinese leaders were faced with an interesting irony — what if indeed the Cox Report was true insofar as the claims about the reliance of the Chinese defense establishment on American technology were concerned? And, more importantly, what would be the nature of US-China collaboration in S&T areas in the future if the Cox Report did hold water? In many respects, the Cox Report, if only partially true, was perhaps an indictment of both the US and Chinese systems? Could the bilateral relationship withstand such an explosion — to use perhaps an inappropriate metaphor in this case!

Fortunately, the weak analysis, mis-conceptualization, and innuendo contained in the document were not allowed to carry the day in terms of the long-term efficacy of the Cox Report. A number of public challenges by highly credible US experts and observers of the Chinese scene were issued, blunting the potential for long-term damage to bilateral cooperation that could have occurred. Nonetheless, even today, the legacy of the Cox Report and its inflammatory accusations seems to remain as a thorn in the side of Sino-US technology transfer relations and has affected various aspects of the bilateral S&T cooperation relationship. And, while today the imperatives of globalization, the new face of international competition, and the tremendous opportunities stemming from China's rapid economic growth seem to be the principal factors driving US business thinking about China, the American government remains faced with the challenge of interpreting the seven core principals suggested above into actual policy on a continuing basis. With the US needing China's support on a range of global issues related to international terrorism, there are bound to be nuanced attempts to achieve some further breakthroughs on various technology transfer issues. US support for China's continued economic development vis-à-vis increasing levels of technology transfer, no doubt, remains strong and an essential component of Chinese expectations regarding the value of the bilateral relationship. American government understanding of how it can best leverage this interest for mutual benefit remains the challenge on the US side. Clearly, there are certain obligations and expectations that come from being a collaborative partner with the US, if only from the US perspective. Dialogue and discussion about how to translate those expectations into some agreed policy framework would do wonders for facilitating a more fruitful, productive tech transfer relationship in the years ahead.

The Impact of Globalization on Sino-US Technology Transfer Relations

The world system inherited from the 20th century is undergoing a series of rapid and pronounced changes, many of which promise to alter fundamentally the nature and flavor of international political affairs and commercial relations. Many of these changes have been engendered by the process of globalization, which has brought with it a great deal of both fluidity and turbulence. The prevalence of fluidity, in particular, stems from the fact that five major continental-size economies — China, plus India, Russia, Brazil and Mexico — have entered the mainstream of world economic and technology affairs. In essence, a new group of influential actors are emerging as key players in the existing regimes for trade, science and technology, environment affairs, etc. The high degree of turbulence emanates from the fact that the once dominant positions of the US, Europe and Japan are starting to give way as there are simply more actors trying to claim a place at the table for managing global affairs. Competition in the economic and technology realms have intensified as well. And so far, it is unclear what the ultimate character and structure of a so-called "new 21st century world order" might look like as more and more state and non-state actors are jockeying for power and position in various regional and international negotiations.

Globalization has had a particularly major impact in the domains of technology, innovation and competitiveness. As Thomas Friedman has argued in his widely read book, The World is Flat, over the last several decades, we have witnessed the emergence of new centers of technological excellence outside of the OECD economies. Instead of simply offering cheap, low-skilled labor, economies such as South Korea, Taiwan, Singapore, Hong Kong, and now China and India, are able to offer high-end technical and engineering talent. As a result, the processes of technology exploration and exploitation have become transborder and transnational. Moreover, in contrast to the traditional 1960s/1970s-based, product life cycle described by Raymond Vernon and Louis Wells at Harvard University, we are witnessing the more rapid movement of new know-how and technology overseas at an earlier point in their life-cycles. Moreover, instead of the previous situation, which was characterized primarily by the unilateral flow of technology, we are now experiencing something more akin to a bilateral flow — to get technology, you might have some technology to offer.

Today, the global innovation environment can best be viewed as a type of ecosystem in which an assortment of factors and forces are co-existent with one another. The most salient features of this ecosystem are a) the growing tendencies towards collaboration and cooperation as a means to reduce risk and acquire needed complementary assets; and b) the increased emphasis on speed, namely enhancing the pace at which embryonic ideas are translated into new commercially viable products and services. The growing willingness, if not necessity, to collaborate combined with the added emphasis on speed have led to a further internationalization of the R&D process. A study completed under the sponsorship of the US National Academy of Sciences in early 2006 has noted that the research activities of the world's leading multinational firms will increasingly be sent to the strong, fast growing economies of the world with strong education systems. More than 38% of the 200+ MNCs surveyed in the NAS study plan substantial changes in the worldwide distribution of their R&D work over the next 3 years. The findings of the NAS report are consistent with previous results obtained by the Economist in a 2004 analysis of the technology strategies of MNCs. In both instances, the existence of lower labor costs and/or tax incentives in these economies were not the overriding consideration for the strategic shifts that are about to occur. Rather, the need for local product adaptation and the high quality of the local talent pool were the major drivers.

In essence, globalization is producing a huge shift in the process of knowledge creation. For example, while the US still remains, by far, the dominant purveyor of new technologies and accounted for 38% of global R&D spending in 2005, China has moved to the number three position in the world — accounting for 9% of the world's spending on R&D. Japan, in the number two position, accounted for 15%. Of course, the US remains the global leader in terms of total aggregate spending by a large margin, but the once seemingly unassailable dominant position of the American economy is being challenged by the rise of alternative centers of complementary and competing capabilities around the world. International R&D patterns have started to reflect some of these shifts, as evidenced by the appearance of over 750 foreign R&D centers in China since 2000. The present situation stands in sharp contrast to the prevailing order for much of the post WWII period. Agglomeration dynamics up until the mid-1990s actually had led to a greater concentration of R&D activities. Despite calls for greater diffusion of technology and R&D activities arising from the call for a New International Economic Order in the 1970s, the fact is that not much had changed in the location of key technology related activities. Globalization, however, has led to a reformation, restructuring and re-definition of existing technological networks. Granted, in some industries these shifts are stronger and more apparent than in others, e.g. autos and electronics versus processed foods. Nonetheless, the new equation — technology attracting technology (hardware and software) — seems to hold true across the board. GE's worldwide R&D system best personifies this new alignment—along with its major global R&D center in Niskayuna, New York (near Albany), GE now has active R&D centers in Shanghai, Bangalore, Munich, and St. Petersburg, Russia.

In fact, the so-called "New GE" as labeled by CEO Jeffrey Imelt, embodies the notion that innovation should be a core value throughout its facilities around the world. The "Imelt Revolution" inside of GE is about creating and supporting a broad range of "imagination breakthrough" projects. Each of the global labs is to serve as innovation magnets and catalysts. From Imelt's perspective, the only way to get closer to the customer is to globalize R&D. Executive compensation, in this model, will be increasingly tied to innovation performance.

GE's experience resonates well with a new business model that Business Week magazine has called "the globally cooperative corporation." According to the BW definition, the ecosystem of knowledge creation is shifting toward reliance on transborder innovation communities and networks. More and more companies are utilizing outside knowledge networks to spur innovative behaviors. Inside P&G, for example, 35% of that firm's products come from outside the firm, up from 20% just three years ago. IBM's Global Innovation Outlook 2006 makes a somewhat similar point with its emphasis on leveraging the collective intelligence and expertise of employees, customers, clients and vendors from around the world. Today's international firms are more porous, more decentralized, and more global than ever before. The Internet is playing a key role in enabling a broad range of individuals and small groups as well as formal organizations to interact, exchange ideas and share knowledge. A new innovation platform is clearly being forged.

Accenture, the world's leading systems engineering consulting firm, refers to these new developments in terms of the rise of the "connected corporation." Hierarchical, insular firms are disintegrating and giving way to firms able to operate within and across industry and organization boundaries that are becoming increasing blurry and amorphous. To ensure that innovation is relevant and market driven, at the center of the connected corporation are its customers. For Accenture, customers must be so integrated into the new corporate fabric that they are involved in everything from product design to the configuration of the supply chain. These trends have been exacerbated by the outsourcing and off-shoring revolutions that have occurred over the last decade or so. "Transformation outsourcing, i.e. leveraging offshore talent to strengthen firm performance and productivity, has meant the introduction of radical business models aimed at changing the nature of competition. The so-called "liberation" of firms from traditional modes of structure and process has been done with the goal of enhancing innovation. Today, as Gary Hamel has noted, corporate resilience — the ability to survive and thrive in this new setting — is derived from the imperative of getting different — and the principal source of getting different is built on unique innovative capacity and capability.

The onset of globalization has had a huge impact on the perspective of US firms regarding China and the potential role the Chinese economy will play in the years ahead. Whereas once China was a marginal player on the outskirts of the global innovation system, today it is steadily moving into the mainstream. To be a global company, it was once thought that simply having a manufacturing plant in the PRC was sufficient. Today, it is now increasingly the case, that to be a truly global firm, a company — whether it is IBM, Intel, Microsoft, etc. must have an R&D and perhaps engineering presence in China. This transition is reflected, as suggested earlier, in the growing appearance of foreign R&D operations in China, with American firms in the lead in establishing not just domestically-oriented product adaptation workshops, but rather full-fledged R&D operations that employ hundreds and thousands of Chinese scientific, technical and engineering personnel. This transition in the nature of foreign investment to China has shifted the foci of technology transfer, perhaps from the more formal mechanisms to more informal ones via the circulation of high level talent in China. In fact, the major issue facing American companies in China today as they move up the value chain and engage in more higher value-added activities is the competition for high-end, experienced technical and engineering talent.

American companies not only see China as a growing market, but also as a source for high end talent. Still, the attractiveness of the domestic market remains real and ever-present in their strategic thinking about how to engage with the PRC. Not surprisingly, this interest in the potential of the Chinese market is shared by European, Japanese, and Korean companies, along with Chinese domestic enterprises. In fact, it is safe to say now that the dynamics of global competition have moved to center stage in the Chinese market; China has become the principal battleground for the playing out of competition between US, EU, Japanese and Korean firms. This suggests that the flow of technology transfer to China might even increase in the coming years as many of these firms attempt to utilize their advanced technology and IP as a way to "win" in the Chinese marketplace. American firms increasingly will be faced with a new strategic imperative: win in China or lose globally…a daunting thought given that just a decade ago, China was still, relatively speaking, on the periphery of the global supply chain and innovation system. GE is an excellent example of a company moving in this direction. Over the last several years, it has implemented its 5+5+5 program…..by 2005, source US$5.0 billion out of China while selling US$5.0 into China. Motorola has implemented a similar program for 2010 — 10+10+10! This huge expectation on the sourcing side has meant that GE engineers and technicians have been working closely with Chinese parts and component suppliers as well as product manufacturers to ensure that they meet world quality standards and production schedules. As one GE executive commented, in these cases, their principal concerns in the IPR area are less over formal violations and more concerned with the loss of trade secrets and embedded know-how. This type of "soft" technology transfer has been and promises to continue to be an important ingredient in China's formula for more rapid, sustained technological progress.

Globalization also has meant an even greater role for the so-called Chinese Diaspora in the US. This pool of technologically well-trained, commercially networked Chinese business executives and mangers in the US represents an important part of the technology transfer relationship; they bring to China critical know-how and ideas about industry and technology trends as well as access to venture capital and other investment funds. The new class of technological entrepreneurs in China will be aided and assisted by the accumulated knowledge provided directly and indirectly through the American and global Chinese network — not in a nefarious manner, but in a mode consistent with the development of an entrepreneurial class elsewhere in the world. The world of MBA training in China, which has grown by leaps and bounds in less than a decade, owes much of its roots to ties with the US, including the well-regarded, but now defunct US-China Management Training Center established in Dalian in the early 1980s. The "transfer" of American managerial know-how to China through advanced education as well as formal and informal tech transfer projects has proven to be an invaluable component of China's rapid advances in manufacturing.

Chinese leaders have clearly embraced globalization, which means that some of the advantaged position held by US firms during the last twenty years may begin to evaporate as more technology transfer channels and options are available. Competition in the Chinese market is only going to further increase, which lead some firms to opt out of China because of the numerous business and operational challenges that remain. Nonetheless, it does seem clear that there are indeed good reasons to expect the US and China to stay tightly engaged in a range of critical technology fields. Fortunately, the choice for each country is not "zero-one" in terms of technological cooperation, but rather how to engage more effectively, more smoothly, and more seamlessly with one another with a shared set of common expectations and rules. Chinese companies also will have to become more adept at working in the new collaborative, networked environment if they hope to play at the cutting edge of global technology competition and innovation. Of course, new problems are bound to appear in Sino-US technology transfer relations as the recent disagreements over technical standards regarding Wi-Fi and cellular phones suggest. Nonetheless, the fact that China is more closely integrated into the global innovation system and that US R&D operations in the PRC are a force for increasing this integration should be viewed in a very positive light. This phenomenon, combined with China's new emphasis on "zizhu chuangxin" (indigenous innovation) has already meant, for example, growing Chinese vigilance regarding IPR protection and enforcement. The potential for synergies remain substantial, with benefits that clearly go beyond the confines of the borders of both nations.

Whither Sino-US Technology Transfer Relations?

Technology transfer in the commercial realm will continue to be one of the most salient dimensions of the Sino-US bilateral relationship. The relationship has evolved from being hierarchical to one where there is much more symmetry and give-and-take. Recognizing and understanding the accompanying concerns and issues will go a long way towards pre-empting potential problems and future minefields. On the Chinese side, it appears that there needs to be a greater sensitivity to the issues of concern to the US in the military realm with regard to the appropriate use of dual-use technologies and the allegations regarding illegal acquisition of technology in the commercial-industrial realm. In a world of globalization, national responsibilities may actually increase as there are fewer and fewer barriers to the global diffusion of technology. This is something that must be appreciated within and across China as there remains a fragile core insofar as the damage that could be done from the appearance of a new Cox-like Report or something similar. As already has become known, the American government decision regarding future purchases of Lenovo computers from China, now that IBM's former PC business is owned by a Chinese firm (Lenovo), could portend other such problems in the future — this could be the case even if the imperatives of globalization that are generating more interconnections between the American and Chinese economies. Sensitivities regarding China already are high in the US, and many American companies are extremely concerned about their domestic image at home with respect to out-sourcing of manufacturing and services, off-shoring of R&D, technology transfer and job loss, etc.

For the US, it is time to recognize that the lag in perceptions and behavior around China technology issues between government and business must be bridged. Too much negativity continues to pervade the halls of Congress and other US government agencies as to Chinese goals and intentions. Debating whether China's growth is bad or good for the US simply is counterproductive in most respects; Chinese growth and modernization is occurring and will continue to take place with or without US participation. Chinese pursuit of its economic interests and technological needs are not inherently antithetical to American interests insofar as we understand and recognize, that as a sovereign nation, China will indeed pursue its own path. Our goal, from the perspective of American business, should be to continue to engage China, to continue to build long-tern relationships and deepen connections, and to forge a long-term strategic network throughout which we can pursue our joint interests re: innovation, production, and building a better society for our citizens. A vibrant Sino-US relationship in the area of technology transfer is critical for American competitiveness in the years ahead and also critical for the performance of the American innovation system. American and Chinese "brainpower" and expertise joined together in the pursuit of common commercial as well as societal goals should be considered one of the fundamental building blocks for long-term, sustainable American prosperity as well as the continuous overall improvement in the quality of life for the Chinese people during the 21st century and beyond.

Who is the Winner ?

——IPR Review in S & T Cooperation

Prof. DUAN Ruichun

State-owned Assets Supervision and Administration Commission (SASAC)

- Director General, Dept. of Policy and Law of State S & T Commission / Ministry
- Director General, IPR Office of State Council Conference
- Chief Negotiator in China Entry WTO / IPR Negotiations
- Vice Minister Official of State Own Assets Supervision and Administration Commission of State Council

S & T Cooperation Agreement Between China and USA

- First Agreement after Recover Diplomatic Relation in Jan. 1979
- Contribute more to Both Countries' Science and Technology Communities.
- One Issue had not Clearly Regulated in the Relationship: IPR

Where the First fighting in IPR Occurred Between China and USA?

The Annex of S & T Cooperation Agreement

- Condition of Technology Transfer
- Ownership and Sharing of IPR conducted under the Joint R & D Results
- The Treatments for the Differences of IPR Legislation in Two Countries.

Main Issues in IPR Negotiation Related to China WTO Entry

- Standard and Level of IP Protection in Legislation
- IPR Enforcement in China and Action Plan
- Marketing Access of Foreign IPR Products

The stories of Special 301 of 1995 ~ 1998: Announces of Sanction and Countersanctions

THREE PRINCIPLES for IPR Insures

- EQUALITY AND MUTUAL BENEFIT
- BASED ON NATIONAL CONDITION
- CLOSE TO INTERNATIONAL RULES

- Governmental S & T Agreement with 98 Countries
- Reach the Requirement of WTO in Legislation
- Shaping Better Platform for Cooperative Affairs

Important Issues on IPR Five Years After Entry to WTO

- Innovation and IPR Raising to National Strategy
- Big Leap of Legislation in Accordance with TRIPS
- IPR Business Scope Ranked World Top Level
- More IPR Institutes and Enterprises Coming up

IPR Legislation in China

	Law and Regulations	Date in implementing
1	Trade Mark Law	Oct. 27, 2001
2	Patent Law	Aug. 25, 2000年
3	Technology Contract in Contract Law	Oct. 1, 1999
4	Copyright Law	Oct 27, 2001
5	Regulation on Computer Software Protection	Jun. 1, 2002
6	Law Against Unfair Competition	Des. 1, 1993
7	Regulation on the Customs Protection of Intellectual property	March 1, 2004
8	Regulation on Protection of New Varieties of Plants	Oct. 1, 1997
9	Regulation on the Protection of Layout-Designs of Integrated Circuits	Oct. 1, 2001
10	Regulation on the Protection of Olympic Symbols	Apr. 1, 2002
11	IPR in Civil Law Principles	Jun. 1, 1987
12	Crime of IPR infringement in Criminal Law	Oct. 1, 1997

Problems in IPR Eforcement

Big Leap Steps
in connection with
Many Blank Pages

Such as
Changing Social Conceptions,
Designing Implementing Rules,
Making of S & T Policies,
Training of Enforcement Teams,
Learning of Judicial Experiences,
Establishing of Legal Environments,
Supporting to IPR-based Enterprises

Evaluation on IPR Infringements and Piracies

MY OPINION : MAINSTEAMS?

More damages
to domestic industry than foreign investment,
More harmful
on spirits and morality than substance aspects
More negative impacts
In long-term course than current affairs

Crackdown IPR Infringements is very Important to Improve the Environment for China's Innovation and Mutual Cooperation.

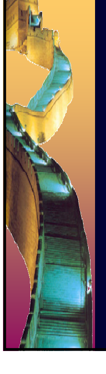
New Steps in IPR

The 11th Five Year National Plan for Economic and Social Development (2006-2010)
Adjusting Economic Structure Based on Innovation

National IPR Strategy Up to 2020 will be Issued and Carried Out by State Council

IPR Protection Action Plan 2006 ~ 2007 Issued by National Leading Group

Conclusion



Let us join our hands to strengthen our ties in cooperative innovation and IPR protection so as to make great progress and reach win & win and co-prosperity.

China-US Science and Technology Cooperation: Past Achievements and Future Challenges[1]

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Cao Cong
University of Oregon and the Levin Institute of the State University of New York

I. Background.

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

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

II. Conditioning Factors.

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

[1] This paper grows out of research conducted with support from the US National Science Foundation (NSF OISE-0440422). We are also grateful to Jin Bihui of the Chinese Academy for sharing unpublished data on China's international co-authoring with us.

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

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

III. The Nature of Cooperation.

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

As the asymmetries in capabilities and institutions faded, and as hundreds of thousands of Chinese students came to receive education in the United States, we have seen the growth of active research collaboration. This can be measured, however imperfectly, by the growth of co-authoring of

2. Richard P. Suttmeier. *U.S.-P.R.C. Scientific Cooperation: An Assessment of the First Two Years*. Report submitted to the Department of State. June, 1981.

scientific papers by researchers in the two countries. Let us briefly review some of the data which describe trends in this co-authoring.

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

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

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

IV. Brain Drains, Gains, and "Circulation."

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

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3. Source for all figures: Jin Bihui, Chinese Academy of Sciences.
4. US National Science Foundation. *Science and Engineering Indicators, 2006.* Appendix 3-18.

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

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

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

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

V. Looking to the Future.

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

1. The Central Importance of China's Medium to Long-term Plan (MLP). China's new MLP represents a fascinating and ambitious effort to bring Chinese science and technology into a leading international position by the year 2020, while also harnessing S&T for the solution or amelioration of pressing national problems.[6] While it is sure to have false starts and

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5. Personal communication
6. See, Cong Cao, Richard P. Suttmeier, and Denis Fred Simon. "China's 15-Year Science Plan: Mapping Research and Innovation Strategies for the 21st Century." *Physics Today*. December, 2006. Pp. 38-43.

disappointments, it nevertheless involves major commitments of resources and intellectual and administrator energies which will shape Chinese research and innovation experiences over the next 15 years. As such, it also offers a template for international cooperation, as discussed further below.

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

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

4. *National Security.* National security concerns have clearly become much more important in shaping the context for the bilateral S&T relationship. In the past, export control issues have been a constant irritant in the relationship, but in light of the asymmetries in power, have been manageable. As differences in the power positions of the two countries narrow, export control questions have become more complex and daunting. The post-9/11 security environment in the United States has produced important changes in immigration policy and implementation, changes which have been irritating to China and have helped sour the attitudes of many members of the Chinese technical community towards the United States. Changes in US immigration policies have had parallels in the export control area as export control policies are being extended to cover the movement of people ("person embodied technology") under the rubric of "deemed exports." While the United States has declared that it seeks to find the right balance between national security and scientific freedom, post-9/11 policies have been tilted towards the former and have the potential to undermine the further development of the S&T relations with China. This is especially the case if deemed export policy is allowed to discriminate against foreign-born scientists on the basis of their country of origin. As seen above, a great deal of bilateral cooperation is built upon the research collaboration between ethnic Chinese in the United States and their counterparts in China.

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

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

VI. The Importance of the MLP.

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

For instance, the MLP places strong emphasis on science and technology in support of the supply of *public goods* - energy, environment, agriculture, public health, etc. These are matters of great concern for the United States as well, and how these two big countries manage these problems has obvious global significance. While not exclusively matters of government concern, these all call for the active involvement of public agencies. Fortunately, the existing government to government agreement has led to a tradition of cooperation in these areas and provides a framework for new initiatives. The recently signed agreement for the supply of nuclear power plants to China illustrates the potential usefulness of this framework.
The MLP also targets the expansion of *basic research* into exciting new areas of science. Again, a good framework for cooperation here exists in intergovernmental and inter-institutional agreements, but also in the critical role played by the scientific diaspora in collaborative research. In this area, governments have a role in facilitating easy travel and communication and, in this context, some of the security inspired policy initiatives of the US side are cause for worry. Successful collaboration in basic research also requires a serious regard for scientific integrity and a system of research administration which maximizes the chances that outstanding work will be supported.

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

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

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

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

VII. A New Stage.

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

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

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

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

Fig. 1 CHINESE INTERNATIONAL CO-AUTHORING

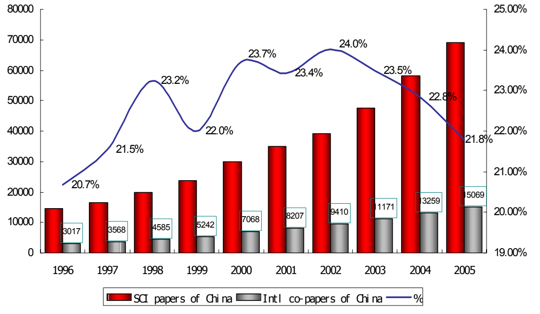


Fig. 2 LOCATION OF CHINESE COLLABORATORS

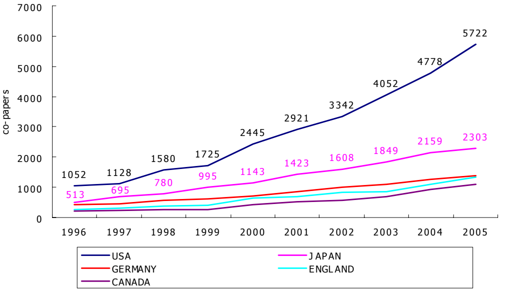


Fig. 3 US CELL BIO '96

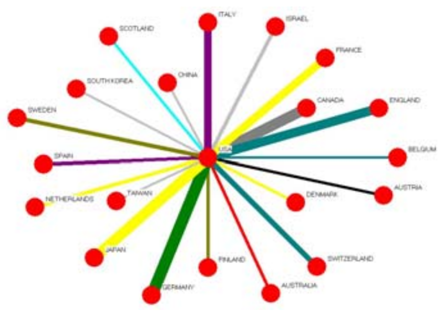


Fig. 4 US CELL BIO '05

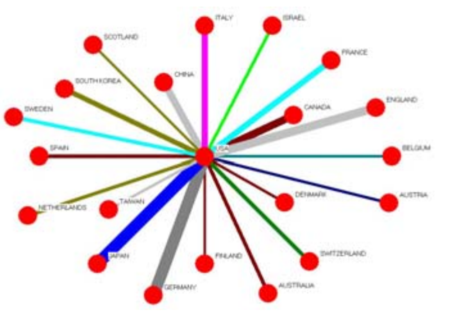


Fig. 5 PRC CELL BIO '96

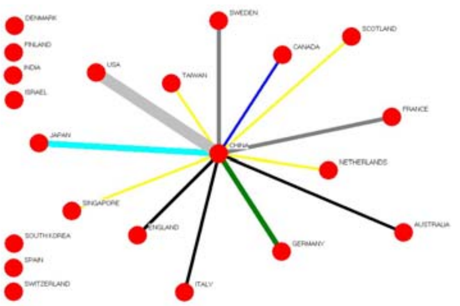


Fig. 6 PRC CELL BIO '05

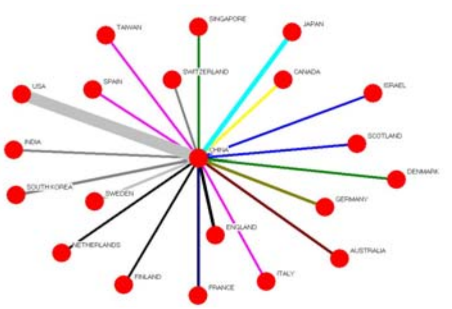


Fig. 7 US GENETICS, '96

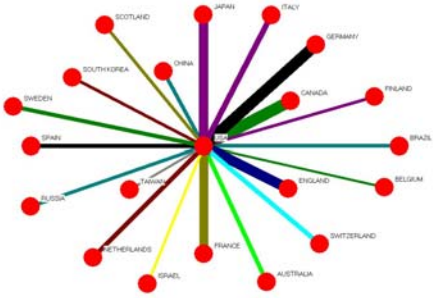


Fig. 8 US GENETICS '05

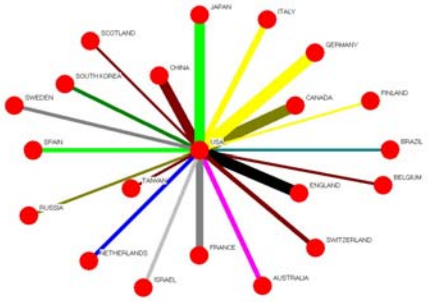


Fig. 9 PRC GENETICS '96

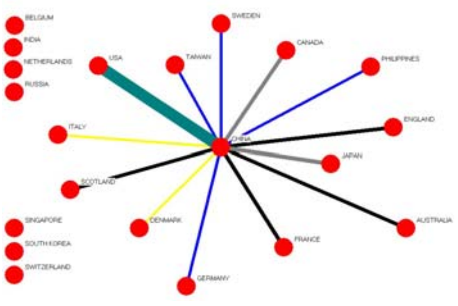


Fig. 10 PRC GENETICS '05

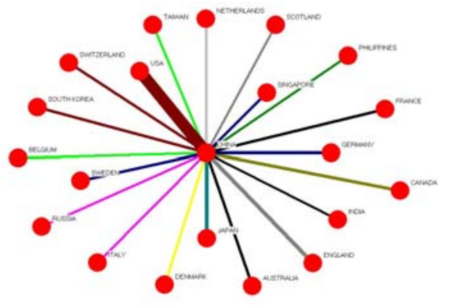


Fig. 11 US CHEM '96

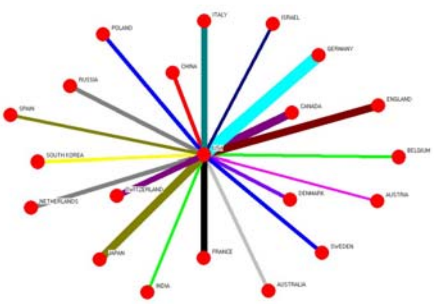


Fig. 12 US CHEM 05

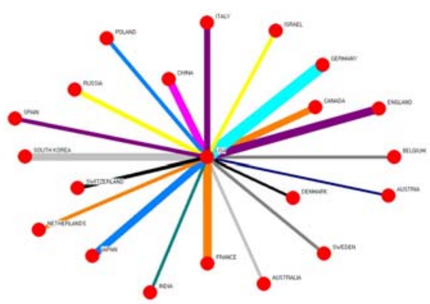


Fig. 13 PRC CHEM ‘96

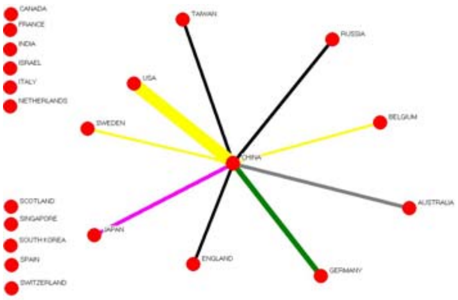


Fig. 14 PRC CHEM ‘05

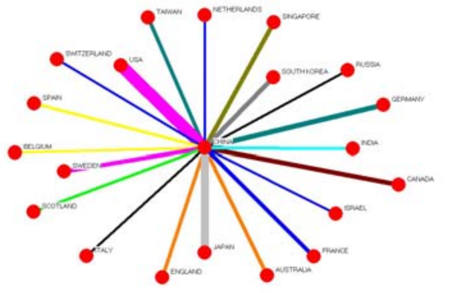


Fig. 15 US NANO ‘96

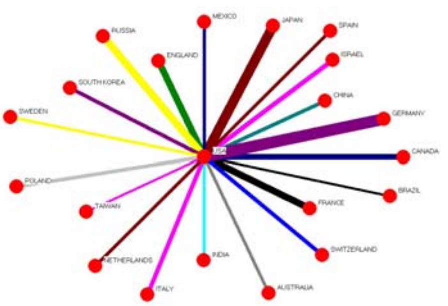


Fig. 16 US NANO ‘05

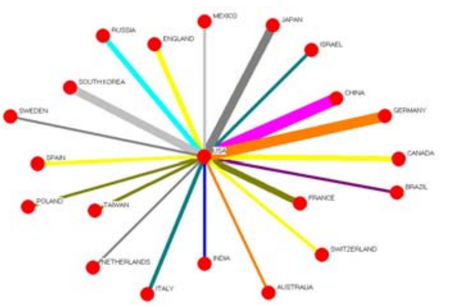


Fig. 17 PRC NANO ‘96

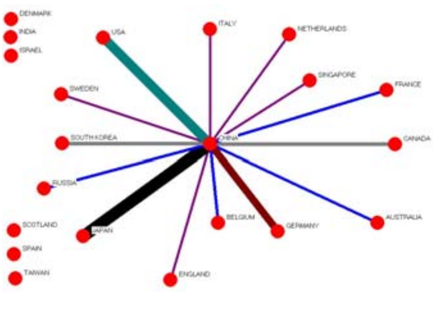
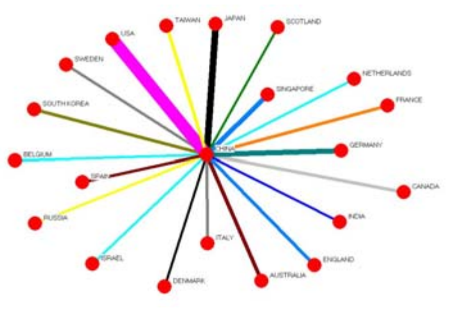


Fig. 18 PRC NANO ‘05



Sino-US cooperation of *Management Sciences*: A perspective from NSFC for the recent 25 years

Dr. Wei Zhang, Deputy Director
Department of Management Sciences, NSFC

October 2006

First touch with US

- After the "culture revolution", China began to send scholars to US to study management in early 1980's
- Chinese system scientists, most of whom had the experiences of study in US before, began to direct their research objectives (the "systems") to the "social-economic" systems in China

First touch with US

- During that time, mathematical programming models and optimal dynamic control theory were applied to the macro-level of the systems for the needs of central-planned economy
- These are basically the *Management Science* adopted from US
- The research was more "model-oriented"

Market economy as the driving force

- In early 90's, MBA education was introduced from USA, since it is gradually clear that establishing a market-economy will be the ultimate objective of China's economic reform
- A new area of management study was emerging to focus on the behavior of enterprises, the micro entities and the basic elements of the market-economy

Market economy as the driving force

- During the whole 90's, business schools in China developed very quickly
- Chinese scholars in this area began to develop academic cooperation, both in education and in research, with US professors
- However, the studies were more in a "imitating" way, i.e. US problems were studied with Chinese data

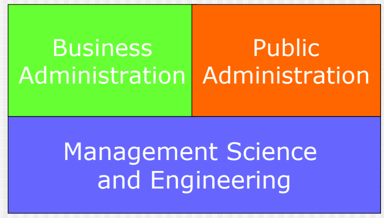
New century, new progress

- At the turn of the century, China is furthering her institutional reform to pursue a more balanced, sustainable, harmonious development
- This means that the governments will pay more attention to social and public affairs, not just to economic growth

New century, new progress

- This practical trend stimulated the need of research in social system management and public administration
- MPA education was, then, introduced from US and related studies with US scholars are increasing rapidly

Building blocks of the *Management Sciences*



"*Management Sciences*" define by NSFC

Trends for tomorrow (1)

- *Management Sciences* are more "context-related", comparing with the "pure sciences"
- It is aware that simply applying western models to Chinese data will not work
- Problem-driven and China-specified studies are gaining more and more attention; new phenomena are discovering and new theories are developing

Trends for tomorrow (2)

- With the increasing impact of China to the world economy, international management scientists, including US ones, began to show their interests in studying Chinese issue
- Chinese scholars are becoming the real academic "partners" of them, no longer the pure "data collectors"

Trends for tomorrow (3)

- Though cooperation with US scholars are still the "main stream", the "context-related" feature of *Management Sciences* makes Chinese scholars more open-minded in international collaboration
- Management knowledge developed under other economies, such as EU, India, Korea, Russia, et. al., are also valuable to China's economic and social development

Conclusion

- Sino–US cooperation has laid a sound foundation of China's *Management Sciences*
- The new level of the cooperation will lead this discipline to a "regime shifting": from following others to making more original contributions to to the global knowledge of management

Proceedings of the China-U.S. Forum on Science and Technology Policy

Section IID– Roundtable 2: U.S. China Relations in the Globalized 21st Century

The Sino-US International Forum on Science and Technology Policy

October 16-17, 2006, Beijing China

The S &T Capacity of US and China: --Change and its Impacts

Mu Rongping

Institute of Policy and Management, Chinese Academy of Sciences

Outline

I. The Gap in Science & Technology

II. The Leading Country in S&T

III. Possible Cooperation in S&T

I. The Gap in Science & Technology

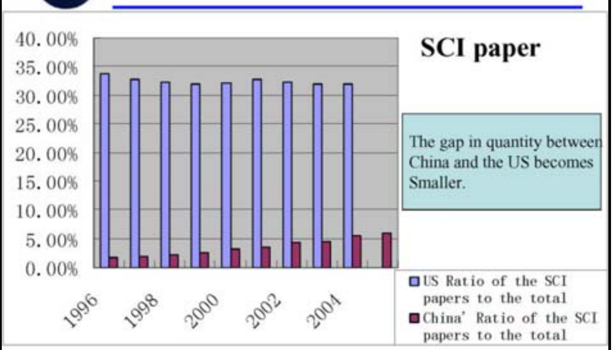


Chart 1 The ratio of SCI papers to the total

I. The Gap in Science & Technology

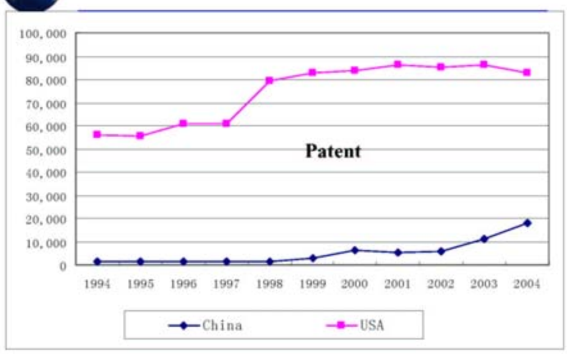


Chart 2 The Number of Domestic Granted Patents in China and the USA

I. The Gap in Science & Technology

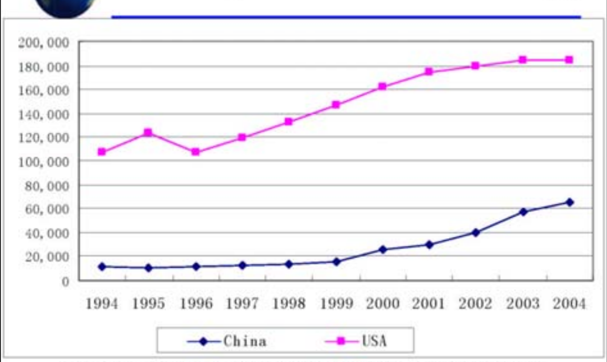


Chart 3 The Number of Domestic Applied Patents in China and the USA

I. The Gap in Science & Technology

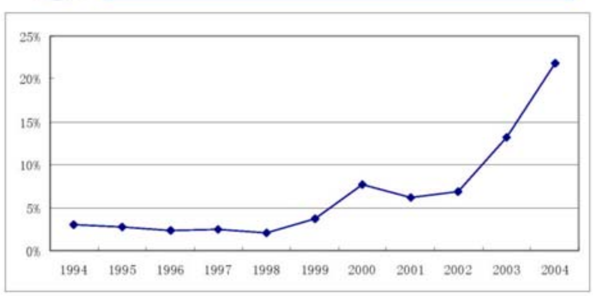
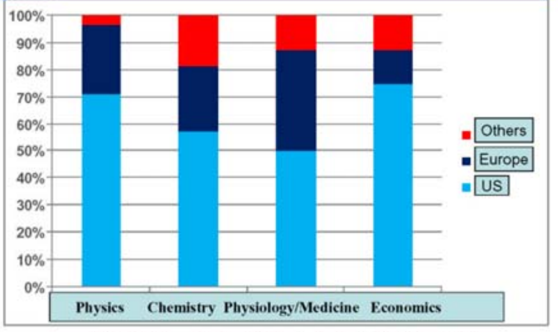


Chart 4 The Ratio of the Number of Granted Patents in China to that of the USA

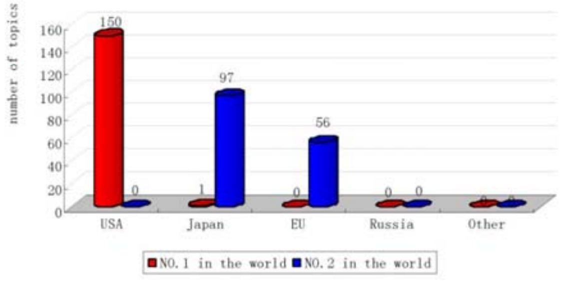
II. The Leading Country in S&T



Distribution of Nobel Prize in the World 1996－2006

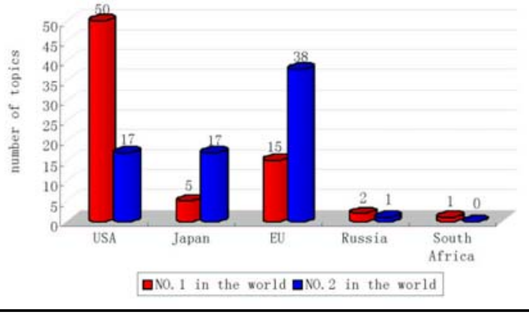
II. The Leading Country in S&T

ICT and Electronics



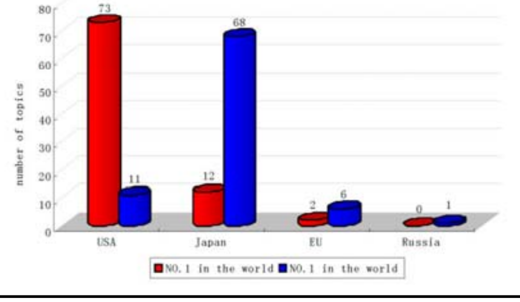
II. The Leading Country in S&T

Energy



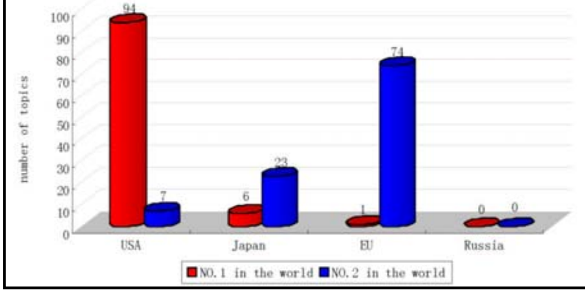
II. The Leading Country in S&T

Materials



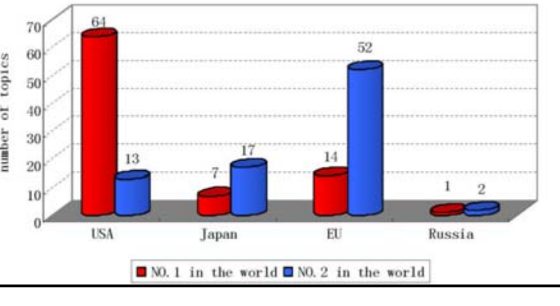
II. The Leading Country in S&T

Biology and Medicine

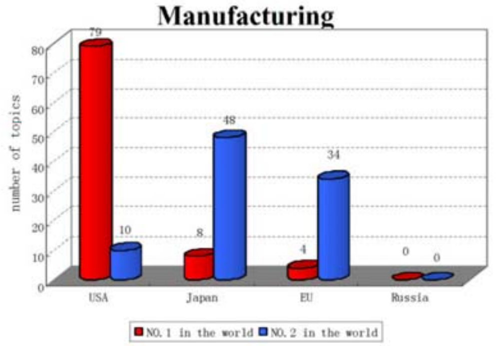


II. The Leading Country in S&T

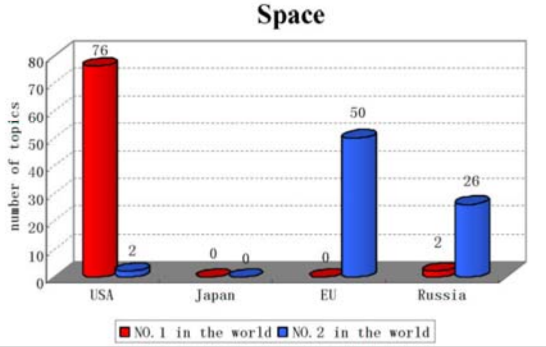
Resources and Environment



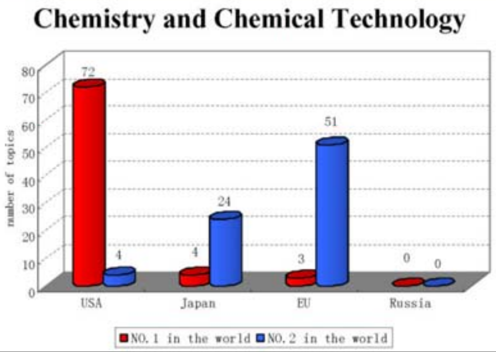
II. The Leading Country in S&T



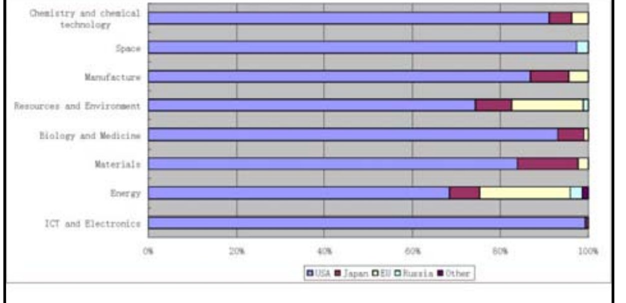
II. The Leading Country in S&T



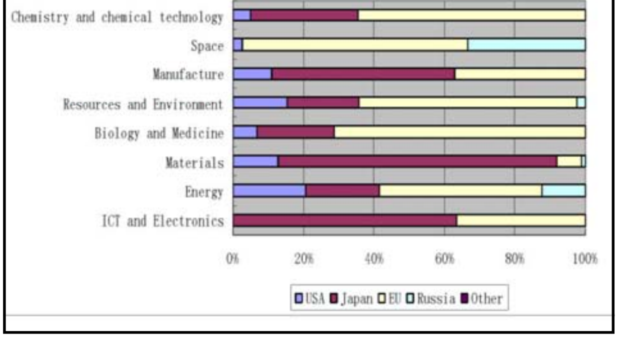
II. The Leading Country in S&T



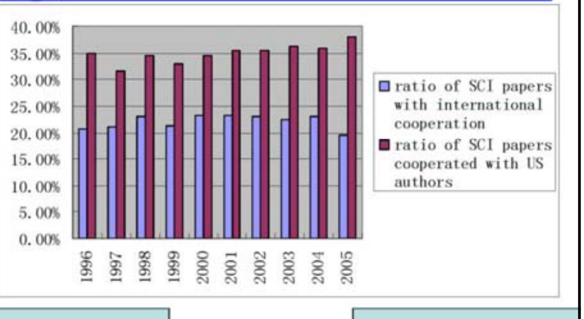
Distribution of Leading Country of Technology Topics



Distribution of the Second Leading Country of Technology Topics



III. Possible Cooperation in S&T



- Globalization
- Cheaper Labor forces

- Abundant Human Resources
- Huge Market

A Time of Unprecedented Opportunity for U.S. – China Cooperation in Science and Technology

Neal Lane
Rice University

Thank you, Mr. Chairman.

I would like to take a few minutes, this morning, to share an optimistic perspective about the future or U.S.-China cooperation in science and technology. I believe it is a time of unprecedented opportunity.

Let me make several statements or assertions, and then follow up with a few comments on each.

First, I think there is little question that our two countries will emerge as world leaders in our respective hemispheres; and each of us face enormous challenges that will require the knowledge and tools of science and technology.

Second, the past century of advances in science and technology has shown that progress, as a nation, requires significant government investments in R&D, freedom on the part of the researchers to pursue the most interesting and important questions, and open sharing of ideas and results.

Third, the U.S. and China have had a long history of informal collaboration between U.S. and Chinese researchers and formal cooperation in selected areas of science and technology, under the "U.S.-China Agreement on S&T Cooperation" and its protocols; but the scale of cooperation has not matched the opportunities, especially in recent years.

Fourth, we are now entering a time of unprecedented opportunity for scientific cooperation between our two countries on a much larger scale than in the past. And it is in both our best interests to take advantage of that opportunity.

Let me make a brief comment about each of these:

My first assertion is about leadership and challenges.

The U.S. and China, indeed all nations of the world, face some common challenges, for example: meeting rising demands for clean, efficient and carbon-free energy; reducing the emissions of CO_2 and other greenhouse gases; cleaning up our environments; providing food, clean water, sanitary living conditions, healthcare and education to our populations; and making it possible for our people to lead secure and peaceful lives.

The energy challenge is, in many ways, the most important. Because without sufficient amounts of clean, carbon-free energy, it is difficult to see how the other challenges can be met. Moreover, no simple extrapolation of current energy technologies (and known reserves of oil, natural gas and coal) appears to meet the world's needs in the 21st century. My former colleague at Rice and Nobel Prize winner, Rick Smalley, who sadly died this past year, often spoke about the need for revolutionary new energy technologies, which he felt nanotechnology would offer. One reason I worked hard to help put together President Clinton's National Nanotechnology Initiative is because I agreed with Rick Smalley. The promise of nanotechnology is enormous; and the research community is making good progress, e.g. in areas like catalysis.

Second on my list of assertions is the need from substantial government investments in R&D and freedom and openness in carrying out the research. I'll comment on the funding situation.

The U.S. total investment in R&D (government and industry funding) is about $300 billion per year (estimate for 2004). The federal government currently spends approximately $ 135 billion per year (2006) in R&D. But over half of that is in defense-related work, primarily weapons development and testing. The research portion of federal funding is about $ 57 billion per year (2006). In the U.S., biomedical research, funded by the National Institutes of Health, has been a very high priority and currently represents half of all federal research funding. However, in recent years, NIH funding has not kept up with inflation. The major funding agencies for the physical sciences are the National Science Foundation (NSF), the Department of Energy (DOE) (Office of Science), and the National Aeronautics and Space Administration (NASA). The President has pledged substantial increases for NSF, DOE (Office of Science) as well as the National Institute for Standards and Technology (within the Department of Commerce) in the coming years. But pressures on the overall federal budget are likely to limit this growth.

My third assertion – that the U.S. and China have had a long history of cooperation in S&T but that the level of cooperation has not matched the opportunities – is evident in a number of studies and reports, in the materials we have received in advance of this meeting and the excellent discussions we are having. U.S. industry has recognized that increased cooperation with China is important not only because of market considerations but also because of the availability of skilled workers, including scientists and engineers in China. Similarly, there are opportunities for increased collaboration in science and engineering research, especially basic research, which is primarily supported by the federal government.

My fourth assertion follows from the third; and it is the point I want to emphasize. I believe that we are now entering a time of unprecedented opportunity for scientific cooperation on a much larger scale than in the past. And it is in both our best interests to take advantage of that opportunity.

Again, I will choose energy as, perhaps, the clearest example. But there are many examples.

In the case of energy, we in the U.S. consume energy at five times the world average and over twice that of Europe, per capita. Correspondingly, we are one of the greatest emitters of CO_2 on the planet. Our challenge is to use energy more efficiently, aggressively pursue renewable energy sources for significant portions of our energy needs, and cut back emissions substantially. This can be done with innovative technologies and sound policy.

In the case of energy and China, you understand the issues far better than I do. But, one thing is clear. China's energy consumption, per capita will increase along with economic growth. With sufficient investments in energy R&D and in the demonstration and deployment of new energy technologies, China can improve on the Western experience by using technologies that did not exist when the U.S. and other Western nations were building up their energy infrastructure. Some of those technologies still don't exist or are not yet ready for deployment. So, considerable R&D is necessary. And since both our countries could benefit, much of that R&D can be done collaboratively. The list of cooperative activities, under the energy protocols, is impressive; but I am confident they are under-funded. Energy R&D focused on U.S. domestic needs is also under-funded by a factor of two or three or more. The U.S. has been "addicted to cheap oil" for a very long time; and that fact is reflected in the lack of attention the U.S. has given over the years to alternative energy sources. Fortunately, with the high price of oil, the political winds are shifting in the U.S. It is becoming clear to the U.S. public that "business as usual" will not be possible in the future. Furthermore, most Americans are concerned about global warming and inevitable climate change. So for the first time, perhaps in its history, the U.S. is ready to get serious about energy R&D; and it makes sense to do that in cooperation with other nations of the world. Stronger cooperation with China on energy R&D is an especially good opportunity.

But, much energy research, particularly basic research, is inseparable from other important areas of research in the earth and life sciences, as well as the physical and mathematical sciences and engineering. Several U.S. federal agencies, including NSF, NASA, NIH and others, should expand their international cooperative efforts with China.

I will conclude my remarks by expressing the view that this is a time of unprecedented opportunity for cooperative research between the U.S. and China in a broad range of research areas. That fact, coupled with the large number of gifted Chinese science and engineering researchers, many of whom have studied in America and either remained there or returned to China, suggests that the time is right to launch a new era in U.S. – China cooperation in science and technology. The ideas generated at this forum will provide a basis for moving forward with what I believe should be a bold initiative at the highest levels of our two governments.

Thank you.

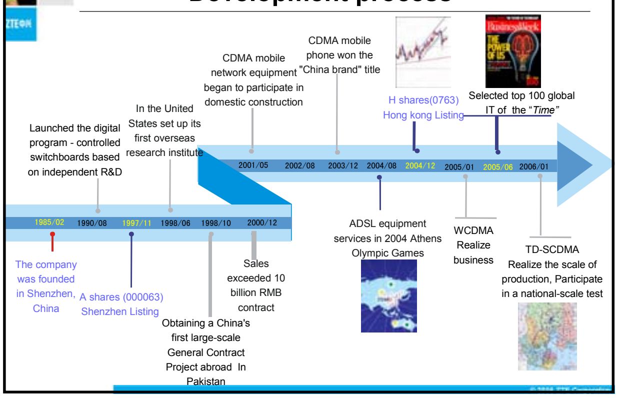
ZTE中兴

ZTE – Qualcomm cooperation on CDMA

ZTE

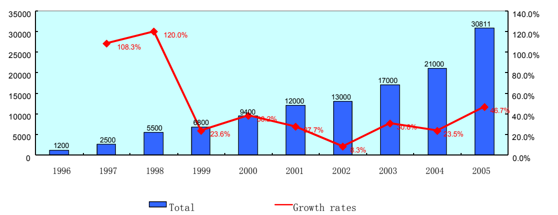
- ZTE Corporation is China's largest listed telecommunications equipment manufacturer and local wireless solutions provider.
- Founded in 1985, ZTE Corporation was listed with A shares in Shenzhen Stock Exchange (ShenZhen 000063) in 1997, and with H shares on Hong Kong Main Board (Hongkong: 0763) in 2004.
- 2005, ZTE was selected among " Global Top 100 IT" by Business Week.
- As China's key high-tech enterprise, our products and services cover wireless, networks, terminals, data four fields, cooperating with 500 operators in more than 100 countries. ZTE has 14 research institutes home and abroad.

Development process



Human Resource

- Till the end of 2005, the number of total staff is 30,811, with an average age of 30 years old, bachelor degree holders and above accounting for more than 75.2%.



2,199 local staff overseas, accounting for 60.6%

R&D strategies

- **Globalization R&D strategies**
  - R & D Investment : More than 10% of annual sales revenue
  - 14 R&D centers in the world, more than 10,000 engineers
  - six oversea R & D institutes, boasting local high-end talent, sharing global technical resources.

Joint R&D

- **Strategic cooperation with global technical partners, to jointly boost the development of telecommunications technology**

ZTE established a strategic cooperative technology department, to launch extensive technical cooperation. Currently, ZTE established a strategic cooperative relationship with IBM, Intel, ADI, Ericsson, Alcatel, Lucent, Cisco, Qualcomm, Microsoft, TI…

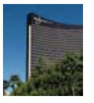
ANALOG DEVICES · CISCO SYSTEMS · ALCATEL · IBM · France Telecom · accenture · NORTEL · agere systems · TEXAS INSTRUMENTS · intel · QUALCOMM · Microsoft

ZTE CDMA global markets

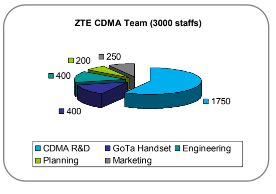
ZTE CDMA2000 products are delivered to 70 countries, serving nearly 100 operators, with wireless capacity of over 40 million lines, mobile phone sales reached 10 million. ZTE is among the top three in the globe.

ZTE strategic cooperation with Qualcomm

- **ZTE established a strategic cooperative relationship with Qualcomm**
  - Standard
  - Products
  - Services
- **ZTE has become the world's largest Qualcomm partners on CDMA**
- **It is a model of scientific cooperation between Chinese and American ICT companies.**



ZTE CDMA Division



CDMA R&D Institutes
- R&D Center in San Diego, USA: High-level system design
- R&D Center in Shenzhen, China: CDMA BSS products and GoTa™
- R&D Center in Nanjing, China: CDMA NSS products and VAS
- R&D Center in Shenzhen and Shanghai, China: CDMA Terminal

Cornerstones in Cooperation

- In 1995, ZTE started cooperation with Qualcomm for CDMA technology development.
- In 1999, ZTE signed the first CDMA R&D agreement in China with Qualcomm. ZTE is the first Chinese vendor signing IPR agreement with Qualcomm in 1999.
- In April 2001, ZTE signed the first licensing agreement on CDMA infrastructure equipment with Qualcomm.
- In June 2001, again, ZTE becomes the first in China signing licensing agreement on terminals with Qualcomm.
- In April 2002, ZTE was as the first Chinese vendor signed joint develop agreement on cdma2000 EV-DO with Qualcomm
- Since 2001, ZTE and Qualcomm established a special strategic partnership for the promotion of CDMA2000 both in China and worldwide. At this moment, ZTE is marketing CDMA in the 20 countries where it had established physical presence.

Cornerstones in Cooperation (con.)

- At the end of 2002, Dr Irving Jacobs, during his visit to ZTE, decided with Mr Weigui Hou, president of ZTE, to expand the cooperation into more fields such as handset, including CDMA/GSM dual mode handset, WCDMA, BREW, etc.
- In March 2003, ZTE reached the first agreement in China with Qualcomm for gpsOne.
- In August 2003, the R&D agreement with Qualcomm on both WCDMA handsets and BREW was signed.
- Promoting CDMA2000 technology around the world is the common interest between ZTE and Qualcomm.

Cooperation model

- Qualcomm authorizing IPR to ZTE, providing technical and services support to ZTE
  - Base-band R&D agreement
  - System R&D agreement
  - Terminal R&D agreement
  - gpsOne R&D agreement
- ZTE to achieve development and industrialization, and market advance
- Jointly optimize CDMA standard and boost its healthy development
- Cooperate in the development, promotion positioning, streaming media and other services products

ZTE's CDMA products in the industry

- The first Chinese company, boasting its own CDMA brand
- The world's first CDMA card separation mobile phone,
- The first Chinese company to get whole set of CDMA network access certificate.
- Application on a large scale in China Unicom, a milestone in the history of China mobile communications
- 1.9G/450M industry's leading position in CDMA
- provides full range, multi-band CDMA technology end-to-end solution (450M/800M/1900M/2100M)

Enhance the competitiveness of CDMA , to achieve Win-Win

- **Innovative GSM1X technology solutions**
  - To solve carrier network development(In particular, C/G dual-network)
  - CDMA operators can provide to enable heterogeneous network roaming capabilities
- **GoTa – PTT over CDMA2000**
  - New generation digital trunking communication products based on CDMA technology
  - 2005, GoTa won the major prize for the information industry
  - The first time a Chinese telecommunications enterprise authorizes IPR to multinational telecommunications companies
  - Application in more than 20 countries, such as Benin, Brazil, Egypt, Russia, Norway, Malaysia.

Enhance the competitiveness of CDMA , to achieve Win-Win (con.)

- **Value-added Service Solutions**
  - Anyservice - the entire series of Value-added service solutions
  - gpsOne, the characteristics LBS solution on CDMA
  - BREW, the open development and business environment of services

The significance of cooperation

- Upgrading the status of the domestic telecommunications enterprises in the global market
- Boosting development of CDMA technology in a global context
- Promoting cooperation and exchanges between China and U.S.A hi-tech enterprises

How Pioneering Innovations Close the Technology Gap and Achieve Technology Sovereignty

Sadeg Faris Chairman and CEO of REVEO

Sino-US Science and Technology Policy Forum
October 17, 2006

What is Innovation?
Indigenous problem solving of Exclusive Differentiation

Closes the technology gap
Leads to technology sovereignty

- *Acquired innovation does not do it. Any body can do it, get commoditized, no differentiation*

Technology Broad Defined:

- *Scientific Knowledge*
- *General knowledge & Know-how & Discoveries*
- *Tools*
- *Inventions & Innovations Trade Secrets*
- *General IP*

Two Types of Innovations:

R-Innovation:
Revolutionary, exclusive, differentiating, disruptive solution to problems creating new markets

E-Innovation:
Evolutionary non exclusive improvements to Solutions in existing markets

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How Pioneering Innovations Close Technology Gap, Achieve Technology Sovereignty & Lead To A Stable, Harmonious Relationship Between People.

Sadeg M Faris
Reveo, Inc.
Elmsford, NY

Technology Colonization?

How Do We Know?

Territorial Colonization

Territory Sovereignty

Technology Colonization

My Background

- Born in Libya, after the war, illiterate parents
- Lived in an orphanage after father died
- Received Exxon Scholarship to study in USA
- Received BS, MS, PhD from UC Berkeley
- Joined IBM where I received many Invention and Innovation Awards and learned about managing science, technology and innovation
- I am the poster boy for brain drain

My Background

- Got VC funding to start HYPRES that succeeded in developing and commercializing the world fastest oscilloscope
- In 1991 I started Reveo with a unique mission to develop the *InventQbation* Business Model that focuses on inventing solutions to problems for humanity that no one else can solve (This is the source of Technology Sovereignty the subject of this talk)

My Background

- I have more than 500 Patents Issued (250) and pending in diverse pioneering activities.
- I have many great Chinese scientists and engineers I had to provide visas for and help become US citizens.
- It is not surprising that I worry about IP protection, level playing field and win-win harmonious relationships
- We have inventQbated several companies around the world and we have a plan this year to start two factories in China.
- Dr. Ed David has been my advisor, mentor and Board Member.

Against This Backdrop that I developed a unique perspective on the following:

- Human's oldest profession, *Trading,* is fundamentally simple, deeply rooted in our programmed DNA and our need to survive to propagate the species
- This natural force applies equally to all races, colors, gender, Chinese, Americans, Arabs etc.
- Therefore, it is not surprising that no race or a country has monopoly of inventiveness
- Each one of us can easily name many Chinese insertions which influenced many civilizations

Trading: The Oldest Profession

Unless somebody proves otherwise that are two kinds of trading

Harmonious Trading

or

Acrimonious Trading

With only 4.6% of The World Population The USA Accounts For 40% of World Economy!

GDP = $ 13, 500 Billion

Per Capita GDP ~$42,000

~50% of US GDP Results from Technology Innovation

Innovation ~ $ 6,750, Billion!

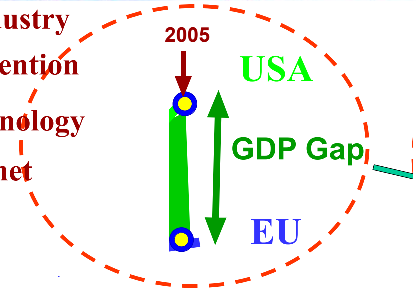
This Can Be Admired of Envied

I Observed A Gap Between
Per Capita GDP ~$42,000 In USA and
Per Capita GDP of $25,000-$30,000 OF EU

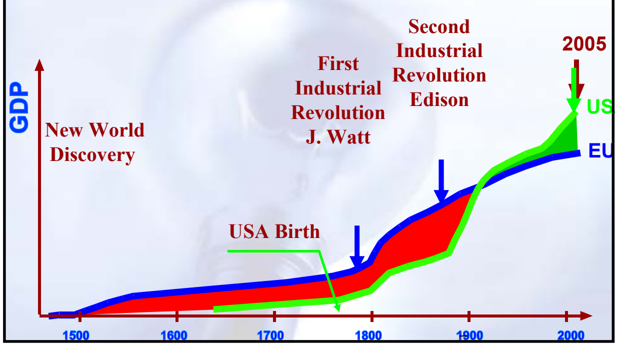
My curiosity lead me to wonder if this were related to technology and innovation GAP. I followed this thread to find the source.

Here is What I found

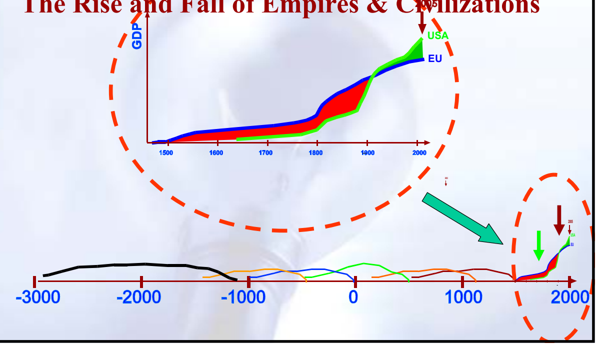
IC Industry
PC Invention
Biotechnology
Internet



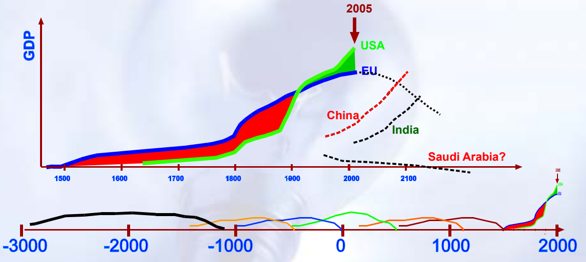
The Innovation & Technology Gap



The Innovation & Technology Gap
The Rise and Fall of Empires & Civilizations



Can We Predict Who Will Close The Gap & Achieve Technology Sovereignty?



Technology Trade Gap (TTG):

Closing TTG Leads to Achieve Technology Sovereignty

InventQbation Business Model

Technology Sovereignty Applies to

- Nations
- Companies
- Individuals

Closing The Gap Leads to Stable
Harmonious Trading
Survival & Prosperity

Scientific research
and
Social development

- The role of research universities and their industrial cooperation

GONG Ke

Outline

- The role of research universities in China's R&D
- The cooperation of research universities and industry
- Conclusion remarks

The role of research universities in China's R&D

- Universities educate 5 million students, among them there's about 1 research students, about half "top" academia working in universities
- Universities themselves are important driving force for technology innovation in China
  - Major role in fundamental research
  - Actively engaged in application research
  - Close university-industry linkage and technological transferring

The role of research universities in China's R&D

- According to MOE, there are 209,000 researchers working in Chinese universities
- In recent 5 years, 50% of the national awards for scientific research are obtained by universities; 70% of the papers indexed by SCI/EI/ISTP are from universities
- By 2004, Chinese universities own 12000 invention patents.

The role of research universities in China's R&D

Program in year 2004	NSF for Innovative Research Groups	NSF for Distin-guished Young Scholars	NSF			973	863
			General	Key	Major		
Total grant	20	157	7711	224	215	31	Expert 176 Program 818
Univ. granted	11	99	6044	146	145	13	Expert 82 Program 270
%	55%	63%	78%	65%	67%	42%	Expert 46% Program 33%

Major national projects undertaken by Univ.

Source: Annual Report on S&T Progress of Chinese Universities 2004

The role of research universities in China's R&D

Lab construction Program/ by the end of year 2004	National lab		State key lab	ERC (Engineering Research Center)	University Science Park
	Initial launch	2nd batch passed review by MOST			
Total launched	5	21	183	251	
Lab based in Univ.	3.5	12	113	72	42
%	70%	57%	61.7%	28.7%	

national research Labs/centers based on Univ.

Source: Annual Report on S&T Progress of Chinese Universities 2004

The role of research universities in China's R&D

Awards and Patents of Univ.

2004	National Award (S&T)	Natural Science Award	Technology Invention Award	Technology Advancement Award	Patent filed	Invention Patent granted
Total granted	233	28	20	185	353,807	49,360*
Univ. granted	132	18	12	102	15,000	3520
%	57%	64%	60%	55%	4.2%	7%

Conclusion: Among 49340, 18241 are granted to Chinese local entities, 31119 are granted to foreign entities. Patents granted to university account for 19% of the total patents granted to Chinese entities, and 29% of the total service-invention patents granted to Chinese entities.

Source: 1. *Annual Report on S&T Progress of Chinese Universities 2004*
2. www.sipo.gov.cn

The role of research universities in China's R&D

R&D Funds and Expenditure of Univ.

R&D data/ year 2004	R&D Funds received, all sources	R&D Expenditure
China in total		196.6 billion (RMB)[2]
Univ.[1]	34.4 billion (RMB)	25.3 billion (RMB)
%		13% (49%, over the total expenditure on fundamental research +applied research)

Source: 1. Annual Report on S&T Progress of Chinese Universities 2004
2. Statistic Report on S&T Investment of China, 2004

The role of research universities in China's R&D

- **The research universities are not only the center for education, but also the center of scientific and technological research and development.**

The cooperation of research universities and industry

- **A very important character of Chinese research universities is their industrial cooperation.**
- **About 50% research funds obtained by Chinese research universities are from industry.**
- **Many R&D results of university are directly used in (transferred to) industry.**

The cooperation of research universities and industry

- **University leads industrial consortium for national standard - Digital TV Transmission Technology**
  - **Universities' innovative technology was selected as national standard**
    - **Unique TDS-OFDM technology**
    - **High performance in mobile receiving**
    - **Supporting multimedia broadcasting**
  - **Core group formed by research universities with close cooperation of TV industry**
    - **Tsinghua, Shanghai Jiaotong, Beihang, etc.**
    - **Changhong, TCL, Haier, Konka, Hisense, Skyworth, Tongfang, Xiahua, etc.**
    - **RS（Germany）、Toshiba、ST（US）、Samsung、LG**

The cooperation of research universities and industry

- **University's technological transfer is important new technology resources of industry**
  - **Many industrial companies have joint labs with universities, e.g. in Tsinghua University, there are 63 (including 20 with companies abroad) joint industrial labs with about 60 companies.**
  - **Large amount of research funds by industry giving to universities for technology transfer**
    - **Tsinghua's industry contract funds: abou66 M$ from domestic and 26 M$ from abroad (2005)**

The cooperation of research universities and industry

- Example 1: digital controlled machine by Huazhong university of science and technology
- Example 2: CIMS by Tsinghua University
- Example 3: Fine distillation and Bisphenol A technology by Tianjin University
- Example 4: In-situ precision measurement for automobile manufacturing lines by Tianjin University

The cooperation of research universities and industry

- University's spin-offs becoming active parts of Chinese high-tech industry
  - FOUNDER from PKU: the leading PC company in China
  - NUCTECH from THU: taking the world's largest market share of Container inspection
- University's science parks are important high-tech companies incubators

The cooperation of research universities and industry

- The international cooperation of research universities with multinational companies are fast growing
  - Contract-based project
    - Entrusted R&D project
    - Joint R&D project
    - Licensing
  - Joint Research Labs
  - Research Foundation

Conclusion remarks

1. Chinese research universities, like their counterparts in other countries, are paying key roles in R&D
2. Chinese research universities, unlike their counterparts in other countries, are more active with applied research and industrial cooperation
3. Chinese research universities should enhance the international cooperation and become more active in the global stage

THE ROLE OF U.S. UNIVERSITIES IN ECONOMIC DEVELOPMENT

Presentation by Allen L. Sessoms, Ph.D.
Beijing, October 17, 2006

DELAWARE STATE UNIVERSITY
Dover, Delaware 19901

The Bayh-Dole Act

- The Bayh-Dole Act allows for the transfer of exclusive control over many government funded inventions to universities and businesses operating with federal contracts for the purpose of further development and commercialization.
- The contracting universities and businesses are then permitted to exclusively license the inventions to other parties.
- The federal government, however, retains "March-in" rights to license the invention to a third party, without the consent of the patent holder or original licensee, where it determines the invention is not being made available to the public on a reasonable basis, (in other words, to issue a compulsory license.)

THE FUTURE BY HENRY SAMUELI, Ph.D. Chairman & CTO, Broadcom Corp (UCLA grad.)

- Who knows what my company's going to be doing in 20 Years? Probably something that was discovered at a university.
- Multidisciplinary centers like UCLA are replacing industry-sponsored research labs. That's the future.
- The only exception is new product development. Private industry continues to control this, as it should. The horizon is usually two or three years. No more than that.

HENRY SAMUELI (cont'd.)

- Virtually all basic research today is university based, with a 10- to 20-year horizon. As that work finds its way into applied research, the engineering schools pick it up and drive it to real-world applications. But the big middle, the vast majority of applied research, is in the 3- to 5- to 10-year time zone. These are high-priority, high-yield concepts that have been identified by industry or government. That's where universities have taken command.

HIGH PROFILE RESEARCH TOPICS

Avian Flu	
Biotechnology	
Energy	
Homeland Security	
Nanotechnology	
Pharmaceuticals	

UNIVERSITY OF ARIZONA

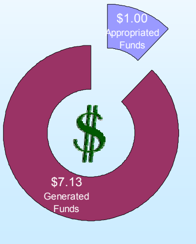
Total impact on Arizona Economy

- 41,272 jobs
- $1.2 billion in direct expenditures
- $98.1 million in tax revenues

Total impact: $2.3 billion
For every $1 of state-appropriated funds in FY 2004, The University of Arizona attracted an additional $1.45 in grants, contracts and gifts.

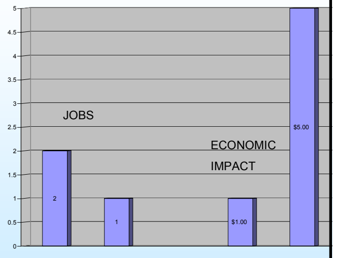
Including a multiplier effect, the University of Arizona generated $7.13 for every $1 of state-appropriated funds in FY 2004.

University of Arizona Economic Impact



UNIVERSITY OF CALIFORNIA at DAVIS

Total Economic impact on California
- 46,301 jobs creating $2.7 billion in revenue
- 2nd largest employer in the seven (7) county region behind State government



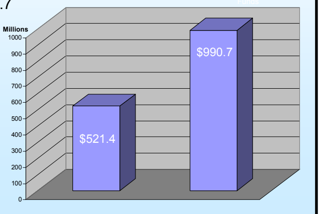
For every two (2) direct jobs at University of California at Davis, one (1) additional job is created in the State of California.

For every one (1) dollar appropriated to the University, five (5) dollars are added back to the economy.

WASHINGTON STATE UNIVERSITY

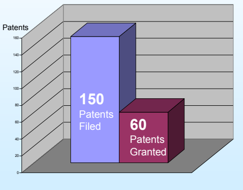
Total impact on Washington Economy
- Created over 10,000 jobs
- State appropriated funds of $521.4 million generated $990.7 million in revenue

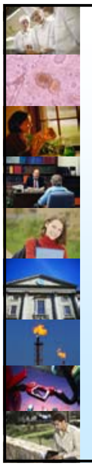
Washington State University Economic Impact



UNIVERSITY OF MISSOURI

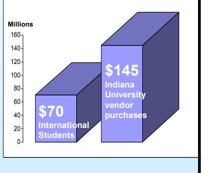
Total impact on Missouri Economy
- 23,000 employees
- 21st largest publicly-held company in Missouri
- $2.1 billion in total revenues
- Conducts more than $200 million in Federally Funded Research
- Over 20 start-up companies that are incorporated
- Every million dollars in grants and contracts creates 39.3 jobs
- Filed over 150 Patents - Granted 60 that is worth $18 million in revenues





INDIANA UNIVERSITY

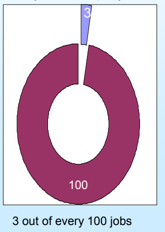
- IU has 15,000 employees, making it the state's fifth largest employer
- IU purchases more than $145 million each year in goods and services from Indiana vendors
- Each $1 million in competitively won grants and contracts generates 41.4 jobs
- IU attracted $737 million in research funds, which supported 30,500 jobs for Indiana citizens
- International students and their families contributed more than $70 million to the Indiana economy in the past year



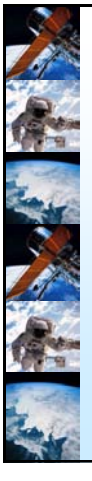
JOHN HOPKINS UNIVERSITY

Total impact on Maryland Economy
- Supports over 85,000 Maryland jobs
- Major Contributor to National Health Care Industry
- Hospital Rated as being America's best
- Three (3) out of every 100 people in Maryland on payroll or have a job because of John Hopkins
- Contribute $7 billion a year to economy
- One of every 28 dollars of state economy starts at John Hopkins

John Hopkins / State of Maryland Employment



3 out of every 100 jobs

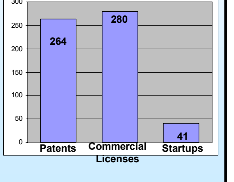


GREATER BOSTON AREA

HARVARD
BOSTON COLLEGE
BOSTON UNIVERSITY
BRANDEIS UNIVERSITY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
NORTHEASTERN UNIVERSITY
TUFTS UNIVERSITY
UNIVERSITY OF MASSACHUSETTS @BOSTON

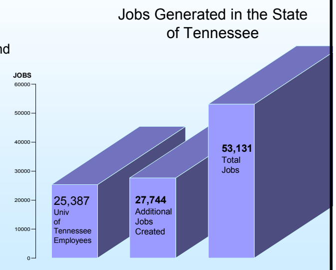
Total Economic impact on Greater Boston Region
- $7.4 billion boost to the regional economy
- Created 48,750 University jobs
- Created 37,000 other jobs for workers in the region
- Continuing Education for 25,000 non-degree students

Innovative Research



UNIVERSITY OF TENNESSEE

- Employs 25,387 people
- Created an additional 27,744 jobs from employee, student, and visitor spending
- $313 million state dollars generated over $1 billion
- $31million in tax revenues



DUKE UNIVERSITY

Total impact on Durham, North Carolina

- Total economic impact on the city and county of Durham is estimated at $3.2 billion per year
- 37,026 jobs created
- Top 5 employers in North Carolina: Wal-Mart, Food Lion, Duke University, Wachovia Bank and Bank of America

TEXAS A&M UNIVERSITY

- Has a $2.35 billion economic impact on the Bryan-College Station community ($941 million directly and $2.35 billion when a standard multiplier effect is applied)
- Its 280,000 former students—comprising one of the largest and most active alumni groups in the nation—include leaders in a variety of fields, ranging from the corporate world to education, the military and other areas of public service
- Scores of its former students have founded or lead Fortune 500 companies or other entities that have major economic impact on the state and nation through the creation of jobs and new products and services
- Its faculty and staff are responsible for creating a host of inventions (more than 350 disclosed to date) and new processes that have led to 125 patents

DELAWARE STATE UNIVERSITY

Total impact on Delaware Economy

- Employment Impact - Over 3525 jobs
- $34 million in Grants and Contracts
- One (1) dollar of appropriated funds by the State generated $5.30 for the State of Delaware economy.