

CHINA'S INNOVATION CHALLENGE

CONG CAO



In the span of less than three decades, China has evolved from being a peripheral player to become the most potent engine in the global economy. Along with its rapid economic progress and the many improvements in the quality of life for large

numbers of the Chinese population, a variety of indicators suggest that China's science and technology (S&T) capabilities also are on a sharply rising trajectory (Table 1). Since the early 1990s, research and development (R&D) expenditure in the People's

Republic of China (PRC) has been increasing at a rate approximately twice that of overall economic growth. In 2006, China spent renminbi (RMB)300 billion (approximately U.S. \$37 billion) on R&D, or 1.42 percent of its increasing GDP, highest among countries with similar economic development level—though the percentage is still lower than that of most of the major developed economies. In terms of overall R&D expenditure, this put China sixth in the world, after the United States, Japan, Germany, France, and the United Kingdom.¹ Chinese institutions of higher education are turning out an increasing number of well-prepared graduates in science and technology. In 2006, China graduated some

TABLE 1: China's Science, Technology, and Education: Some Indicators

	1998	1999	2000	2001	2002	2003	2004	2005	2006
R&D Expenditures									
Gross Expenditures on R&D (GERD) (\$1 billion)	6.65	8.2	10.8	12.6	15.56	18.61	27.75	29.91	36.79
GERD/GDP (%)	0.69	0.83	1.00	1.07	1.22	1.31	1.23	1.34	1.42
R&D Performance									
Enterprises (%)	44.83	49.59	59.96	60.43	61.18	62.37	66.83	68.32	71.08
Basic Research (%)	5.25	4.99	5.22	5.33	5.73	5.69	5.96	5.36	5.19
Papers Cataloged by Science Citation Index									
Share of the Total (%)	2.13	2.51	3.15	3.57	4.18	4.48	5.43	5.30	5.90
Rank	12	10	8	8	6	6	5	5	5
Human Resources									
Scientists/Engineers Engaged in R&D (1,000 persons-year)	485.5	531.1	695.1	742.7	810.5	862.1	926.2	1,119	1,224
Graduate Student Enrollment (1,000 persons)	198.9	233.5	301.2	393.3	501	651.3	819.9	978.6	1,100
Undergraduate Student Enrollment (1 million persons)	3.41	4.09	5.56	7.19	9.03	11.09	13.33	15.62	17.39

Source: National Bureau of Statistics and Ministry of Science and Technology (comps.), *China Statistical Yearbook on Science and Technology* (Beijing: China Statistical Press, various years.)

Cong Cao is senior research associate with the Neil C. Levin Graduate Institute of International Relations and Commerce of the State University of New York in New York City.

159,000 students with masters and doctoral degrees, on top of 1.34 million engineering undergraduates as well as 197,000 science undergraduates. Unequivocally, this represents the world's highest output in terms of overall numbers.

In recent years, there also has been a steady increase in the number of international papers published by Chinese scientists. Measured by the number of papers included into the *Science Citation Index (SCI)*, a bibliometric database published by Thompson Scientific, China in 2006 ranked fifth in the world. Although China lags behind the world's leaders in many areas of science and technology, notable achievements have been recorded in a number of emerging scientific fields such as genomics and nanotechnology. In nanotechnology, for example, in terms of published papers, China is second only to the United States.²

Foreign investment as well as imported technology and equipment continue to pour into China, making it one of the largest recipients of foreign capital and know-how in the world. While most attention has been focused on the rapidly expanding export side of China's foreign trade, it also must be remembered that China has become one of the world's largest importers. And, most recently, many of the world's technologically most innovative companies have decided to move beyond setting up manufacturing facilities in China to establishing advanced R&D centers to develop new products and services for global markets as well as the Chinese domestic market. By the end of 2007, there were well over 1,000 foreign R&D centers operating in the PRC.

In early 2006, with a great deal of fanfare, China's leadership issued a new "Medium to Long-Term Plan for the Development of Science and Technology 2006-2020" (MLP). A remarkable piece of policy in a variety of ways, the MLP builds on important S&T-related policy initiatives since the mid-1980s, including the 1995 commitment to "strengthen the nation through science, technology, and education" (*kejiao xingguo*) and the more recent notion of "empowering the nation through talent" (*rencai xiangguo*). In addition to setting ambitious national priorities and formalizing the leadership's commitment to allocate substantial financial and human resources to turn China into an innovation-oriented nation by 2020, the MLP specifically

defines enhancing indigenous innovation (*zizhu chuangxin*) capability, leapfrogging in key scientific disciplines, and utilizing S&T to support and lead future economic growth as its major objectives.³ In a word, once considered one of the more backward developing countries, China today stands as one of the world's most robust and dynamic economic forces. These trends have led many observers to ask, in a similar vein, whether China also is poised to become a global leader in science and technology.

PROBLEMS AND VULNERABILITIES

China's current trajectory in supporting the development of science and technology is, in its ambitions, attracting the attention of observers around the world. While notable progress has

Many of the world's technologically most innovative companies have decided to move beyond setting up manufacturing facilities in China to establishing advanced R&D centers to develop new products and services for global markets as well as the Chinese domestic market.

been made and many more achievements from the MLP can be expected in the coming years, a balanced perspective on the prospects for Chinese science and technology requires attention to some of the challenges that China faces in realizing its ambitions.

First, China has yet to establish an enterprise-centered national innovation system. At face value, enterprises account for two-thirds of China's R&D expenditure;⁴ in reality, they have few financial resources to carry out innovative R&D activities.

According to a comprehensive survey of the nation's R&D resources in 2000, the latest with detailed, micro-level information, firms within high-tech parks spent an average 1.9 percent of their sales on R&D, far below the 5 percent standard by the Chinese definition of a high-tech firm, while those outside the parks spent merely 0.63 percent. Chinese enterprises as a whole do not do better, as they cannot afford to spend money on technology. The 2006 statistics indicates that only a quarter of large and medium-sized enterprises had set up S&T institutes, with only 1.5 percent of the sales revenue being used for S&T activities and 0.8 percent of revenue spent on R&D. Equally serious is the dearth of qualified personnel because of a severe "brain drain" of Chinese talent to foreign countries as well as to foreign-invested enterprises in China.

As a whole, Chinese enterprises spend more money on technology importation than on R&D.

In pursuing a quick and short-term pay-off, Chinese enterprises are keen to import foreign technology as the way to upgrade production technology; in such purchases, equipment dominates over software such as patents, know-how, blueprints, and so on. As a whole, Chinese enterprises spend more money on technology importation than on R&D. And once the equipment is imported, almost no financial resources are given to absorption, assimilation, and innovation, thus resulting in a vicious cycle of "importing, lagging behind, importing again, and lagging behind again."


Enterprises also lack the interest in engaging domestic institutions of learning for R&D efforts. The reform in the S&T system since the mid-1980s has to some extent activated the enthusiasm of researchers in these institutions (the supply side of technology), but enterprises (the demand side) have been reluctant to acquire technology from domestic sources. That is to say, the deeply-rooted problems of the separation of innovation

and the economy and of the organizational rigidity between enterprises and institutions of learning have not been solved.

Second, it is always questionable whether money has been well spent. As noted, enterprises are mainly interested in acquiring technology from foreign sources. It is no secret that a significant portion of the research carried out in China, even those under the major national programs, is derivative of what has been done elsewhere, which surely has wasted increasing but still limited resources. This explains why Chinese science has not yielded significant breakthroughs consummate with the rising investment in R&D. In fact, citations to the increasing number of Chinese S&T papers have been quite disappointing.

Misuse of research funds is widespread. More seriously, the rampant corruption in science and research has not only eaten a not-so-small-part of the research money but also eroded the morale of the research community. For example, Chen Jin from Shanghai Jiaotong University grabbed hundreds of millions worth of funds from various government agencies, including the Ministry of Science and Technology, the Ministry of Information Industry, and the National Development and Reform Commission, by using a purchased chip as his innovation. Although Chen Jin was fired by the university, his various honors removed, and some of the research money recovered, Chen himself has never been prosecuted for his cheating, nor have the government agencies involved been investigated for their responsibility in this scandal known to the world.⁵

Therefore, with the MLP supporting mega-science and engineering projects whose investment will be at the scale of billions of RMB, and the revised Law on the Progress of Science and Technology promoting greater innovation and creativity by fostering a "tolerance for failure,"⁶ the question of money being well spent is more than an issue of governance in scientific research; rather, it relates to whether China will eventually achieve its ambitious goals and play a more significant role in the frontier of international science and technology. Along with the money, there is a major responsibility to create a new economic development model that is not capital-intensive, labor-intensive, and



resources-intensive. It is in this sense that one of China's senior science policy-makers commented that the scientific community will not have another opportunity if it does not succeed in implementation of the MLP.

Third, China still has a long way to go to perfect its intellectual property right (IPR) regime. At first glance, China's IPR laws and regulations are as perfect as those promulgated by other countries; the problem lies in the enforcement. In fact, a decentralized China has made IPR protection at the local level difficult, if not impossible. China's weakness in IPR protection has been a major concern for foreign investors. But entering the 21st century, two of the three initiatives—patents and technical standards—put forward by China's scientific leadership are IPR-related (the other is about the development of talent). This is not only because the leadership realizes that the nation has been overwhelmed by the current international IPR regime. In the long run, an innovative China has to and will generate its own IPRs. In other words, China will not become innovative unless it takes more seriously the issue of IPR protection.

Fourth, China faces a serious talent challenge as it seeks to sustain domestic economic growth and technological advance. There is little doubt that China's current S&T talent pool is impressive: The number of scientists and engineers in China is the world's second largest, after only the United States; the evolving pipeline seemingly remains full as Chinese universities graduate the world's largest number of students; and the quality of graduates from key Chinese institutions of higher education is internationally acclaimed. Despite this fact, however, complaints continue to proliferate from multiple segments of the economy and society—from among Chinese government officials to enterprise CEOs, including the country heads of most multinational corporations (MNCs) that operate in China—about the problems that plague the local talent pool. Demand seems to be exceeding supply, quality problems are rampant, and the talent already in place remains difficult to manage and retain.

The active members of China's professional community are young when compared to their counterparts in the West—many being fresh out of school—so they lack the concomitant experience

China faces a serious talent challenge as it seeks to sustain domestic economic growth and technological advance.

of their peers abroad, especially in many leadership positions in the Chinese research system. China's lack of talent is most serious in the 50 to 60 year-old group and at the high end of the talent spectrum. In fields as well as locations where there is an apparent surplus of professionals, many problems limit the value and impact of these individuals. In some instances there is a gap between the knowledge students acquired in college and the precise skills required for their jobs; in other cases, the structure and distribution of the talent pool at senior, middle, and junior levels is misaligned or does not match up well in terms of disciplines with the exact skill needs of the immediate region. A number of programs, offering generous incentives, have been initiated to recruit Chinese scientists working abroad to come back to China, and as the condition of the Chinese research environment continues to improve, it is expected that the volume of the "reverse brain drain" will increase.

The talent shortage could have a negative impact in the near-to-medium term. The ability of employers to attract "the best and the brightest" will be affected by the shortage and China could experience the onset of a real "talent war." Foreign direct investment (FDI) will continue to be one of the key drivers for the demand of scientists and engineers in China, and if there is not enough talent available for foreign-invested enterprises, especially MNCs, FDI might decline not only in level but also in quality. Consequently, China's pace of economic growth, especially in terms of the development of new, technology-intensive sectors and its ability to attract higher value-added foreign investment, might be jeopardized.

More seriously, China's capacity for overcoming its S&T talent shortage, including its ability to provide training-related quality improvements, will determine the extent to which the PRC can

develop indigenous innovation capabilities and reduce its current dependency on foreign technology and invention. These are the MLP mandates. It is under these circumstances that a rapid response is needed to moderate, if not ameliorate, any possible negative impact, and that first and foremost the “fix” must be focused on closing the experience gap.

Last but not least, there is the question of whether China can become an innovation-oriented nation without being open to different ways of thinking.

Last but not least, there is the question of whether China can become an innovation-oriented nation without being open to different ways of thinking. This is more than just a question of philosophy. While Chinese researchers and entrepreneurs are encouraged to think outside the box and not to be afraid of failure, at least equally important is that other ingredients of innovation—autonomy, free access to and flow of information, and especially dissent, scientific as well as political—are not tolerated. However, it is generally believed that tolerance is as critical as talent and technology in driving creativity and growth.⁷ For example, Thomas L. Friedman, the *New York Times*’ columnist, has stated that censoring Google in China is equivalent to “curtailing people’s ability to imagine and try anything they want.”⁸ Therefore, allowing “blooming

and contending” is more important than purely worshipping innovation as a new “religion.” If the former is not allowed, the success of the innovation strategy is called into question.

ENDNOTES

1. According to the Organization for Economic Cooperation and Development (OECD) in its *Science, Technology and Industry Outlook 2006*, using the purchasing power parity (PPP) measure, in 2006, China became the world’s second largest spender on R&D (\$136 billion), ranking only behind the United States (\$330 billion). Of course, it should be noted that attempts to measure China’s economic output in PPP terms are subject to discussion, as its PPP-based GDP was reduced by forty percent in a recent recalibration. It should also be recognized that the gap in spending between China and the United States remains substantial, with the United States spending more than twice that of the Chinese.
2. China is one of six countries participating in the decoding of the human genome. On China’s achievement in nanotechnology, see Ping Zhou and Loet Leydesdorff, “The Emergence of China as a Leading Nation in Science,” *Research Policy*, Vol. 35 (2006): 83-104.
3. Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, “China’s 15-Year Science and Technology Plan,” *Physics Today*, (December 2006): 38-43.
4. This increase in part reflects the fact that many government R&D institutes have been “corporatized,” or converted into enterprises themselves.
5. See, for example, David Barboza, “In a Scientist’s Fall, China Feels Robbed of Glory,” *New York Times*, May 15, 2006; Hao Xin, “Scientific Misconduct: Invention of China’s Homegrown DSP Chip Dismissed as a Hoax,” *Science*, Vol. 312 (May 19, 2006): 987.
6. Hao Xin, “Science Scope: When It’s Okay to Fail,” *Science*, Vol. 317 (September 7, 2007): 1309.
7. Richard Florida, *The Rise of the Creative Class: And How It’s Transforming Work, Leisure, Community and Everyday Life* (New York: Basic Books, 2003).
8. Thomas L. Friedman, “Learning to Keep Learning,” *New York Times*, December 13, 2006.