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Testimony before the U.S.-China Economic and Security Review Commission
Hearing on Research and Development and Technological Advances in Key Industries in China
Panel III: R&D: Domestic and Foreign-Funded
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Summary:

U.S.-based and other global companies are increasing their investments in R&D facilities in China and other emerging market countries. The nature of the China-based facilities includes adapting products to the Chinese market, pursuing applied research to improve products, and, more recently, conducting basic research that is part of the firm's global strategy.

The growing investment in Chinese R&D facilities will complement China's efforts to become an innovative power. In a country with a passion for education, every high-technology factory and every R&D facility is a learning opportunity for China.

While China has given greater flexibility to a variety of institutions to choose individual research projects, the R&D activities are generally a complement to China's overall industrial and national security strategy. They are also part of China's desire to become more independent of technologies developed and licensed by foreign companies.

China's emergence as an innovative power poses opportunities and, increasingly, challenges for the United States. In response, the United States needs to carefully monitor global trends in innovation, strengthen the American innovation system, and adopt policies that encourage investment in high-tech manufacturing and advanced research in the United States.

China's Drive to be an Innovative Force:

Three Decades of Chinese Growth: Over the past three decades, China has made serious strides in creating a national innovation system that has become increasingly attractive as a site for research and development by American and other foreign-based global companies.

China has built on a base that was initially modeled on the R&D structure developed by the Soviet Union. R&D was centrally directed toward economic development and national security. While elements of that structure are still part of the Chinese R&D system, China has made enormous progress in moving to a system that is considerably more decentralized and commercially-oriented.(1)

Shortly after the 1979 shift toward markets and the global economy, China announced its Key Technologies R&D Program (1982). (2) In 1986, the Chinese government adopted the Spark Program with a focus on rural development and village and town enterprises. In 1987, China announced the 863 Program and its emphasis on high-technology R&D. The program was designed to monitor global trends in high technology and to concentrate research in 8 areas that ranged from biotechnology to space.(3) The 1987 863 Program was complemented in 1988 by the Torch Program focused on high-tech industrial development.

In 1997, China added the National Key Basic Research (973) Program with an emphasis on original innovation. This emphasis on original, Chinese innovation has been amplified in the fifteen-year plan that began to be implemented in 2006.(4) China's goal is to become a knowledge economy by 2020 with considerable Chinese innovation, which will reduce China's dependence on foreign technologies, foreign firms, and the potential of restrictions imposed by foreign governments.(5)

Funding the Future: China has matched its programmatic efforts with growing financial support. Over the past decade, China's GDP has grown at an average of ten percent per year while R&D spending has grown at about twice that rate. By 2006, China was spending $37 billion dollars (at then prevailing exchange rates) to rank fifth worldwide in terms of national spending on R&D. A recent OECD study using purchasing power parity put Chinese R&D at the equivalent of $136 billion, putting it in second place just ahead of Japan. While the OECD figure is controversial and is viewed by a number of experts as overstated, it does support the broader point of China's intense commitment to becoming an innovative economy.

China has also made strides in terms of publishing scientific papers. According to the Thompson Scientific Science Citation Index, China ranked fifth in the world in total output of published scientific papers. In terms of key emerging fields, China is even more prominent. In nanotechnology, for instance, China is second only to the United States.(6)

Building the Talent Pool: China is racing to add more scientists and engineers to an already expanding talent pool. In the ten years between 1995 and 2005, the number of college graduates grew fourfold from 800,000 to over 3 million.(7) More than a third of Chinese students study engineering, and including the number of students pursuing science brings the total to about 40%.(8)

China is intent on creating world-class universities. Chinas' Project 211 will give priority to 25 universities concentrated on critical disciplines. (9) Chinese universities are also advancing through partnerships with American and other international universities. In many cases, they have also forged close ties with industry, including the formation of science parks.

The Commission's invitation letter posed five separate questions. Let me respond to them in order:

Question 1: Is Chinese R&D becoming more focused on basic, rather than applied, research?

China is intent on becoming an innovative power and has moved to increase its focus on basic R&D, almost all of which is state-funded. Rather than focusing on well-defined frontiers of knowledge, they are seeking to become a force in newer, less well-developed fields such as nanotechnology.

They are investing in education, encouraging the return of Chinese who have studied and worked overseas, and, generally, working to expand their talent pool.

They have, however, a long way to go. Research is still heavily concentrated on applied research that will support key industrial and other national goals.

Question 2: Is China able to capitalize on the R&D undertaken in China by foreign-invested companies?

China is able to capitalize on much of the foreign R&D taking place in China -- directly or indirectly through the circulation of personnel.

Early R&D investments by multinational corporations (MNCs) were focused on adapting products to the Chinese market and were often linked to their manufacturing facilities in China. In the last few years, however, MNCs have shifted toward establishing R&D facilities that can be part of their global R&D strategy.(10) For the most part, these investments have been concentrated in the information technology (IT) or computer fields. But, by 2006, a number of pharmaceutical and chemical companies had indicated their intent to undertake R&D investment in China as well.(11)

There is a debate over whether or not the foreign direct investment (FDI) in R&D is a net plus for China's own innovation system. In the 1990s, many MNCs made joint venture commitments as part of entering the Chinese market. The joint venture structure facilitated spillover effects for Chinese manufacturers and Chinese researchers. In an environment of weak intellectual property (IP) protection, there was considerable borrowing of technologies, whether licensed or not.

Since China joined the WTO, the pattern of MNC investments has shifted toward wholly-owned facilities. The wholly-owned structure can limit the opportunity for spillovers to the overall Chinese innovation system. In a weak IP environment, MNCs tend to keep key technologies closer to home or in countries with strong IP protection. Even when the Chinese facility is used as part of an overall project, key technologies are carefully protected. (12)

There are countervailing forces. Despite high graduation rates, the demand for talent in China creates significant mobility. For instance, Intel reports high levels of turnover at its Chinese facilities. While Intel views the turnover as helping foster a growing IT industry that in turn benefits Intel, their attitude might be different were they engaged in the kind of next generation research undertaken in their Indian research center.(13)

Businesses also emphasize positive relations with Chinese universities. Some complain that the U.S. Bayh-Dole law, initially adopted to encourage the commercialization of university research, has led to lengthy bargaining over terms of licensing. By contrast, agreements with Chinese universities are reported to be relatively speedy.

The recruiting of Chinese professionals with overseas management and research experience can also be a path to acquiring R&D expertise and know-how. Over time, China's commitment to strengthening its universities and its investments in R&D will make China not only a more attractive location for the R&D facilities of global companies but will increase China's ability to capitalize on the R&D of global firms.

Question 3: Does China's government dictate the nature and scope of R&D projects?

The Chinese government funds almost all the basic research in China and sets broad areas for R&D research toward the fulfillment of national goals.

Neither the Ministry of Science and Technology (MOST) nor the Chinese Academy of Sciences (CAS), however, is stuck in the former era of central planning. To quote Professor Richard Suttmeier, the system has changed from one “based on central planning...to a system with a strong commercial orientation, in which the industrial sector now accounts for some 65 percent of the nation’s R&D.”(14)

Still, the series of R&D programs and plans represent a significant degree of state direction. Most individual companies that lack the resources to be major innovators are likely to turn to universities or the state, or acquire technology elsewhere, including overseas.(15)

While there is ongoing rivalry between MOST and CAS, this does not indicate a reduction in state influence in R&D. In any case, with China still able to move towards the current frontiers of technology, state direction (as opposed to detailed mandates) is made considerably easier.

Question 4: What do China's R&D activities reveal about its economic and national security goals?

China's R&D activities indicate a three-fold strategy: first, use applied research and incentives for foreign direct investment to strengthen industry, foster rural development, and close the technology gap that exists between China and the advanced industrial nations.

Second, concentrate research on a few areas of science and technology that are not yet well-defined. Nanotechnology and aspects of biotechnology would be prime examples.

Third, China intends to become an innovative power with reliance, to a considerable degree, on home-grown technologies.

In terms of national security, there has been a considerable focus on space exploration and rocketry. The expansion of the China-based IT industry has the potential to facilitate the modernization of the Chinese military.

Despite what some might call a growing emphasis on techno-nationalism, China has also demonstrated an interest in international collaboration in some key technologies. For instance, China is participating in the international effort to develop fusion power and the European Union's Galileo global positioning system, in addition to having forged partnerships with Brazil in aerospace.(16)

Question 5: What ties exist between the military, the universities, and the state-owned companies cooperating on R&D?

National security -- including access to hydrocarbons and other key commodities -- is a clear Chinese priority. Dependence on imported petroleum and the concern over secure supply lines has dictated the global reach of Chinese investments and diplomacy. Logically, it should also require modernization of the Chinese Naval Fleet.

In *Technological Superpower China*, Jon Sigurdson describes the changing structure of China's defense and space industries and their growing involvement with commercial enterprise. China is, for example, a major subcontractor for both Airbus and Boeing.(17)

In the first decades of the Cold War, there was considerable emphasis on how technologies were spun-off from military advances to the benefit of the civilian economy. The pace of innovation and the rise of international competition brought that era to a close. By the 1980s, there was recognition that the innovations in the commercial arena where adapted or "spun-on" to meet military needs.

While military-driven innovations can still have an enormous, even transformative effect on the civilian economy -- think of the Internet -- the civilian economy has become a key part of every major military power's defense industrial base.

The extensive contribution of MNCs in building the Chinese IT, electronics, and aerospace sectors creates the potential for strengthening the Chinese military.

But, I would draw on the work of my fellow panelist Kathleen Walsh to recognize the limited scope of our knowledge. In her *Foreign High-Tech R&D in China*, Walsh cautions that while “there is the *potential* spillover effect from foreign high-tech R&D in China on PRC defense capabilities...limited understanding of how China's defense industry and military function interact--with one another or with the civilian sector—[means that] one can only speculate…" about the impact of foreign R&D on China's defense posture.(18)

<u>The U.S. Response:</u>

Strengthen American Strategy: The growth in R&D investments by U.S-based and other global companies creates opportunities and poses challenges for the United States. How should the United States respond? What strategy should the United States adopt? At the very least, the United States needs to adopt a number of steps that can be clustered under three broad headings: first, monitor R&D developments in China and elsewhere around the world; second, strengthen the American Innovation System and adapt it to the growing reality of innovation as a global phenomenon; and, third, adopt a national innovation strategy that includes policies that encourage investment in advanced manufacturing and R&D in the United States.

Monitor Global Trends: The Congress should encourage the continued collaboration of the Bureau of Economic Analysis in working with key scientific agencies to trace the global R&D and other investments of MNCs. Funding for the effort should be adequate and sustained.

The United States should release periodic reports on global trends in R&D and investment in R&D facilities. The Government Accountability Office should continue its work on monitoring trends of the outsourcing of R&D in key industries. The Congress should reconstitute an updated Office of Technology Assessment that could provide a technological and scientific perspective on global R&D trends and their implications for the United States.

The President should task the President's Council of Advisors on Science and Technology to make its own assessment.

The Department of State should increase the number of scientific officers serving in embassies in R&D-intensive countries around the world, including the emerging market countries.

Good policy must be based on as clear as possible knowledge of current and likely future trends.

Strengthen the American Innovation System: The *Rising Above the Gathering Storm* Report of the National Academies, the President's State of the Union Address in 2006, and Congressional passage of the America Competes Act are all steps in the right direction. In addition to funding the Competes Act, the Congress and the country will need to make continued efforts to upgrade our entire American learning system.

Since the rise of Fascism in Europe, the United States has benefited from an enormous flow of talent -- in science as well as other fields. In more recent years, we have drawn talent from the developing world, particularly India and China. The contributions of the international talent have been immense. AnnaLee Saxenian's work has found that a third of Silicon Valley startups over the past two decades have been started by Chinese or Indian immigrants.

At the same time, we have allowed ourselves to become dependent on that flow of foreign talent. For the first time, the United States is facing serious competition for that talent, as not only Europe and Japan, but also China and India seek to attract or retain scientists and engineers. With the Sputnik generation reaching retirement age and the aforementioned competition for global talent, the United States will need to create the conditions that encourage more Americans to choose science, technology, engineering, and mathematics (STEM) careers. In addition to improving math and science instruction, attracting students to STEM subjects will require everything from financial incentives to an improved environment for post-doctoral students, and more attention to introductory courses.

Finally, in an era where global collaboration is going to be a growing factor in innovation, more American STEM graduates need to have some language ability. We should borrow from the National Defense Foreign Language Fellowship (NDFL) program adopted as part of the post-Sputnik National Defense Education Act. Under the NDFL, students studied graduate level science (including economics) and a foreign language. In the modern era, we should start extensive language education in kindergarten. Perhaps, federal matching grants could be offered to school systems that have promised early-age language instruction in key languages -- Chinese being a prime example -- that would continue on to give the student full fluency. Those students choosing STEM careers would already be poised for international collaboration.

Adopt a Strategy that Encourages Advanced Manufacturing and R&D in the United States: Too often, United States policies are formed in reaction to the national strategies of our key competitors. Instead, we need a national strategy that will keep America at the forefront of innovation. In addition to creating a climate that favors investment, we will need to balance our international accounts, adopt improved tax incentives that favor R&D and advanced manufacturing, and be willing to counter incentives offered by competitors in order to attract U.S. manufacturing or research facilities.

<u>Endnotes</u>

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3. Sigurdson, IBID. p. 9.

4. Richard P. Suttmeier, Cong Cao, Dennis Fred Simon, “China's Innovation Challenge and the Remaking of the Chinese Academy of Sciences,” *Innovations,* Summer 2006, p. 79.

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10. Nannan Lundin and Sylvia Schwaag Serger, “Globalization of R&D and China: Empirical Observations and Policy Implications,” IFN Working Paper No. 710, 2007, p. 20.

11. Ibid, p 20.

12. Jerry Thursby and Marie Thursby, “Here of There? A Survey of Factors in Multinational R&D Location,” The National Academies of Science, 2006. See also, Woodrow Wilson Center Conference on the Thursby Report, at http://www.wilsoncenter.org/index.cfm?topic_id=1408&fuseaction=topics.event_summary&event_id=202007.

13. Drawn from a Draft Conference Report of “The Dragon and the Elephant: Understanding the Development of Innovation Capacity in China and India,” September 24-25, 2007. The conference was sponsored by the National Academies in conjunction with other organizations including the Woodrow Wilson Center.

14. Suttmeier, op.cit., p. 101.

15. Cong Cao, op. cit., pp. 27-28.

16. Sigurdson, op. cit., pp. 206-208.

17. Sigurdson, op. cit., Chapter 7 on Space and Defense Technologies.

18. Walsh, op. cit., p. 106.