I. EXECUTIVE SUMMARY

U.S.-China Seminar on Technical Innovation

Washington, DC
March 18-20, 2002

The U.S.-China Seminar on Technical Innovation was held in Washington, DC, March 18-20, 2002. This seminar was the second China-U.S. seminar to address technical innovation and the third event in the U.S.-China Cooperation Program in Science Policy, Research and Education. The co-chairs of the seminar were Lewis M. **Branscomb,** Professor emeritus, Public Policy and Corporate Management, John F. Kennedy School of Government, Harvard University, and Zuoyan **Zhu,** Vice President, National Natural Science Foundation of China, P. R. China, Member of the Chinese Academy of Sciences.

The U.S.-China Cooperation Program in Science Policy, Research and Education is a decade long initiative. Information on the program can be found at: http://techcenter.gmu.edu/programs/science_trade_policy/us_china.html.
The relationship between the National Science Foundation of the United States of America (NSF) and the National Natural Science Foundation of China (NSFC) is a cornerstone of this cooperation. It aims to expand bilateral science policy cooperation, and to provide a foundation for strengthened partnerships in science and engineering.

Information on the NSFC can be found at: http://www.nsfc.gov.cn

Information on the NSF can be found at: http://www.nsf.gov

The first China-U.S. Seminar on Technical Innovation was held in Beijing in April, 2000, with Tsinghua University Professor Ju Jianji and Prof. Otto Schnepp, Director of the East Asian Studies Center of the University of Southern California, as co-chairs.

OPENING KEYNOTE / PHILIP BOND

The Opening Keynote was held the evening of March 18 at the Governor's House Hotel. Following remarks by Mark **Grady**, Dean, George Mason University (GMU) Law School, Xueyong **Li,** Vice Minister of Science and Technology, PRC, and Zuoyan **Zhu**, Vice President, National Natural Science Foundation (NSFC), PRC, the evening Keynote was presented by Hon. Philip **Bond,** Undersecretary Technology, U.S. Department of

Commerce. Professor J. Thomas Ratchford of the GMU Law School and Director of the U.S.-China Cooperation Program in Science Policy, Research and Education, presided.

Undersecretary Bond addressed the importance of Technical Innovation to the United States and, more specifically, the role of the U.S. Department of Commerce in enhancing policies and initiating programs to encourage increased innovation. The role of the National Institute of Standards and Technology (NIST) in spearheading Commerce Department innovation initiatives was noted. Director of the NIST, Dr. Arden Bement, was in attendance, and an important participant in the Seminar program.

OPENING SESSION

The Opening Session for the formal program of the U.S.-China Seminar on Technical Innovation was held at the Industrial Research Institute on the morning of March 19. This session featured the Keynote by Mr. Xueyong Li, Vice Minister of the Ministry of Science and Technology (MOST), Peoples Republic of China. Mr. Zuoyan Zhu, Vice President of the National Natural Science Foundation of China and Professor Ratchford presided.

Xueyong Li

Vice Minister Li spoke on "China's Policy for Technical Innovation in the New Century." He outlined China's innovation policy since the reform as well as current trends and perspectives on innovation in China. Vice Minister Li described China's innovation policy since the late 1970s, with special attention to China's efforts in harnessing R&D for development. These efforts include:

- Implementation of key national science and technology programs such as the High-Tech Development and Research Program (863 Program);
- Development Plan for National Basic Research;
- Torch Program and the Spark Program;
- Increased and continued input in R&D;
- Restructuring the R&D system;
- Encouraging enterprises to increase input to R&D;
- Science and Technology Industrial Parks (STIP);
- Policies encouraging personal involvement.

Vice Minister Li described trends and gave his perspectives on future innovation policy in China. Priorities for future policy initiatives include:

- Further strengthening the existing national strategy of revitalizing China through science and education;

- Utilizing R&D to promote sustainable national development and to upgrade people's standard of living;
- Increased national investment in science and technology;
- Continuing institutional innovation and management reforms;
- Increased support to small and medium enterprises (SME);
- Further development of intellectual property right system; and
- Promoting innovation at regional level and balancing the uneven regional development.

Vice Minister Li concluded with a look at international S&T cooperation, especially Sino-US S&T cooperation in innovation. He emphasized the support from the Chinese government for this activity, and stated his sincere belief that growing S&T cooperation and exchange will greatly benefit both China and the US.

Lewis M. Branscomb

Professor Lewis M. Branscomb, Co-chairman of this Seminar followed Vice Minister Li and spoke on "The Transition from Invention to Innovation." Professor Branscomb noted the relationship to priorities set by the government of the US as it seeks to increase the vitality of the U.S. national system of innovation and growth.

In his paper Professor Branscomb asks:

- Do we understand how research is converted into successful commercial innovations?
- Are there financial, institutional or entrepreneurial "gaps" that increase the risks and costs of radical, technology-based innovations?
- What is the role of governments, federal and state or provincial, in promoting the commercial transition from an invention to an innovation?
- Does the Advanced Technology Program of the US Department of Commerce, which is intended to meet this need, work as intended?
- How might it be improved?

Professor Branscomb points out that virtually all economic growth in the US economy, and indeed all industrial economies, comes from incremental improvements in productivity, products, and markets, not from the exciting new enterprises and businesses based on radical new technologies. But the sources of new industries, of new commercial opportunities come from radical, market and technology-based innovations which create new markets from new technology.

The Government Performance and Reports Act requires all research funding agencies to document in their budget submissions not only the outputs in publications and patents

and training, but the outcomes in economic and social terms. The agencies have found this requirement very difficult to satisfy. The result is that federal S&T policy still depends on the following principles and policies:

- A residue of confidence in the "social contract for science" that assumes the outcomes from science are real and of high value but are difficult if not impossible to predict.
- Statutes intended to increase the incentives for commercializing government-funded science (technology "pull" policies).
- A larger number of statutes, which can be characterized as technology "push" polices, intended to encourage the transfer of government research to commercial enterprises.
- Two statutes intended to create government investments in research for technologies of high commercial promise. The ATP (Advanced Technology Program) statute was a primary function of the Omnibus Trade and Competitiveness Act of 1988 but has been highly controversial from the time of its passage.

Professor Branscomb noted a sequential model of development and funding is needed to answer questions such as "how can radical, technology-based innovations come about? What can governments do to foster such innovations?" His paper (see page 47) describes this model in detail. Professor Branscomb quoted Congressman Vern Ehlers' term "Valley of Death" that is used to dramatize the particular challenges facing entrepreneurs engaged in the transition from invention to innovation. An alternative image of the Valley of Death is proposed as the Darwinian Sea, which is a metaphor for the three disjunctures between inventor/innovator and financier/manager.

In summary, Professor Branscomb pointed out that the chaotic character of the "Darwinian Sea" is probably necessary to provide a wide range of alternative ways to address issues of technical risk, to identify markets that do not yet exist, and to match up people and money from disparate sources. He noted that programs like ATP, which has elements of both push and pull, should become more securely anchored on the research shore of the Sea and, with the aid of a more prominent role for universities, might their projects may enjoy increasing support in the Congress.

Qingrui Xu

The Keynote Session was concluded with a paper by Professor Qingrui Xu, who spoke on "Transition from Imitation to Innovation." Professor Xu described the evolutionary process of technological innovation and technology management practiced by Chinese

firms since 1949. During this period technological innovation in China experienced a 3-stage path:

- Imitation Stage (early 1950s-1957);
- Creative Imitation (late 50s to ' 78);
- Improvement to Secondary Innovation (since 1978).

Professor Xu used dynamic capability and knowledge management to analyze the structure of technological innovative capability and the paths for enhancing it. More specifically, he advances a new paradigm for innovation management, i.e., **competence-based innovation portfolio.** This perspective tells if a firm's core competence and capability is comprised of the three elements whose interaction determines how effectively the organization can exploit it. These elements are:

- Knowledge and skills;
- Technical know-how; and
- Personal know-how.

There should be a paradigm shift in the management of technological innovation from conventional technological management to one based on knowledge and skills. For an enterprise's long-term success, it should cultivate and improve its core competence. The relationship between innovation and competence is extremely important, especially with regard to the integration of technological vs. organizational and institutional innovation, and with regard to independent vs. collaborative innovation. The relationship between core competence and portfolio innovation is viewed as comprised of mutual interactions. The choice of innovation portfolio is based on the firm's core competence, while portfolio innovation is the pathway for core competence to be cultivated and enhanced.

Thus, the path of technological capability evolution in developing countries is brought forward: from imitating capability to creative imitating capability, and then to indigenous innovative capability. This is shown in the path of technological capability evolution in Chinese telecommunication companies (such as EASTCOM).

Finally, Professor Xu pointed out the relationship between financing technological innovation and competence accumulation. Firms have to distribute R&D capital carefully to obtain the correct balance of imported and indigenous technology. This in turn leads to the 3I (Imitation-Improvement–Innovation). When companies have adequate capital accumulation then they can support indigenous R&D. The impact of capital accumulation on technological competence is the result of interaction of many factors, so it is necessary to use simulation and modeling techniques in order to find the optimum rate of capital accumulation under a variety of conditions.

CREATION OF INNOVATIONS: RESEARCH CENTERS, INSTITUTES AND UNVERSITIES

Session B focused on Creation of Innovations: Research Centers, Institutes and Universities. Four speakers delivered their papers in this session, which was co-chaired by Professor Scott Shane of the University of Maryland and Xielin Liu of the Ministry of Science and Technology of China.

David Mowery

Professor David Mowery of Haas Business School, University of California at Berkeley, addressed "Cooperative R&D Agreements and R&D Collaboration between Firms and Public Laboratories in the United States." He dealt with a particular federal policy instrument known as Cooperative Research and Development Agreements, or CRADAs. He surveyed his research and that of others to outline this form of collaboration between federal, public laboratories in the United States and private firms and to describe some case studies on the operation of CRADAs.

Professor Mowery began with the history and meaning of CRADAs, including the incentive for private sector participants to receive government generated intellectual property under the Bayh-Dole Act. He went on to note that CRADAs are an important but little known source of innovation with possibly substantial effects on private firms' innovative performance. They supplement the traditional licensing and innovative activity within the public laboratories.

Mowrey provided data on CRADAs' effectiveness, including conclusions of two studies of CRADAs involving U.S. Energy Department laboratories. The first study (Ham-Mowery) pointed out that the public laboratories had capabilities, equipment and facilities resulting from the investment of public funds that would be difficult to find elsewhere. He also noted incentives for the government researchers to negotiate CRADAs because of the likelihood of obtaining further public funds. Small firms, however, had problems in managing and absorbing the technologies under CRADAs. The conclusion from these studies was that CRADAs are useful, even with problems associated with negotiating intellectual property rights, but not ideal for all types of R&D collaboration.

The second study involved a group of large, technically sophisticated firms that needed public laboratories' facilities for developing extreme ultra-violet lithography. Most funds for the public as well as private researchers came from the companies. This arrangement seems to have worked out better, though the laboratories have done little in retrospective studies to evaluate what worked well and what did not. The bottom line, according to

Mowery, is that we really do not know much about the operation of these agreements and further study and analysis is warranted.

Rongping Mu

Mr. Rongping Mu, a policy researcher from the Chinese Academy of Sciences, spoke on "The Impact of R&D Institute Reform on Technological Innovation in China." In his paper, Mr. Mu pointed out that China's economic reform has moved from reforming micro-operational mechanisms to reforming the allocation system for resources, and finally to setting up the socialist market economy system of China.

The State Council in 1998 abolished 10 ministries; 242 R&D institutions were associated with these ministries and needed to be transformed. The basic question is "how to transform" these state-owned R&D institutions with staff totaling 115,000? There were four models:

- Shifting to existing enterprises as R&D centers;
- Operating as stand-alone corporations;
- Operating as self-supporting enterprises; or
- Becoming Technological Service Organizations.

Reform of the Chinese Academy of Sciences (CAS) began in June 1998 with the aim of establishing the national Knowledge Innovation Program. This reform was a key element of China's transformation to a market-driven economy. It involved disciplinary changes in R&D, organizational restructuring and changes in operational mechanisms. CAS Institutes were merged and some abolished, and some new ones established to meet the new challenges in innovation.

These transformations and reforms have strengthened the linkage between R&D and production and increased the innovation capability of enterprises. There have also been problems, especially with regard to institutions that have no obvious close relationship to short-term economic activity. The models used to plan the transformation have been too simplistic in some cases, and efforts to evaluate the reforms are under way.

Bhaven N. Sampat

Professor Bhaven Sampat of the Georgia Institute of Technology delivered a paper entitled "International Emulation of Bayh-Dole: Rash or Rational?" Professor Sampat provided basic background related to the Bayh-Dole act and its contribution to US economic growth.

During the past decade, many nations have considered or enacted policies to reform their university systems so the universities can better contribute to technical progress in industry and stimulate economic growth through more innovation. These changes typically have assumed the growth of university-industry interaction in the United States over the past 25 years or so is evidence that the American system "works." Many of the proposed changes explicitly attempt to emulate the U.S. model of university-industry technology transfer.

Sampat provides an overview of the economic roles of universities, and the channels through which universities contribute to technical progress in industry and to overall economic growth. He discusses the university patent practices and policies in the United States in the pre-Bayh-Dole era, to provide a baseline for comparison. He notes that the effects of Bayh-Dole have not been carefully evaluated, and that it may or may not be all it is assumed to be by its supporters.

Professor Sampat concludes that international emulation of the Bayh-Dole act is more "rash" than "rational" and there is simply no evidence for the claim that allowing and encouraging universities to patent and license publicly funded inventions increases social returns from university research. He argues that if other countries want their universities to be as economically productive as U.S. universities appear to be, Bayh-Dole type policies are likely not the answer and that the widespread trend towards emulation of Bayh-Dole type policies is probably misguided. Rather, other characteristics of U.S. universities may be worthy of careful study.

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Lan Xue

Lan Xue, Tsinghua University Professor, spoke on "University-Affiliated Enterprises in China: Evolution and Assessment." Professor Xue focused his paper on the evolution of university-market linkages in China, with special attention to university-affiliated enterprises.

His historical review of the development of university-affiliated enterprises in China went back to the 1950s when university-related factories were initiated. Modern university-affiliated enterprises date from the 1980s when reform and market economy were developing. These operations were focused mostly on technology transfer, development and consulting. The second stage was from 1991-2000. Support from China's State Council and from Deng Xiaoping accelerated the development of these enterprises. Presently there are over 5000 enterprises of all types affiliated with regular Chinese universities. Some of these enterprises are listed on stock markets and are very sophisticated business enterprises.

Universities have entered the innovation process for several historical and economic reasons. One description relates to push and pull factors that have shaped the current university-market linkages. The "pull" factor (market opportunities calling for more industrial R&D capability) originates in China's weak industrial R&D capability. This goes back to the Russian-based early planned economy. As a percentage of sales Chinese enterprises invest very little in R&D. For example, one survey in 1999 showed firms spent only 0.5 percent of sales on R&D, on the order of one eighth of that spent by firms in industrialized countries.

The "push" factor (slow reform in higher education system and government policy orientation) also encouraged universities to establish closer linkages to the market. Just as in the U.S., local and provincial governments in China see universities as engines of economic development and provided incentives and supportive policies to encourage them to develop closer ties with local industry.

Professor Xue concluded that as the university system and economic reforms mature in China, current institutions are expected to evolve. As technology finds a more secure home in industry the university-affiliated enterprises will be less appealing. Problems in management of these affiliated enterprises will further acceleate the trend to put management in the hands of professionals and minimize the potential damage to academic institutions. But in the meantime, university-affiliated enterprises will continue to play an important role in Chinese innovation.

INNOVATIONS IN LARGE ENTERPRISES AND THEIR SUPPLY CHAINS

Jian Cui

Jian Cui, Assistant of the President, Dean of the Research Institute, Baosteel Group addressed "Baosteel: from High-level Introduction to Autonomous Innovation." Mr. Cui provided a brief evolutionary history of China's steel industry over the past decade. He then focused on the Chinese open system of technological innovation found in the steel industry. He gave special attention to Baosteel Co. Ltd, the largest steel manufacturer China.

Cui noted the policy of Baosteel to cooperate technologically with its customers based on direct and open research collaboration. In order better to encourage and educate its customers to use Baosteel products, Baosteel has set up several technical service groups and agencies in customers' facilities. This effort is complemented by quality consultation hotlines, set up by the Baosteel Technology Department.

China's entry into WTO provides both challenges and opportunities for Baosteel. Only by enhancing its own competitiveness can Baosteel prosper. To achieve its goal of "being the most competitive steel company in the world" Baosteel is implementing a new Enterprise System Innovation (ESI) Program. ESI integrates production, marketing, R&D, and other functions; and reduces lead times, including for R&D.

Mr. Cui concluded with suggestions for improving the innovation system in China. First, government should enact policies to coordinate all related sources of innovation, avoiding separate management of research and of technology development. Secondly, the assessment and evaluation of technological innovation and of researchers should be emphasized, with separate standards for the evaluations of traditional industries and high technology industries.

Lonnie Edelheit

Mr. Lonnie Edelheit, GE's former Senior Vice President, Corporate R&D, addressed "Global Technology at GE." Mr. Edelheit noted that GE re-entered the China market in 1981 and now has a number of joint ventures and affiliates there. GE research centers are located all over China. Today all of GE's businesses have activities in China. GE Global Research (Shanghai) is a window to GE China's technology development. In addition to these core technologies, GE has developed a series of research collaborations in China, and supports many Universities in China in long-term research.
In GE's view, China will become:

- The world's largest consumer market
- Number 2 or 3 industrial market
- Hottest healthcare market
- Largest consumer finance market
- Number 1 aircraft market
- Largest power consumer.

GE's unique blend of strengths is focused on growth: diversity of businesses, the unique culture, financial strength, growth initiatives, size, values, innovation and technology, and talented people. Ownership, trust and communication are crucial needs for a global organization like GE, and are integral components of GE's technology globalization strategies. GE believes it is important to grow the global team with mentoring and try to keep the team structure simple.

I. EXECUTIVE SUMMARY

Guoxin Liu

Guoxin Liu, Professor of College of Management, Wuhan University of Technology, delivered his paper on "Analysis on Value Chain and Technical Innovation of Chinese Telecommunication Industry."

The paper first introduces the concept of value chain, and applies it to the Chinese telecommunication industry in order to better understand the industry. In China there are scarcely any enterprises integrating with telecom services and equipment manufacturing. The telecom operating industry is in the mid- and downstream part the industrial value chain. It is an enterprise group based on network facilities and services. Chinese telecom equipment manufacturers and operators are separate, with little vertical integration

The Chinese telecom industry is rapidly expanding. The main reasons for this rapid development of the Chinese telecom industry are:

- Rapid economic development, leading to continual increase of per capita income and bigger demand for telecom service;
- Vast investment in the telecom operating industry has resulted in rapid increase of fixed assets;
- Technical advance has accelerated in Chinese telecom equipment manufacturing industry;
- Institutional and organizational innovation in the Chinese telecom industry has added to its competitive vigor and thus has upgraded its market performance.

Huawei is cited as an example of technological and managerial innovation to illustrate innovation in the Chinese telecom manufacturing industry. In spite of all these advances and great achievements, Mr. Liu points out that at present the Chinese telecom manufacturing industry still shows symptoms of low concentration, few benefits from scale and weak technical innovative ability. Technical innovation in the Chinese telecommunications industry has come far but still has a long way to go.

F.M Ross Armbrecht

F.M Ross Armbrecht, President of Industrial Research Institute, Inc., spoke on "Enhancing the Effectiveness of Industrial Innovation: Recent Results from the Industrial Research Institute." The Industrial Research Institute (IRI), a membership organization of Chief Technical Officers of many of the largest U.S. corporations, has a long history of providing an organizational framework and professional forum for comparing best research and development practices. Its meetings and publications serve to advance industrial R&D, as well as to build ties between industrial technology and university and government laboratories.

GLOBALIZATION: TRANSNATIONAL DEPENDENCES IN INNOVATION

Jim Jarrett

Mr. Jim Jarrett, Vice President of Intel, addressed "Intel China Labs: A Key Element in a Global Effort." He focused primarily on Intel China Labs and their relationships with both China's academic community and Intel R&D labs in other countries.

Jarrett described Intel as a global company: 60% of its sales are outside the United States; its research and development effort utilizes a worldwide network. Its R&D activities are focused in four areas:

- Internet
- Communications
- Computing
- Silicon Manufacturing.

The Internet in turn has made globalization of the company much easier. Multinational R&D teams work on common problems, sharing data on a daily basis via the Internet.

Intel China Laboratories include Intel China Software Lab (ICSL), Intel China Research Center (ICRC), IXA Development Center, Flash Application Development Center and Wireless Center. These laboratories perform a variety of R&D and technical support functions, with hundreds of scientists and engineers involved. Intel researchers in China have filed an impressive number of patents and published in world-class journals.

In addition to these traditional industrial R&D activities, Intel China supports long-term academic research in China. Topics include distance learning, failure analysis and natural language processing. Overall Intel has donated 26 laboratories at eight target universities in China.

Finally, Jarrett pointed out that in the last few years Intel has invested about $500 million in the Asia-Pacific region. One third of this has been in China.

Karen Guo

Mrs. Karen Guo, Director of Motorola China Research and Development Institute in Beijing, spoke on "Motorola Technology Innovation and Management in China." She pointed out that Motorola has become the largest and most successful foreign-invested enterprise in China over the last decade. There are now 15,000 employees, and business

income in China is currently USD $4.5 billion. Technology innovation is responsible for this success and for the development of Motorola's presence in China.

The Motorola China R&D Institute is a centerpiece of the company's presence in China. It was set up in 1999 for two reasons:

- Rapid R&D growth in China, with more than 700 technical researchers in China in 1999
- The Chinese government strategy of making China prosperous through technology and education provided Motorola with confidence for long-term investment in China.

Motorola expects to have 5000 R&D scientists and engineers in China by 2006. The Institute is tangible evidence of the company's commitment to innovation. Intellectual assets have become the new growth point for promoting the company's development and growth.

This focus by Motorola on technology development and innovation has led to a very great emphasis on Technology Management. Its three components – technology planning, technology development and commercialization – are incorporated in what one might call a "strategic vision." The fact that the Motorola China R&D Institute is becoming one of the important global R&D bases of the company implies Chinese scientists and engineers will be leaders in more and more technologies in the future.

Cathleen A. Campbell

Ms. Cathleen A. Campbell is Director of International Technology Policy and Programs, Technology Administration in the U.S. Department of Commerce. Her paper, "Globalization of Innovation," pointed out that innovation and technology represent two pillars shoring up the U.S. economy. Both the continued commitment to technology and continuing innovation are critical to the long-term global competitiveness of the U.S.

Ms. Campbell noted that it is important to consider these two concepts in the context of global knowledge creation through R&D. Her paper describes the international trends in six indicators that are representative of the movement towards globalization of innovation. The indicators are:

- Research personnel
- R&D investments
- Scientific publications
- U.S. patents
- Alliances

- Industrial R&D expenditures.

These indicators show the changing participation of nations in the R&D enterprise. It is clear that investment in and performance of S&T is international, and that in order to compete at the global scale, research enterprises must be prepared to handle the opportunities and challenges of globalization. It is also clear that research organizations in government, industry, and universities have started to adjust their S&T strategies by creating global bi-lateral and multi-lateral partnerships, thus taking this new global reality into account.

INNOVATION IN SMALL AND NEW HIGH TECH ENTERPRISES

Jin Chen

Mr. Jin Chen, Professor of Zhejiang Univ. delivered his paper (co-authored with Xinwei Mo) on "Technological Innovation Process of Complex Product System: Pattern of Chinese Firms." The paper analyses the innovation processes of a complex product system (CoPS) in China.

CoPS is high cost, high technology, highly customized and systematically complex product, subsystem or infrastructure. The most prominent difference between CoPS and a simple product is the production method. Although CoPS products are relatively few in number, their value is high because of their high unit costs.

The authors bring forward their own innovation process model for CoPS, which combines the flow of innovation together with the innovation system itself. Taking a typical CoPS innovation project in Hangzhou SL Software Co., Ltd. as an example, the authors elaborate on the CoPS innovation process based on this model. Technological innovation of CoPS is an issue new to China's enterprises, and the authors opine that understanding the innovation process of CoPS will strengthen the competitiveness of Chinese firms in an age of globalization.

Gang Xiang

Mr. Gang Xiang, Professor of Kunming University of Science and Technology, spoke on "Some Exploratory Research on Chinese State-owned Enterprises' Sustainable Innovation Process." Enterprises' Sustainable Innovation (ESI) addresses a challenge faced worldwide by enterprises and academia. Supported by the NSFC of China, Professor Xiang has examined the theory and practice of the Chinese State-owned Enterprises' Sustainable Innovation (CSESI) process for years.

Several trends were identified:

- Green and sustainable innovation that is economically and ecologically desirable
- Rapid development of information technology
- Movement of State Owned Enterprises (SOEs) to multiple ownership
- Evolution from Entrepreneur-oriented to mechanism-oriented ESI.

Professor Xiang concludes with the observation that the fundamental objective of ESI in the SOEs is to build a viable management mechanism that will assist top management in carrying out its tasks effectively.

David Hart

"Entrepreneurship and High-Tech Innovation: What's Governance Got To Do With It?" was the topic of Professor David Hart of the Kennedy School of Government at Harvard University. Hart defines "entrepreneurship" as "the processes of starting and continuing to expand a business." His definition of "governance" is "conscious collective action that can extend well beyond government."

He then briefly sketches out the history of the debate about what he calls "entrepreneurship policy" in the U.S. and outlines a broad framework for thinking about the central problem that entrepreneurship policy-makers face. He then turns to researches by three colleagues in the areas of biotechnology (drawing on the work of Andrew Toole of Illinois State University), telecommunications (drawing on the work of Eli Noam of Columbia University), and electronic commerce (drawing on the work of Kennedy School Viktor Mayer-Schönberger) to make these ideas more concrete and relevant.

Professor Hart concludes a careful balancing act is necessary for good outcomes. For example, intellectual property and contract laws are necessary to protect entrepreneurs. But if the legal regime is too rigid, entrepreneurs can be overwhelmed by corporations with "extremely deep pockets." This emerging area of policy is one where policy-makers may be ahead of academics but much work remains to be done by both.

Yuan Li

Mr. Yuan Li, Professor of Xi'an Jiaotong University, delivered his paper (co-authored with Feng Ren and Yi Liu) on the "Relationship between the Innovation Behavior and Innovation Type: the Choice of Product Innovation and Process Innovation during the Transition Period in China." In this paper, the authors surveyed 550 State Owned Enterprises (SOEs) to obtain data about product and process innovation from 1995 to 1999 in China. They examined in their theoretical and empirical study the relationships among:

- Market motivation
- Improvement of internal governance
- Government control
- Capability constraint and capital constraint
- Motivation for innovation and investment in innovation.

This complex study developed 11 hypotheses and presented a structural equation model, which adds internal governance and governmental control as factors that influence innovation in transition. The hypotheses are:

- Market motivation will be positively related to the motivation on innovation
- Improving internal governance will be positively related to the investment on innovation
- Government control will be negatively related to the motivation on innovation
- Capability constraint will be negatively related to product innovation
- Capability constraint will be negatively related to process innovation
- Motivation on innovation will be positively related to investment in innovation
- Motivation on innovation will be positively related to product innovation
- Motivation on innovation will be negatively related to process innovation
- Capital constraint will be negatively related to investment on innovation
- Investment on innovation will be positively related to product innovation
- Investment in innovation will be positively related to process innovation.

Results were obtained using appropriate statistical analyses. The model supported 10 of the 11 hypotheses tested. The one not supported was "Motivation on innovation will be negatively related to process innovation." The authors also point out certain limitations in the study that may limit its wide applicability unless additional research is done.

FINANCING INNOVATIONS

Jian Gao

Professor Jian Gao of Tsinghua University presented a paper on "Financial and Performance of Technological Innovation in China." His systematic study of the structure of financial sources and performance of technological innovation in China was in three parts. They are:

- The level of economic development and the stage of technological innovation development; this involves analyses of the characteristics of and changes in the finance system on the one hand and the S&T system on the other.
- Source structure for financing technological innovation in the last decade in

China, dealing with objectives, functions, scope and change for each financial source, as well as the relationships between different sources.
- Two indicators: numbers of patents and the degree of technological sophistication.

Gao found that internal funds of firms are the most important sources for technological innovation in China. External sources of fund are mainly from (local and central) government and banks. Equity market and external equity financing channels play a limited role in technological innovation.

Increasing inputs of funds can spur innovation. Since the middle 1990s the number of patent applications and patents granted has rapidly increased. At the same time the degree of technology sophistication has also changed. All these effects indicate that with growing inputs of funds technological innovation in China grows. Yet to be understood are efficient ways in which the government can spur innovation in China. The role of venture capital is also not well defined, and further research needs to be done.

Philip Auerswald

Professor Philip Auerswald of the Kennedy School of Government, Harvard University (now Assistant Professor at George Mason University), spoke on "Valleys of Death and Darwinian Seas." He began with a quotation from Chinese Former Minister of Science and Technology, Zhu Lilan, who responded to a reporter's question about a government initiative in S&T that had not met expectations. Zhu stated: "The main reason why results have fallen short is that there is inadequate investment in S&T. Starvation of funds for science is an international problem – it even occurs in wealthy countries like the U.S."

Auerswald noted the current debate over the existence of an "innovation gap." The question is: what happens between the research and invention stage and the business and new firm creation stage? How can we understand better the coupling between research and innovation? This has been the object of study between Auerswald and Branscomb that led to five core findings:
- Most funding for technology development in the phase between invention and innovation comes from individual private equity "angel" investors, corporations, and the Federal Government—not venture capitalists.
- Markets for allocating risk capital to early stage technology ventures are not efficient.
- Despite (or in response to) market inefficiencies, many institutional arrangements have developed for funding early stage technology development. This suggests

that funding mechanisms evolve to match the incentives and motivations of entrepreneurs and investors alike.

- The conditions for success in science-based, high-tech innovation are strongly concentrated in a few geographical regions, indicating the importance in this process of innovator-investor proximity and networks of supporting people and institutions.
- Among corporations, the fraction of R&D spending that is dedicated to early stage technology development varies both among firms and within industries. The latter variation may be related to industry lifecycles.

Auerswald proposes that the challenge described here by former Minister Zhu paralleled those faced by the leading technology corporations in the United States in the 1960s, 70s, and 80s. In the Darwinian Sea, the struggle for survival is inevitable. Achieving an appropriate balance between order ("anchoring one side") and flexibility ("letting the other side go free") is a fundamental challenge facing technology managers in the United States, China, and elsewhere in the world.

INNOVATION NETWORKS AND SOCIAL CAPITAL

Denis Simon

Denis Simon, President of Monitor China, addressed the topic of the relationship between regional competitiveness and innovation, "The San Diego Study." A full copy of the study, done in collaboration with the Council on Competitiveness, can be found at: http://www.compete.org.

The essence of the model that underlies the study is the belief that if you want to look at the sources of prosperity you have to go back to the beginning, innovative capacity. Innovative capacity is often found in "clusters" of firms found in a favorable natural and policy environment. Some are high-tech clusters, others are not. The nature of competition and the degree to which government can set the environment determine to some extent whether and how firms come together to form clusters.

Five clusters were studied in the report: Wichita, Pittsburgh, San Diego, Atlanta, and Research Triangle. Understanding the dynamics of clusters leads to understanding regional economic growth, how clusters develop, how innovation arises in those clusters, and what kind of lessons could be learned. Simon sees the methodology used to understand these relationships has the potential to be used in China.

The importance of this study is that it addresses not only growth but growth that increases the livelihood and the welfare of the people who live in the area. The kinds of measures used in the study are innovation output measurements as well as traditional economic measures. The study looked at different types of clusters, trading clusters versus local clusters. There's a certain amount of economic activity that's founded in that particular area and it's measurable. One of the essential conclusions of the study is that government should stand back and let the private sector do its thing.

Finally, some basic conclusions about clusters are:

- The need to promote cluster awareness
- The need for an ongoing diagnostic of the cluster's competitive position. Of the five clusters studied, each failed to provide a sustainable model for long-term growth and became less competitive over time.
- Governments play a core role in clusters, training workers and recruiting firms.
- Widening institutional membership to include all players is important.

Xielin Liu

Xielin Liu, Professor at the Research Center for Innovation Strategy and Management, Ministry of Science and Technology, PRC, delivered his paper on "Networks and Incentives in Transition: Multi-Level Analysis of China's Pharmaceutical Industry." Professor Liu investigated the institutional and organizational sources of persistence and change in a product innovation system that brings new products to market in China's transition economy. He focused on the interaction between incentives and networks comprising that system.

Even after two decades of economic reforms, the research institutes, manufacturers and wholesalers in many state-dominated industries have not moved significantly beyond the functional boundaries established decades ago under the Soviet-style command economy. A case study in the pharmaceutical industry shows that while the system may still be comprised of functionally-specialized organizations, the dynamics underlying this structure have changed dramatically with reforms. Further, organizations are beginning to pursue alternative strategies for creating and acquiring complementary assets, although these are not always in line with overall reform objectives and, in some cases, lead to suboptimal system performance.

Liu's study shows the sources of emerging variation within these cross-functional and intra-functional networks. Some of the functionally specialized organizations are diversifying into other functional areas; research institutes into manufacturing, manufacturers into R&D and marketing, wholesalers into manufacturing. They find

increased collaboration across organizational boundaries within the intra-functional R&D network, in stark contrast to the lack of inter-organizational relationships within manufacturing intra-functional networks (except for mergers among manufacturers).

Dan Berglund

Dan Berglund , President & CEO of the State S&T Institute, State of Ohio, submitted a paper (co-authored by Marianne Clarke) "Using Research and Development to Grow State Economies." He was absent due to illness, and Professor Branscomb delivered the paper.

In the paper, the authors point out that the U.S. economy is undergoing a dramatic transformation. This is occurring as the nation moves to an economy driven by high-technology industries and by the broad application of technology in traditional industries. To compete in this "new economy," states must have an economic base of firms that constantly innovate and maximize the use of technology in the workplace. Also critical is a strong research and development (R&D) base that can provide these technology-intensive companies with access to state-of-the art research, researchers, and research facilities.

A technology-based economy requires:

- A strong intellectual infrastructure, such as universities and public or private research laboratories that generate new knowledge and discoveries
- Efficient mechanisms through which knowledge is transferred from one person to another or from one company to another
- Excellent physical infrastructure, including high-quality telecommunications systems and affordable, high-speed Internet connections
- A highly skilled technical workforce; and good sources of capital.

Each element has a direct impact on a state's R&D base and, therefore, on its ability to support a technology based economy. Many states are building their R&D base through initiatives that address these elements.

Scott Shane

Professor Scott Shane of the University Maryland presented his paper on "Start-Up Companies and University Technology." He pointed that there have been very large increases in university entrepreneurial startup activities in the last 20 years. This has been particularly true in the biomedical field, and there is no indication that the trend is in a downturn.

Shane noted that for startups there is also a wide variation among universities. In part that variation is because of the policies that each university adopts, the relative prestige or ranking of the university, and the source of funding that the university has received for its research. Within a given university there are also a number of variables, such as the form of intellectual property involved, the nature of the technology, the nature of the technical regime in which that technology tends to be exploited, and the characteristics of the people involved. All these variables influence the likelihood that there will be startups to exploit a particular invention.

The financing prospects of inventions depend heavily on social relations within the process. And lastly, the commercialization potential for startups varies as a function of the manufacturing intensity, and the number of firms inside that particular industry market segment.

Jianing Mi

Jianing Mi, Professor at the Harbin Institute of Technology, spoke on "China's High Technology Policy and its National Technological Innovation System." Professor Mi addresses objectively high technology policy in China from the perspective of public policy, and reviews China's technology innovation strategy and its national technology innovation system. The focus of his research is on:

- How inventions from public research organizations transfer to technological innovation in the national technology innovation system
- Looking at the technology invention as a public good and the technology innovation as something with commercial value
- The suitable role for the Chinese government in high technology policy.

Mi also noted that in China public policy has played a major role in directing economic development. The implication is that this directive role of public (government) policy is also expected in technology/innovation policy. This differs from the U.S. where the directive role of public policy is more muted. Professor Mi's case study of the Haidan S&T Park in Beijing illustrates some of these points. He further treats the economic and technological development zone as a case to evaluate the national technological innovation system **ION.**

SUMMARY DISCUSSION

Professor Lewis Branscomb and Professor Zuoyan Zhu chaired the closing session. Professor Qingrui Xu, and Professor J. Thomas Ratchford gave closing summaries touched on some of the main points of the seminar.

Prof. Xu considered some of the policy issues considered at the seminar. He noted the very successful seminar discussions highlighted important opportunities for further China-U.S. cooperation and research in policy issues, just as there has been successful cooperation in basic sciences. He reviewed three levels of policy issues, based on a triangular view: national level, regional level and industrial level.

Prof. Ratchford thanked those people who made the conference possible, including the co-chairs and organizing committee members. Then he briefly summarized some of the topics that were woven through the seminar papers and presentations. These included why and how the Chinese economy has done so well for such an extended period, contrary to the predictions of Western economists, the dependence of that growth on high technology. He also noted five issues that were identified and discussed to some extent, but lack complete treatment:

- State-owned Enterprises (SOEs) in China: they lose money, employ many workers, and play a central role in the Chinese economy. They are not well understood in the U.S., and a "bright line" is hard to discern between SOEs and private companies.
- Is there too much emphasis on radical innovation in the U.S.? In the 1960s and 1970s the U.S. automobile industry took many radical innovations to production, while Japanese automobile companies successfully emphasized small incremental improvements and reliability.
- Intellectual Property Rights (IPR): they are integral components of innovation and could well deserve a seminar devoted to their characteristics and applications in order to better encourage innovation.
- Monopolies: technology causes monopolies, mainly through IPR and successful defense of trade secrets. Reconciling these technology-produced monopolies with principles of free trade and competition policy remains a challenge.
- Clusters were discussed often in this seminar. Better understanding of how they occur, how they are constructed, and their impact on innovation and economic growth deserve more attention.

SUMMARY STATEMENT BY THE CO-CHAIRS

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The economies of both China and the United States are strongly dependent on a high rate of technical innovations, but for very different reasons.

China is in a rapid economic transition to a socialist market economy, whose rate of productivity growth depends on a high rate of injection of advanced technology and modern methods of management. Policies to encourage this growth have been highly successful, but they have been driven primarily by the injection of capital and technical knowledge from outside China, as well as by the restructure and modernization of more traditional Chinese industrial enterprises. To capture maximum benefits and reduce the dependence on foreign capital in the future, China requires the growth of indigenous new technical enterprises based on Chinese funded venture capital and equity markets. The Chinese papers at the conference illuminated many successes in this direction and evaluated the policies that stimulated them.

The United States economy is dependent on rapid innovation in order to retain the opportunity for Schumpeterian profits based on protectable, superior products and services. While the growth of the economy, in the US and elsewhere, depends almost entirely on incremental improvements in productivity and in products for established markets, it is the radical innovation that may destabilize old markets and open the way for new growth based on new technology and new business models. US success in financing innovations through private equity markets is enviable, but is subject to cyclical swings in investor risk tolerance. The government also has not yet gained political confidence in the policy tools that might link the massive American investments in research more effectively to private investment.

While these two pictures would appear on the surface to be sufficiently different that one might not reasonably expect common frameworks for evaluating public policies in each nation. However, the analysis in the conference shows that the nature of innovation is inherent in both social and technical systems common to all political economies. Thus the very differences in systems were useful in elucidating the range of options each country might consider.

Furthermore, the two economies are linked by a very strong link in trade and with Chinese accession to the WTO both economies are linked by common commitments at the level of international trade.

There were also some misconceptions that conference papers were able to expose. The Chinese state-owned Enterprises (SOEs) are not well understood in the U.S., and a "bright line" is hard to discern between SOEs and many large private companies in China. The creation of new firms by Chinese research universities has been impressive, but the Universities are now cutting back their financial commitment to such firms as some of them encounter serious financial problems in highly competitive markets. But overwhelmingly impressive is the amount of direct foreign investment by American firms, which seek to link the deep resource of high-level technical talent in China to the firms' international requirements for research capacity.

In the US, the notion that American firms may have placed too much emphasis on radical innovation in the 1980s, when Asian firms were demonstrating lower costs, high quality production and quick product cycles, has now been put into better balance by the refocus of US managements on production technology and management agility in the 1990s, which won back a lot of lost market share.

Intellectual Property Rights (IPR) emerged as integral components of innovation and could well deserve a seminar devoted to their characteristics and applications in order to better encourage innovation. The correct balance between protection of intellectual property to ensure rapid innovation, and the need for limited rights or an efficient market in rights in order to sustain the rapid diffusion of technical knowledge on which a global economy depends, was addressed at length in the seminar.

A second issue that stimulated interest in both countries is the need for better understanding of the networks and other social attributes of highly innovating communities. In the U.S., in China and in India, for example, there is a strong tendency for certain urban areas to demonstrate innovation rates far in excess of the average for the nation as a whole. Just what are the basic requirements for those networks of institutions and individuals, and the social climate that fosters rapid innovation? This question is now attracting active research in both countries. Even when these factors are better

understood there will remain a difficult question about the limitations on public policy for fostering them.

The very successful seminar discussions highlighted important opportunities for further China-U.S. cooperation and research in policy issues, just as there has been successful cooperation in basic sciences. The co-chairs strongly recommend the continuation of the NSF and NSFC collaboration to carry out the program of Decade-long Science Policy Dialogues. The major objective is to create a platform for exchanging information and experience, sharing science policy related interests and concerns, and enhancing closer and substantial cooperation, which we need more and more with the rapid development and globalization of science and technology.