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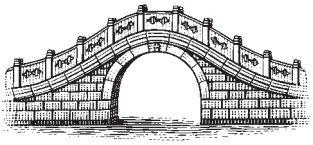
RESEARCH NOTE

China's Fifteen-Year Plan for Science and Technology: An Assessment

Sylvia Schwaag Serger & Magnus Breidne



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KEYWORDS: CHINA; SCIENCE & TECHNOLOGY; FIFTEEN-YEAR PLAN; ECONOMIC POLICY

EXECUTIVE SUMMARY

The essay provides a critical assessment of China's latest fifteen-year plan for science and technology.

MAIN ARGUMENT

The latest long-term plan for science and technology reflects China's determination both to overcome growing domestic social and environmental problems through technology and to become a world leader in innovation. The plan presents no radical departure from earlier strategies and continues to define policymaking by a strong belief that innovation can be "decreed" or steered by the government. The plan relies heavily both on supply-side policies for research and education and on a technology-driven view of innovation, rather than tackling less tangible and more complex issues such as deficits in social capital, institution-building, and building an innovation-friendly environment. New targets to strengthen "independent" or "indigenous" innovation raise concerns abroad over the emergence of "techno-nationalism" and implications for China's future economic openness.

POLICY IMPLICATIONS

This essay identifies two policy implications for China:

- Rather than focus on a possible conflict between imported and indigenous innovation, policymaking would benefit more by concentrating efforts on how to increase positive spillovers from foreign R&D. Helpful would be if policies aimed to improve the ability of companies, consumers, and institutions to generate but also to receive, absorb, and internalize knowledge as well as new ideas, products, and processes.
- In addition to natural sciences and technology-driven innovation, policy efforts would benefit from focusing on markets and consumers, organizational and process innovation, social capital, and (particularly) trust and institution-building.

The essay identifies three policy implications for the international community:

- China's development is part of a fundamental shift in the international distribution of knowledge. Other countries would benefit by responding positively and constructively to this development and working to better understand China's innovation system.
- China's new ability to both attract and provide knowledge resources offers significant opportunities for mutually beneficial exchange and cooperation in research and education.
- By working with China, the international community might prevent techno-nationalistic tendencies from steering China toward protectionism.

On February 9, 2006 the State Council presented its plan to strengthen China's scientific and technological (S&T) progress in the coming fifteen years.[1] The announcement of the plan was eagerly awaited both within and outside of China for several reasons. This announcement marks not only China's first long-term plan in the new century but also the first plan China presented since becoming a member of the World Trade Organization (WTO) and since President Hu Jintao and Prime Minister Wen Jiabao came to power in 2003. For the international community, the plan indicates how Beijing aims to strengthen China's future economic and technical development—undoubtedly having a profound impact on the rest of the world. The plan warrants careful analysis because it reflects Beijing's ambitions to make China one of the world's most important knowledge bases. Also of importance is that the plan contains an explicit target to reduce China's dependence on foreign research and development as well as to use public procurement to strengthen China's domestic industry. Additionally, rather than using the word *jihua* (plan)—which had been used for previous long-term strategies—the State Council made a point of using the word *guihua*, or long-term "program," distancing the plan from the notion of a traditional "plan economy."[2] In practice, however, many government offices—including the homepage of the Ministry of Science and Technology (MOST)—still refer to the long-term "plan."[3]

This essay provides a critical assessment of China's latest long-term plan for science and technology. The essay is organized as follows:

- pp. 138–144 provides a brief overview of recent developments in China's research, development, and educational system
- pp. 144–148 summarizes key components of the plan
- pp. 148–149 discusses key details of the plan
- pp. 149–151 examines the actors and processes involved in the development of the new plan
- pp. 151–156 looks at concrete steps undertaken for its implementation

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1 "National Outline for Medium and Long Term Science and Technology Development Planning (2006–2020)," Ministry of Science and Technology of the People's Republic of China, China Science and Technology Newsletter, no. 456, February 9, 2006 ~ http://www.most.gov.cn/eng/newsletters/2006/200611/t20061110_37960.htm; and State Council of the People's Republic of China, *State Council Decision Notice of the Implementation of the Long-Term Plan for the Development of Science and Technology and the Increase of Independent Innovation* (Beijing: China Legal Publishing House, 2006).

2 State Council of the People's Republic of China, *Guojia zhongchangji kexue he jishu fazhan guihua gangyao (2006–2020)*, February 9, 2006, http://www.gov.cn/jrzg/2006-02/09/content_183787.htm.

3 See, for example, Ministry of Science and Technology ~ http://www.most.gov.cn/eng/photonews/200704/t20070429_43489.htm.

- pp. 156–159 analyzes the plan in the context not only of China's rapidly increasing knowledge resources and of the characteristics of its innovation system but also in the context of China's larger socio-economic challenges
- pp. 159–163 assesses how the fifteen-year plan reflects some of the principal weaknesses in China's innovation policy and system
- pp. 163–164 reflects on the implications of the analyses for other countries and attempts to formulate some policy recommendations

BACKGROUND: RESEARCH AND DEVELOPMENT IN CHINA

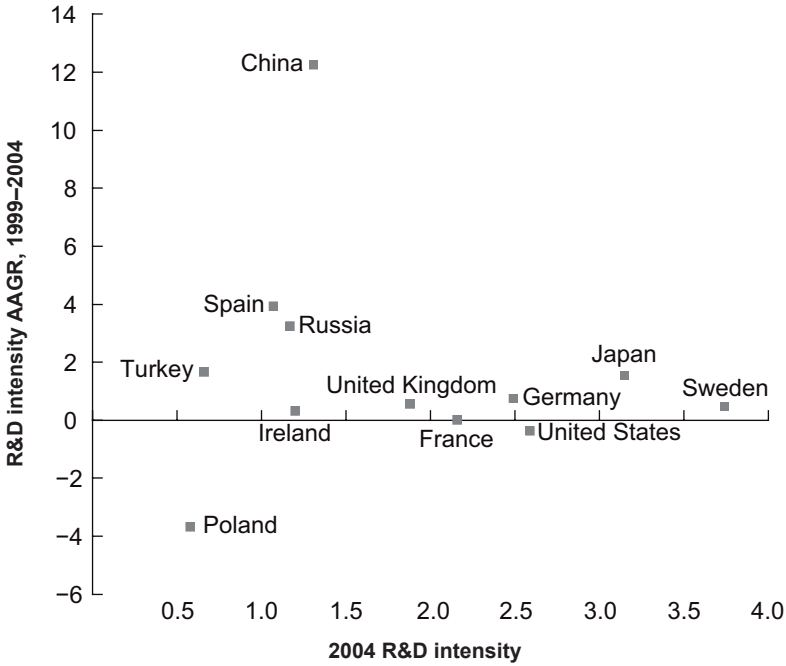
Technological development in China is driven by long-term five-year plans, the first of which was presented in 1956.[4] Until 1965 China followed a system of central planning patterned after the Soviet system. Although not implemented to the same extent as in the Soviet Union, the system resulted in a highly bureaucratic and hierarchical research and development (R&D) structure. Although China developed both nuclear weapons and ballistic missiles (with support from the Soviet Union) during this time, central planning severely hampered technological and scientific development. During the Cultural Revolution (1966–1976) many universities shut down while professors were sent to the countryside to work in the fields and on farms, resulting in the loss of a generation of researchers. At the same time, China weakened its ties with the Soviet Union and came to realize the disadvantages of importing developed technology rather than developing its own. It was not until after Mao's death and Deng Xiaoping's accession to power that China began to open up economically to the rest of the world with the launch of the "four modernizations" (in agriculture, industry, science and technology, and national defense).[5] The far-reaching transformation of these four sectors lead China into the modern era. Although the roadmap has since been adjusted, Deng Xiaoping's motto "science is the first productive force" (*keji shi di yi shengchan li*) remains the guiding principle. Since the latter half of the 1990s China has strived for a more market-oriented and high quality research system by implementing a number of policy initiatives. R&D expenditure increased dramatically. **Figure 1** shows

[4] For a good overview of the historical development of China's science and technology system, particularly its plans and policies, see Ke Yan, *Zhongguo keji: Gaige yu fazhan* (Beijing: Wuzhou chuanbo chubanshe, 2004). Translated by Chen Ru as *Chinese Science and Technology: Reform and Development* (Beijing: China Intercontinental Press, 2004).

[5] Zhicun Gao and Clem Tisdell, "China's Reformed and Technology System: An Overview and Assessment," *Prometheus* 22, no. 3 (September 2004): 311–31; and Kathleen Walsh, "Foreign High-Tech R&D in China," The Henry L. Stimson Center, Report, June, 2003.

FIGURE 1

*R&D Intensity in 2004 and Annual Average Growth Rate (AAGR) of R&D Intensity, 1999–2004**



Source: Eurostat, "R&D expenditure in Europe," *Statistics in Focus*, European Communities, June, 2006.

* R&D intensity is R&D expenditure as a percentage of GDP.

that China's R&D expenditure as a share of GDP has been growing much more rapidly than in the United States, Japan, or any European country. This growth is even more impressive given that China's GDP has simultaneously grown by close to 9% per year on average.

Along with China's increasing R&D expenditures has come a far-reaching structural transformation of the country's R&D system. First, involvement of the business sector in R&D funding and performance increased dramatically; the business sector's share of total R&D expenditure increased from 30% in 1994 to 64% in 2004.[6]

[6] National Bureau of Statistics and Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2005* (Beijing: China Statistics Press, 2005).

Second, China's traditionally large research institute sector has been significantly reduced. A number of institutes have been transformed into enterprises or incorporated as R&D divisions within existing companies.[7] Whereas in 1991 China's almost 6,000 government research institutes employed 1,000,000 employees, in 2004 there were less than 4,000 research institutes with approximately 560,000 employees.[8] While the number of government research institutes decreased considerably, however, as a whole the research institute sector continues to receive more funds for R&D than the university sector. For example in 2004 research institutes received 22% of overall R&D funds while institutions of higher education received only 10% (see **Figure 2**).[9] In 2003 research institutes received nearly four times as much government funding as universities (see **Figure 3**).

Third, the education sector has changed significantly in recent years. Since 1999 the number of new students increased on average by around 24% per year, and the number of graduate students has increased at a similar pace. The growth in the number of new students is likely to taper off as China's birth rate declines; since 1996 primary school enrollment dropped 22%.[10] At the same time, the percent of the population with secondary and tertiary levels of education is likely to continue to rise, resulting in part from a government policy increasing access to free secondary education in rural regions—thus partially offsetting the effect of the falling birth rate. The so-called 211 and 985 government programs target a number of universities for special support to create world-class universities. According to one estimate, by 2010 China will produce more PhDs in science and technology than the United States.[11]

China has been both strengthening intellectual property rights (IPR) legislation and working to develop domestic standards.[12] The government has also gone to great lengths to attract foreign companies and their technological know-how to China. Beijing's hope has been to raise China's

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7 Richard P. Suttmeier, Cong Cao, and Denis Simon, "'Knowledge Innovation' and the Chinese Academy of Sciences," Science 312, no. 5770 (April 7, 2006): 58–59.

8 National Bureau of Statistics and Ministry of Science and Technology, *China Statistical Yearbook 2005*.

9 Background information also obtained from Xielin Liu, "Role of University in Chinese System of Innovation" (presentation given at a joint seminar organized by the Swedish Institute for Growth Policy Studies and Development Research Center, Beijing, August 28, 2006).

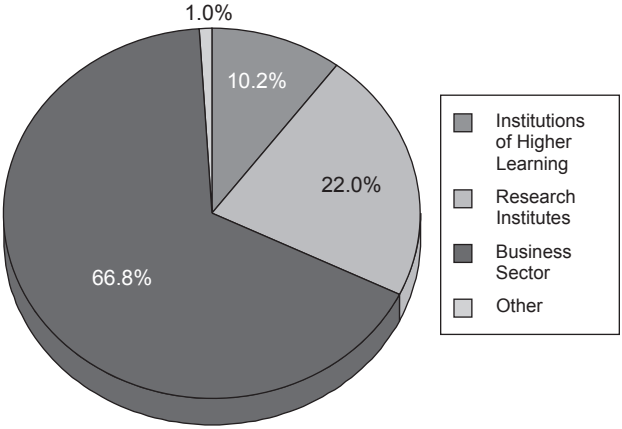
10 National Bureau of Statistics, *China Statistical Yearbook 2006* (Beijing: China Statistics Press, 2006).

11 Richard B. Freeman, "Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership?" The National Bureau of Economic Research, *NBER Working Paper*, no. 11457, June 2005 ~ http://papers.nber.org/papers/w11457.pdf.

12 Richard P. Suttmeier and Yao Xiangkui, "China's Post–WTO Technology Policy: Standards, Software, and the Changing Nature of Techno-Nationalism," The National Bureau of Asian Research, *NBR Special Report*, no. 7, May 2004.

FIGURE 2

R&D Funds in China by Performing Sector, 2004



Source: National Bureau of Statistics and the Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology 2005* (Beijing: China Statistics Press, 2005).

domestic innovative capacity through foreign direct investment (FDI) and the technology transfer expected to accompany these investments.

China's technology policy has yielded impressive results in a number of areas, including telecommunications and nanotechnology. China's contribution to international scientific publications and patenting activity have increased significantly. In 2005 the number of patents increased (albeit from a low level) by about 40%; China's share of total patents registered with the World Intellectual Property Organisation (WIPO), however, remains small. **Figure 4** shows the rapid increase in Chinese patent applications (both domestic and foreign).

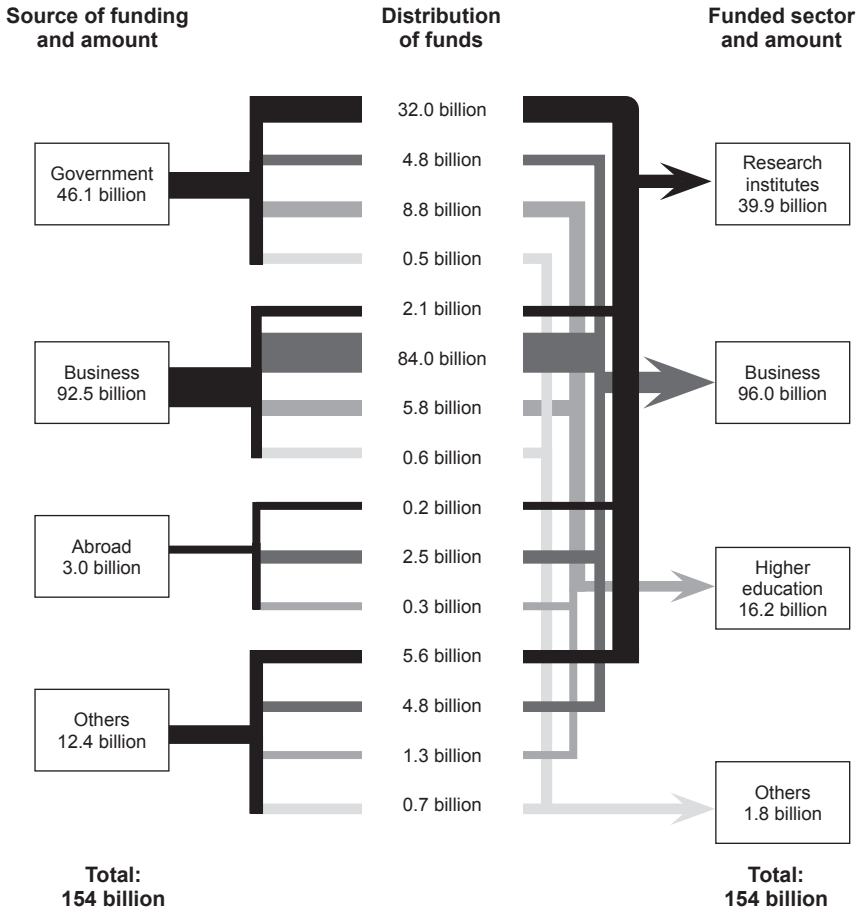
China attracts the third largest amount of FDI in the world, behind the United States and the United Kingdom.[13] During the past five years foreign companies established hundreds of new R&D centers in China. According to several recent surveys, executives from multinational companies rated China as the most attractive country for future R&D investments.[14] China has become a large exporter of high technology products, accounting for one-fourth of China's total exports in 2005.

[13] United Nations, *World Investment Report 2005* (New York: United Nations, 2005).

[14] See, for example, United Nations, *World Investment Report 2005*.

FIGURE 3

R&D Expenditure Flows in China, 2004 (RMB)

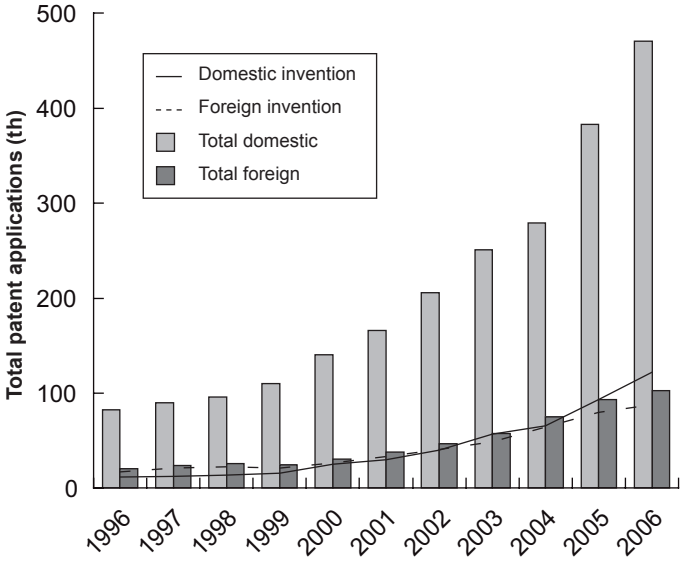


Source: National Research Center for Science and Technology for Development, *China Science and Technology Indicators 2004* (Beijing: Science and Technology Publication House, 2005).

China's research and educational systems still face considerable challenges. Business sector R&D has increased rapidly, but R&D expenditure as a share of value added remains low. Chinese manufacturing sector R&D expenditure equaled only 1.9% of total value added in 2004, compared to 7–11% in France, Germany, Japan, Korea, the United Kingdom, and the United States. In high tech industries, R&D expenditure in Chinese firms was only 4.6%, compared with around 20% in Korea and close to 30% in

FIGURE 4

Patent Applications in China, 1996–2006



Source: State Intellectual Property Office of the People's Republic of China ~ http://sipo.gov.cn.

Japan, the United Kingdom, and the United States.[15] Compared to many other countries, however, the share of total R&D expenditure allocated to basic research in China—only 6%, compared with 14% in both Korea and Russia and 25% in both the United States and Europe—is small.

Chinese universities have struggled to cope with dramatic increases in student enrollment during stagnating or declining public funding. Introduction of tuition fees and the partial privatization of education has resulted in great inequalities both in access to and in quality of education.[16] Furthermore, academic corruption is a serious problem receiving increasing attention;[17] beyond plagiarism, critics have identified that academic abuse is undermining not only the quality of China's academic system but also, more generally, the stability of the China's social and economic fabric. Examining

[15] See "China High-Tech Industry Statistics 2006," China Science and Technology Statistics (STS) website ~ http://www.sts.org.cn/.

[16] See, for example, Oganization for Economic Co-operation and Development, *Governance in China* (Paris: OECD Publishing, 2005).

[17] See "Science Friction," Business Week, May 29, 2006; "Faking It," *The Economist*, May 20, 2006; and Heping Jia, "Frequent Cases Force China to Face Up to Scientific Fraud," *Nature Medicine* 12, no. 8 (August 2006).

the academic evaluation system, Liu Ming, a prominent Chinese scholar, notes that academic corruption—which includes nepotism, bribery, and the exchange of favors to influence the appointment of academic positions or the distribution of research funds—differs significantly from other forms of corruption. Ming identifies such corruption as a significant threat to the quality of education and research, both vital prerequisites for China's future economic development and prosperity.[18]

In addition to the problems of growing inequality in the educational system and academic corruption, several indicators signify a fundamental mismatch between the education offered by many Chinese universities and the skills demanded in the labor market. The educational system is producing university graduates at a rapidly accelerating pace—the number of university graduates in 2006 was 750,000 or 22% higher than the previous year—yet despite a severe shortage of highly skilled labor in China, a significant number of these graduates cannot find employment.[19]

Finally, from the view of both domestic and foreign observers, China's long-standing strategy of attracting foreign technology and knowledge has been only partially successful. One important goal of China's technology and research policy has been to establish domestic capacity to produce high technology goods. Beijing's focus on combining FDI with development of theoretical technical expertise is an attempt to lead China through a transition from importing technology to assimilating technology to generating indigenous technology. Many sectors have not yet reached this goal, leaving a large share of China's high tech exports still consisting of imported high tech components assembled in China.[20] This is the single most important problem that the new plan is attempting to address.

THE PLAN: KEY ELEMENTS

The most important aspects of the latest long-term plan, which spans the period 2006–2020, can be summarized in three points. First, China will increase R&D expenditure as a share of GDP. Second, China will strengthen

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18 Liu Ming, *Xueshu pingjia zhidu pipan* [Critique of the Academic Evaluation System] (Chang Jiang: Chang Jiang Literature and Arts Publishing House, 2006).

19 See, for example, Diana Farrell and Andrew J. Grant, "China's Looming Talent Shortage," *The McKinsey Quarterly*, no. 4 (2005): 70–79; and "1.24m Grads Can't Find Major-Related Jobs," *China Daily*, November 18, 2006 ~ http://www.chinadaily.com.cn/china/2006-11/18/content_736662.htm.

20 Cong Cao, "Challenges for Technological Development in China's Industry," *China Perspectives*, no. 54 (July–August 2004): 4–16.

domestic innovative capacity and reduce dependence on foreign technology. Third, enterprises and the business sector will be the central driving force of the innovation process. Beijing's plan is a technology-oriented growth strategy placing priorities on energy, water supply, and environmental technologies and recognizing that IPR and standards will strengthen China's competitiveness.

The official title of the plan is "The National Program 2006–2020 for the Development of Science and Technology in the Medium and Long Term" (*Guojia zhong changqi kexue he jishu fazhan guihua gangyao 2006–2020*). In typical Chinese fashion, the government summarizes the plan with four sets of four characters representing four concepts: independence (autonomy or indigenous development) innovation, breakthrough, national development, and future.[21] Speaking at the Fourth National Conference on Science and Technology on January 9, 2006 Wen Jiabao summarized the plan's ultimate goals for China to achieve by 2020:

- to develop technologies related to energy and water resources and environmental protection
- to master core technologies in information technology (IT) and production technology
- to catch up with the most advanced nations in selected areas within biotechnology
- to raise the pace of development in space and aviation technology as well as oceanology
- to strengthen both basic and strategic research[22]

R&D Expenditures to Increase Significantly

Two key goals for 2020 are to increase R&D expenditure to 2.5% of GDP from the current level of 1.4% and to quadruple GDP using 2000 as a baseline. From 1996 to 2006 R&D expenditure grew from 0.6% of GDP to 1.4%, while GDP growth was close to 10% per year. Given that GDP is projected to increase at a similar pace, increasing R&D expenditure as a share of GDP implies a massive increase in absolute terms. In terms of purchasing

[21] The first set of four characters is *zizhu chuawgxin*.

[22] "Innovation 'Motive Power for Development,'" Chinese Government's Official Web Portal, January 11, 2006 ~ http://www.gov.cn/english/2006-01/11/content_220696.htm.

power parity (PPP), China already has the third-largest R&D expenditure in the world, trailing only the United States and Japan.[23]

Original Innovations, Indigenous Innovation

Perhaps the most interesting feature of the new plan—and certainly the goal most widely discussed by foreign firms and experts—is the aim to strengthen "independent" or "indigenous" innovation. Emphasis on indigenous innovation raises concerns abroad over the rise of "techno-nationalism" or "neo-techno-nationalism" and over implications for China's future economic openness and the protection of foreign intellectual property in China.[24]

China strongly depends on foreign technology; in 2003 foreign-invested enterprises represented 85.4% of China's total volume of high tech exports.[25] Since the 1990s Bejing pursued a policy offering considerable financial and other incentives to encourage multinational firms to locate R&D activities in China.[26] In recent years, the failure of this policy to deliver the expected knowledge and technology spillovers to Chinese enterprises is an increasing source of frustration for the Chinese leadership. Furthermore, academics and policymakers are criticizing the presence and behavior of foreign firms in China, claiming that these firms charge unduly high licenses for their patents, "crowd out" domestic firms in the market for highly skilled labor, monopolize technology standards, and thwart technology transfer and knowledge spillovers.[27] Critics argue that foreign firms dominate standards and technology platforms, reducing Chinese companies to the role of producers with low profit margins. The new plan, therefore, aims to establish domestic technology platforms and enable China to lead development in new

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23 Oganization for Economic Co-operation and Development, *OECD, Science, Technology and Industry Scoreboard 2005* (Paris: OECD, 2005). It should be noted, however, that attempts to measure China's R&D in PPP terms are subject to discussion; for example, it is extremely difficult to account for large regional cost differences within China.

24 For a discussion of techno-nationalism and neo-techno-nationalism, see Suttmeier and Yao, "China's Post–WTO Technology Policy."

25 National Research Center for Science and Technology for Development, *China Science and Technology Indicators 2004* (Beijing: Science and Technology Publication House, 2005).

26 Sylvia Schwaag Serger, "China: From Shopfloor to Knowledge Factory?" in *The Internationalization of Corporate R&D: Leveraging the Changing Geography of Innovation*, ed. Magnus Karlsson, (Stockholm: Swedish Institute for Growth Policy Studies, 2006), 227–66 ~ http://www.itps.se/Archive/Documents/English/Publikationer/Rapporter/Allmänna/A2006/A2006_007.pdf.

27 Zhongping Lin, "The Influence of MNCs upon China's Independent Innovation Capacity," *Zhongguo keji touzi* [China Venture Capital], May 2006, 40–43 ~ http://www.cvcht.com/.

technology areas. This will provide China a greater role in setting standards for consumer products.[28]

Hoping FDI would result in domestic inventions of world-leading products, China's policymakers identified low innovative capacity as the most important explanation for the failure to upgrade the country's technological capabilities. As evidence, policymakers point to the relatively low level of patenting activity (particularly invention patents) by wholly Chinese-owned firms.[29] Large foreign firms—holding roughly two-thirds of all invention patents granted in China in 2004—dominate patenting activity in China.[30] The plan includes features designed specifically to address this problem, such as the goal to reduce China's dependence on foreign technology to 30%.

China's leadership wants to reduce dependence on foreign technology in part because foreign technology dominates strategic areas (such as processors and software) and to avoid paying high licensing fees. For example, Sina Technology estimates that broadcasting digital television according to the international standard (MPEG-4) would cost China more than 10 billion RMB in licensing fees per year.[31] A 2006 Chinese newspaper article pointed out that "due to lack of core technology, domestic enterprises have no choice but to pay foreign patent holders 20% of the price for each China-made cell phone, 30% of each computer's cost and 20% to 40% of the price of each computerized numerical control machine."[32]

For Beijing, another motivation for reducing dependence on foreign technology is the bargaining leverage that indigenous technology provides; indigenous technology can be used to acquire foreign technology in other areas. Finally, reducing reliance on foreign technology is also a matter of national prestige for China.

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28 For a discussion of China's efforts to develop standards, see Suttmeier and Yao, "China's Post–WTO Technology Policy"; and Scott Kennedy, "The Political Economy of Standards Coalitions: Explaining China's Involvement in High-Tech Standards Wars," *Asia Policy*, no. 2 (July 2006): 41–62.

29 China has three types of patents: design, utility, and invention. Invention patents are considered the most relevant for international comparison.

30 Tom Miller, "Still More 'D' than 'R,'" *China Economic Quarterly* 10, no. 3 (Hong Kong: Dragonomics Research and Advisory, 2006): 30.

31 Jin Chao, "Shuzi dianshi yang biaojun bei zhi jiang nianshou zhongguo baiyi zhuanli fei," Sina Technology, November 9, 2005 ~ http://tech.sina.com.cn/it/2005-11-09/2349761554.shtml.

32 "China's Dependence on Foreign Technology Exceeds 50%," *Chinanews*, May 26, 2006 ~ http://www.china.org.cn/english/scitech/169484.htm.

Companies to Be Driving Force of Innovation

Almost nonexistent 30 years ago, business sector expenditure on R&D has increased dramatically in recent years; since 2001 business sector expenditure has exceeded governmental expenditure on R&D. In China's new plan, Beijing aims to increase the role of business enterprises in determining the strategic areas for R&D investment. To increase Chinese competitiveness and innovative capacity, the plan encourages Chinese companies to establish R&D activities abroad.

THE FIFTEEN-YEAR PLAN IN DETAIL

The new plan identifies key priorities in a number of areas, including improving the access to and efficient use of energy and water resources, developing environmental technologies, and promoting the development of IPR-protected technology based on IT and material technologies. Continued priority sections under the new plan are biotechnology, aerospace, aviation, and marine technologies. Finally the plan emphasizes the need to increase investments in basic research, particularly in multidisciplinary research.

The plan identifies and addresses eleven priorities in detail:

- energy resources
- water and mineral resources
- environment
- agriculture
- production technology
- transportation
- IT and services
- health care
- urban development
- public securities
- national defense

Mention in the plan of investments in military technologies is limited to emphasis Beijing places on so-called dual-use technology (i.e., technology that can be used both for military and civilian purposes).

The plan lists sixteen key projects to be launched. Common project criteria include the need to address significant socio-economic problems, further developing areas in which China already possesses sufficient competence in relevant technologies, keeping costs manageable, and yielding results in both civilian and military applications. Key projects include sending a Chinese astronaut to the moon and developing the next generation of jumbo jets. Other projects focus on developing fast processors and high-performance

chips, oil and gas extraction or exploitation, nuclear power technology, water purification, developing new drugs, fighting AIDS and hepatitis, and developing the next generation of broadband technology.

The plan also addresses technologies with likely significance for the next generation of high technology, listed in importance from biotechnology, followed by IT, advanced materials, production technology, advanced energy technology, oceanography, and laser and space technology. In contrast to the other technologies detailed, the plan does not offer comments on the relevance of laser and space technology for China's high tech development, indicating these technologies are intended primarily for military purposes.

Although many of the general themes are not new, nor are the methods used to address them, the plan conveys an increased sense of urgency or ambition. Compared to previous plans, however, the tools proposed for implementing the plan show a greater clarity. [33]

One of the most noteworthy and novel methods suggested in the plan is the introduction of tax incentives for small and medium-sized enterprises (SME). These and other financial incentives are intended to encourage companies to invest in R&D and to establish R&D activities abroad. Perhaps unique to China, the incentive to establish R&D centers overseas will likely lead to an increased presence of Chinese science and technology companies in business centers of the United States and Europe.

THE PROCESS

Prime Minister Wen Jiabao chaired the steering group that officially led the process of developing the new plan, involving many ministries.[34] The preparation and drafting of the plan took around three years—one year longer than intended. Initiated in 2003 the process commissioned twenty strategic studies focused on key R&D issues from both a scientific and a socio-economic perspective:

- S&T development strategies in general
- S&T system reform and national innovation system
- S&T issues in the manufacturing industry and in agriculture

[33] One likely reason that the top government leaders delayed presenting the plan for more than a year was concern that suggestions for implementing the plan were not concrete enough.

[34] Cong Cao, "China Planning to Become a Technological Superpower," East Asian Institute, National University of Singapore, *EAI Background Brief*, no. 244, May 2005.

- S&T issues in energy
- resources and marine development
- traffic and transportation
- modern service industry
- population and health
- public security
- ecological construction
- environmental protection and cyclical economy
- urban development and urbanization
- national defense
- strategic high tech and associated industrialization
- basic scientific study
- S&T conditions and infrastructures
- S&T personnel, investment, and associated management
- S&T laws and policies
- innovation culture and popular science
- regional S&T development

Two thousand researchers were involved in the preparation of these twenty studies. Compared with previous plans the process was (at least in the initial stages) "remarkably open" and involved many stakeholder groups.[35] The twenty reports were reviewed by the Chinese Academy of Sciences (CAS), the Chinese Academy of Engineering (CAE), and the Chinese Academy of Social Sciences (CASS). The Ministry of Science and Technology (MOST)—in consultation with other actors, such as the Ministry of Finance, CAS and CAE—spent twelve months drafting the plan. A request by China's political leaders, concerned that the plan was not concrete or focused enough, prompted direct intervention by Wen Jiabao resulting in a six-month delay for plan modification.[36]

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35 Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China's 15-Year Science and Technology Plan," *Physics Today* 59, no. 12, December 2006, 38–43.

36 Cao, Suttmeier, and Simon, "China's 15-Year Science and Technology Plan."

IMPLEMENTATION OF THE PLAN: THE 99 SUPPORTING POLICIES IN THE FIRST INSTALLMENT

Following the February 2006 presentation of the plan, in June 2006 the State Council presented the first batch of a "consolidated list of the rules for implementation of the supporting policies for the 'Outline of the National Medium- and Long-term Planning for Development of Science and Technology' formulated by the relevant department."[37] For each of the 99 supporting policies, one lead ministry or government institution and one person within the lead institution is assigned responsibility for its implementation. The designated person generally is at vice-minister level or, at least in one case, at minister level. The list indicates institutions, in addition to the lead institution, tasked to help implement the policy as well as indicating the deadline for completion. Examples of supporting policies are listed in **Table 1**. Although varying in terms of scope or level of detail—for example ranging from advising on attracting more overseas talent to delivering a "national industrial technology policy"—these supporting policies are all concrete policy tools or action plans for implementation of overall objectives.

Lead responsibility for implementing the largest number of supporting policies goes to the National Development and Reform Commission (NDRC) with 29 policies, followed by the Ministry of Finance with 21 policies (or 25 if the state administration of taxation is included), MOST with 17 support policies, and the Ministry of Education with 9. NDRC and the Ministry of Finance have lead roles not only in a large number of supporting policies but also in implementing what arguably are some of the pillars of the new long-term plan. Thus, NDRC is charged with strengthening innovation in SMEs and with devising a plan for special projects promoting independent innovation capabilities; the Ministry of Finance is responsibile both for designing fiscal incentives aimed at increasing R&D and innovation in enterprises and for drafting public procurement policies aimed at promoting independent innovation (see **Table 2**).

MOST is responsible for allocating funding for setting up and strengthening incubators and science parks as well as implementing measures to support research and development in scientific technologies, both key areas of China's

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37 State Council of the People's Republic of China, "Guowuyuan youguan bumen fuze zhidingde guojia zhongchangqi kexue he jishu fazhan guihua gangyao peitao zhengce shishi xize zongbiao" [*Consolidated List of the Rules for Implementation of the Supporting Policies for the "Outline of the National Medium- and Long-term Planning for Development of Science and Technolog,y" Formulated by the Relevant Department*], 2006 ~ http://www.gov.cn/gongbao/content/2006/content_310755.htm.

TABLE 1

China's Long-term S&T Plan: Examples of Supporting Policy Assignments, Departments, and Leaders

Lead dept.	Lead person	Supporting policy no.	Description of task	Other participating departments	Deadline
National Development and Reform Commission	Zhang Xiaoqiang	no. 1	To promote several policies for the industrialization of independently produced innovations	Ministry of Science and Technology, Ministry of Finance, etc.	June 2007
	Ou Xinqian	no. 3	To develop guidelines for increasing the recognition of independent Chinese brands	Ministry of Finance, Ministry of Commerce, etc.	Dec. 2006
	Ou Xinqian	no. 5	To develop policies that support the technology innovation of small and medium-sized enterprises	Ministry of Science and Technology, etc.	Dec. 2006
	Zhang Xiaoqiang	no. 29	To develop guidelines for building national engineering laboratories	Ministry of Science and Technology, etc.	Dec. 2006
Ministry of Education	Zhao Qinping	no. 30	To advise on strengthening the construction of research-oriented universities and increasing the independent innovation of colleges and universities	National Development and Reform Commission, Ministry of Finance, etc.	Dec. 2006
	Zhao Qinping	no. 33	To advise on attracting more overseas talent	Ministry of Central Government Organization, Ministry of Personnel, etc.	Dec. 2006

TABLE 1 (CONTINUED)

Lead dept.	Lead person	Supporting policy no.	Description of task	Other participating departments	Deadline
Ministry of Science and Technology	Ma Songde	no. 53	To advise on promoting the development of national high tech industrial development zones and strengthening independent innovation ability	National Development and Reform Commission, Ministry of Education, etc.	Dec. 2006
	Xu Guanghua	no. 54	To advise on the overall establishment of a sound coordination system for the rational distribution of science resources	National Development and Reform Commission, Ministry of Education, etc.	Dec. 2006
Ministry of Finance	Zhang Shaochun	no. 62	To develop a finance supporting policy for encouraging the innovation of enterprises	National Development and Reform Commission, Ministry of Science and Technology, etc.	Dec. 2006
	Zhang Shaochun	no. 72	To develop methods for managing the procurement of significant innovative products	National Development and Reform Commission, etc.	To be decided
SASAC*	Shao Ning	no. 98	To promote and improve the evaluation system for measuring the performance of innovative technologies of state-owned enterprises	Ministry of Science and Technology, etc.	Dec. 2006

Source: State Council of the People's Republic of China, "Guowuyuan youguan bumen fuze zhidingde guojia zhongchangqi kexue he jishu fazhan guihua gangyao peitao zhengce shishi xize zongbiao" [Consolidated List of the Rules for Implementation of the Supporting Policies for the "Outline of the National Medium- and Long-term Planning for Development of Science and Technology" Formulated by Relevant Department], 2006 ~ http://www.gov.cn/gongbao/content/2006/content_310755.htm.

* State-owned Assets Supervision and Administration Commission.

science and technology policy. Several ministries are, however, competing first over responsibility for China's innovation system and second over the fundamental direction of China's innovation policy. Compared to previous plans, the role of MOST in implementing China's latest fifteen-year plan has been reduced. The extensive responsiblities the plan gives to ministries such as NDRC and the Ministry of Finance reflect the new emphasis placed on enterprises as the engine of China's innovation system. The plan's focus on public procurement and emphasis on independent innovation expands the role of ministries and agencies responsible for enterprise, industrial policy, and government purchasing regulations (again NDRC and the Ministry of Finance) as compared to earlier plans. That MOST is the ministry with the third largest number of supporting policies, after NDRC and the Ministry of Education, is perhaps a further indication that MOST, while still important, is no longer the dominant actor in China's science and technology policy. The Chinese scientific community has recently been critical of MOST's lack of transparency, efficiency, and professionalism in allocating research funding. Scientists have also expressed disappointment that significant increases in government funding of scientific research, much of which has been administered by MOST, have not brought the expected scientific outputs.[38] This disappointment may, however, be due to unrealistic expectations and impatience as scientific and other results, particularly in fields such as biotechnology, take a long time to materialize. Finally, criticism of MOST is triggered in part by a more general realization that scientific research does not automatically lead to innovation and improved well-being for society. Despite rapidly increasing funding for life science research, Chinese scientists were unable to provide solutions during the 2003 Severe Accute Respiratory Syndrome (SARS) outbreak. This event was traumatic for China. Critics concluded that either the system allocating research funding was flawed or policy efforts had focused too much on scientific research and too little on enabling an environment conducive to innovation and to generating economic and societal returns from R&D.

Some observers interpret the recent appointment of a new minister for science and technology in April 2007 as a signal that Beijing is seeking a trend change not only in the role of MOST but also in China's science and technology system—and possibly even more generally in Hu Jintao's reform

[38] David Cyranoski, "Biologists Lobby China's Government for Funding Reform," *Nature* 430, No. 6999 (July 2004): 495; Cao, Suttmeier, and Simon, "China's 15-Year Science and Technology Plan"; and Hepeng Jia, "Chinese Research Not Reflecting Increased Investment," SciDev.Net, February 1, 2007 ~ http://www.scidev.net/News/index.cfm?fuseaction=readNews&itemid=3382&language=1.

TABLE 2

China's Long-term S&T Plan: Areas of Responsibility and Total Number of Supporting Policies by Department

Leading Department	Total no. of supporting policies	Areas of responsibility
National Development and Reform Comission	29	• Venture capital • Strengthening innovation in small and medium-sized enterprises • Industrial technology policy • Strengthening public venture capital funds • Independent innovation capabilities
Ministry of Finance	21	• Financial policies to support or encourage innovation in enterprises • Public procurement
Ministry of Science and Technology	17	• Incubators and science parks • Measures for supporting research and application of significant technologies • Popularizing science
Ministry of Education	9	• Universities • Attracting overseas talent
Ministry of Finance, State Administration of Taxation	4	• Tax incentives to encourage innovation in enterprises
Ministry of Personnel	4	• Increasing education of personnel in scientific fields • Encouraging the return of overseas Chinese
Ministry of Commerce	2	
China Banking Regulatory Commission	2	
China Insurance Regulatory Commission	2	• Regulations on investing insurance funds in venture capital enterprises
State-owned Assets Supervision and Administration Commission	2	• Innovation and S&T management in state-owned enterprises
Ministry of Information Industry	1	
China Development Bank	1	• Soft loans to enterprises in national high tech fields
Export-Import Bank of China	1	• Instruments (special accounts) for supporting the development of high tech enterprises
General Administration of Customs	1	
Ministry of Central Military Equipment	1	

Source: State Council of the People's Republic of China, "Guowuyuan youguan bumen fuze zhidingde guojia zhongchangqi kexue he jishu fazhan guihua gangyao peitao zhengce shishi xize zongbiao" [Consolidated List of the Rules for Implementation of the Supporting Policies for the "Outline of the National Medium- and Long-term Planning for Development of Science and Technology" Formulated by Relevant Department], 2006 ~ http://www.gov.cn/gongbao/content/2006/content_310755.htm.

agenda.[39] Wan Gang is the first minister in 35 years who is not a member of the Communist Party. He also has significant industry experience having worked for German car-maker Audi and spent fifteen years studying and working abroad.

The latest long-term plan indicates that China is moving away from a science and technology policy (see **Figure 5**) toward an innovation policy. In this new arena, China's innovation governance may be in flux as several ministries and institutions compete for control. In addition to the ministries mentioned above, CAS and the Development Research Center (DRC) under the State Council are important actors shaping and influencing innovation policy and governance.

A CRITICAL ASSESSMENT

The above has presented the main characteristics of the latest long-term plan for science and technology development, including the process leading up to and the concrete steps currently being undertaken to implement the plan. This section of the essay critically assesses the plan by examining the driving forces and motivations, identifing missing elements of the plan, and assessing implications for China's innovation system.

Why a Plan? China's Challenges Drive Technology Development

Beijing's determination since the early 1980s to strengthen the country's knowledge base and innovation capacity is driven by the real and daunting challenges facing China. A second driving factor is Beijing's strong faith—some say excessive belief—that technology will help China overcome these challenges. Beijing expects that technological development will help China to eradicate poverty, ensure the country's future demands for water, raw materials, and energy are met, and combat epidemics such as avian influenza or SARS. Finally, Beijing has ambitions to raise the country's position and influence in the international economic and political arena. China's investments in space research—highly publicized during China's recent manned space mission—are a reflection of ambitions to become a leading international knowledge base.[40]

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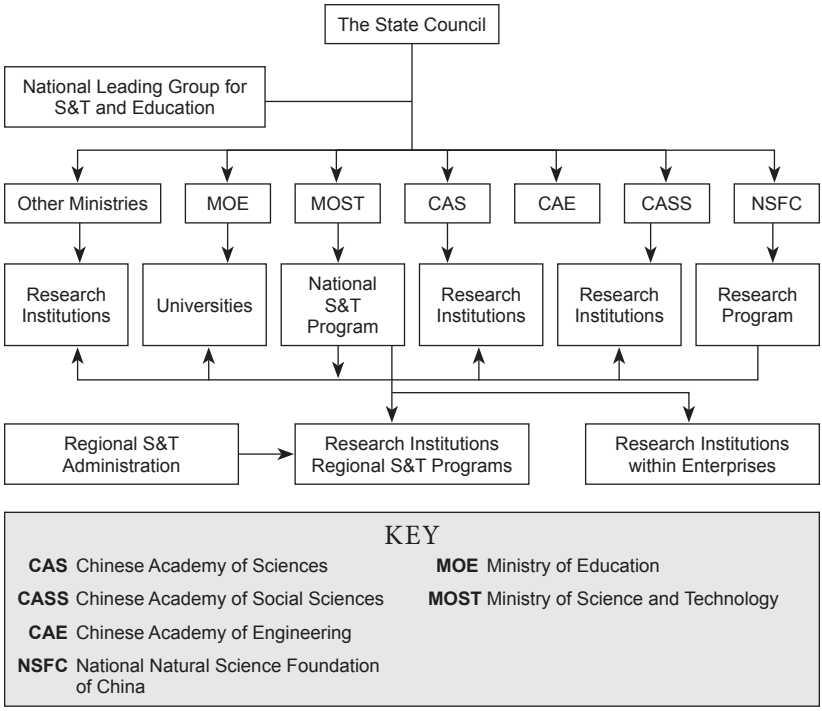
39 Hepeng Jia and Christina Scott, "China Appoints Democratic Science Minister," *SABC News*, May 7, 2007; and Richard McGregor, "China Breaks Mold for New Minister," *Financial Times*, April 27, 2007.

40 Estimates hold that today 600 million people live below or just above the international poverty line in China (defined as one U.S. dollar per day).

FIGURE 5

Governance Structure of China's Science and Technology System



Source: Rongping Mu, "Development of Science and Technology Policy in China," 2004 ~ http://www.nistep.go.jp/IC/ic040913/pdf/30_04ftx.pdf.

Whose Plan? China's New Companies

Who will execute the plan? In spite of claims placing the business sector at the heart of R&D development, the fifteen-year plan is still a product by and for civil servants. While identifying the entrepreneur as a concept, the plan fails to name the entrepreneur as an implementing actor. A number of experts on China's R&D system are skeptical of Beijing's ability and willingness to transfer as much leverage and power to Chinese entrepreneurs as the plan indicates.[41] Many of China's true entrepreneurs work in privately owned small and medium-sized firms, the overwhelming majority of which

[41] The authors conducted a number of interviews with Chinese and foreign experts on China's R&D system between February and September 2006 in Beijing.

are not classified as high tech or technology-intensive firms. These firms—often important drivers of innovation in other countries—are unlikely to be affected or addressed by the plan. Large state-owned enterprises (SOEs) account for a large share of business expenditure on R&D; of the 50 Chinese companies with the largest R&D expenditure in 2006, more than 80% were state-owned.[42] The ability of SOEs both to innovate and to absorb knowledge is, however, often low when compared with private enterprises. Analyses attribute the low innovative and absorptive capacity of SOEs to problems in corporate governance, weak management skills and organizational structures, power monopolies, subsidies, and preferential policies.[43]

Can the plan lead more of China's SOEs toward independence and innovation, and if so will the government allow this to happen? On a related note, how much influence did private enterprise and other stakeholders, aside from scientists, have in drafting the plan? Worth remembering, however, is that attitudes of Chinese firms regarding the plan are complex and do not simply correspond to the type of firm ownership or size.

How to Implement the Plan? New Incentives for Companies to Develop Technology

Fiscal policy is an important tool in implementating China's new long-term plan. The provision of tax incentives—perhaps the most novel policy—is designed to encourage company R&D investments. Suggestions include making R&D expenditure 150% tax deductible, effectively constituting a net subsidy, as well as introducing accelerated depreciation for R&D equipment worth up to 300,000 RMB. Public procurement is another important new instrument for promoting innovation in Chinese companies. The plan directs government agencies to support innovative Chinese companies by purchasing

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42 Data on R&D expenditure is from "A Report on the Development of Chinese Enterprises (2006)," China Enterprise Confederation ~ http://www.cec-ceda.org.cn/china-500/english/.

43 Chi Hung Kwan, "Who Owns China's State-Owned Enterprises? Toward Establishment of Effective Corporate Governance," Research Institute of Economy, Trade and Industry, *China in Transition*, July 28, 2006 ~ http://www.rieti.go.jp/en/china/06072801.html; Yuan Li, Yi Liu, and Feng Ren, "Product Innovation and Process Innovation in SOEs: Evidence from the Chinese Transition," *Journal of Technology Transfer* 32, No. 1–2, (April 2007): 63–85; and "SOEs Have Low Innovation Capacity: Official," *China Daily*, November 18, 2005.

their goods or services.[44] This more active use of public procurement policies could have implications for foreign companies competing with domestic firms for national and sub-national government contracts in areas such as telecommunications.[45] Although China has not yet signed the WTO's Government Procurement Agreement (GPA) protecting foreign firms from public procurement discrimination, Beijing recently committed to initiate formal consultations to join the GPA by December 2007.[46] Numerous countries use public procurement as an important tool for promoting innovation. Still difficult to predict is both the extent that implementing the plan will involve public procurement to strengthen domestic innovation and the effects this will have on foreign firms.

The plan also both encourages Chinese companies and institutions to acquire and further develop foreign technology and strongly emphasizes the provision of financial support or financial incentives to encourage domestic innovations. For example, China Development Bank—one of China's so-called policy banks—is tasked with providing "soft loans" to high tech companies.

CONCLUSIONS

China's research policy is strongly needs-driven in that it approaches science and technology as a multipurpose tool for combating environmental problems, epidemics, and poverty; meeting China's growing demand for raw materials; securing the country's future competitiveness and growth; and realizing the government's political ambitions.[47] The overarching goal of China's long-term plan is to maintain a high rate of economic growth and development while providing solutions to social and environmental challenges. Energy, water resources, and the environment may top the list of prioritized

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44 In the *Report on the Work of the Government* presented at the 10th National People's Congress on March 5, 2007, Premier Minister Wen Jiabao stated that: "We will improve the mechanism for rewarding independent innovation and implement fiscal, tax and banking policies and the government procurement system to encourage and support independent innovation." See also Xinhua News Agency, "Lawmakers Call on Government to Buy Domestic Products to Encourage Innovation," March 11, 2007 ~ http://news.xinhuanet.com/english/2007-03/11/content_5828597.htm.

45 According to a study prepared on the behalf of the European Commission, in large procurement contracts, "50% of R&D in big public procurement contracts has to be carried out by domestically controlled suppliers". See European Commission, Pre-Commercial Procurement of Innovation: A Missing Link in the European Innovation Cycle, March 2006, 8.

46 John Liuzzi, "Opening up the Chinese Government Procurement Market," International Trade Administration, U.S. Department of Commerce, *International Trade Update*, May 2006 ~ http://www.ita.doc.gov/press/publications/newsletters/ita_0506/gpa_0506.asp.

47 Charles Wolf, Jr., K. C. Yeh, Benjamin Zycher, Nicholas Eberstadt, and Sungho Lee, *Fault Lines in China's Economic Terrain* (Santa Monica: RAND Corporation, 2002).

technology areas, but Beijing's attempts to slow growth in order to save the environment have so far been relatively unsuccessful. High unemployment in certain regions and sectors puts the government under pressure both to maintain growth and to avoid any political unrest possibly resulting from further increases in unemployment. Furthermore, high economic growth continues as a top goal for provincial and local governments.

Efforts to increase China's innovative strength have been driven by a strong belief that by dedicating enough money to science and technology, China will generate innovative and competitive companies. Simply put, the government is investing in world-class scientists, perfectly equipped labs, and science parks (sometimes cynically referred to as "dollars, divas, and dazzling buildings") but is also neglecting the "intangibles"—such as favorable institutional and framework conditions that significantly influence a country's innovative capacity. There are many reasons for China's sub-optimal environment for innovation, including insufficient venture capital, a mismatch between the skills provided by the majority of Chinese universities and the skills required for developing and managing projects, processes, and knowledge organizations; academic corruption; and a lack of social capital. The term social capital captures the concept that the creation of economic value depends not only on physical capital (such as land and machinery) and human capital (knowledge and skills) but also on the value that derives from a willingness and likelihood to share knowledge and information. Social capital can also refer to shared values, norms, and trust, which collectively reduce transaction costs.[48] Disrespect of IPR and corruption—both significant problems in China—are indicators of weak social capital. These behaviors in turn undermine the linkages and interactions conducive to innovation, leading to a sub-optimal allocation of resources.[49] In China many actors and components of a strong national innovation system are in place, but linkages are formalistic and weak. One of China's challenges is how to handle the conflict between innovativeness—which is strongly determined by creativity, critical thinking, and the willingness to take risks and to accept failures—and a political system and educational and organizational culture that discourage dissension and individualism.

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48 Michael Woolcock, "Social Capital and Economic Development: Towards a Theoretical Synthesis and Policy Framework," *Theory and Society* 27, No. 2 (1998): 151–208.

49 For a more in-depth discussion, see Sylvia Schwaag Serger, "Foreign Corporate R&D in China: Trends and Policy Issues," in *New Asian Dynamics in Science, Technology and Innovation*, ed. Govindan Parayil and Antony D'Costa (forthcoming, 2007).

Chinese experts and policymakers are not unaware of the challenges to increasing China's innovative capacity. Chinese academic circles are engaged in lively debate on how to address and overcome these challenges. A recent news article pinpointed critical weaknesses in China's research and development system, concluding that although already a "heavy R&D investor" China still has a long way to go to become a "powerful nation in the science and technology world."[50] In a 2005 paper, Mu Rongping from the Institute for Policy Management at the Chinese Academy of Sciences identified key weaknesses in China's innovation system. Among other things Mu called both for increasing market- and people-orientated innovations and for creating a sound environment for innovations and start-ups. Furthermore, he urged the government to build an environment that nurtures, attracts, and develops innovators.[51] A more recent paper by the Development Research Center points to a number of policy challenges in developing a strong national innovation system in China. These include reforming the educational system to develop relevant skills, improving the financing of innovation, and strengthening IPR protection. The paper also calls for better coordination of innovation policies and for an innovation policy that is not only less dominated by scientific and technology objectives and indicators but also more focused on the economic and social benefits of innovation.[52]

As with previous plans, China's new long-term plan is strongly supply-driven and assumes that innovation can be decreed "from above." Rather than focusing on needed skills or products or services the market might demand, many goals specify the amount and type of R&D Beijing aims to achieve or the number of engineers or scientists it intends to "produce." Markets and customers—important catalysts driving the innovation process—are hardly mentioned. Many domestic companies also underestimate the importance of customers and markets in driving successful innovation. A recent article examining innovation in China's IT industry pointed out that domestic companies lagged behind foreign competitors; while having necessary core technologies, product development was too technology driven and lacked sufficient market-orientation, noting that "Technologies alone cannot make Chinese enterprises

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50 Xiaojing Guan, "Zhengque kandai woguo de zeji shili" [Having a Clear Picture of China's Scientific and Technological Strength], *China Information Newspaper*, December 22, 2006 ~ http://www.zgxxb.com.cn/news.asp?id=5688.

51 Rongping Mu, "Recommendations for Reconstructing the National Technological System," in *2007 High Technology Development Report*, ed. Chinese Academy of Sciences (Beijing: Science Publishing House, 2007), 190–97.

52 Wei Lu, "To Improve the National Innovation System and Strengthen Innovation Ability" (paper presented at the China Development Forum, Beijing, March 18–19, 2007).

world-class manufacturers. They also need to set up industrial chains and make strategies for related know-how, products and services." [53]

The plan is also characterized by tendencies toward so-called techno-nationalism. One concrete objective aims to reduce China's dependence on foreign technology to less than 30% (the current figure is 60%). The plan emphasizes domestic innovation and reducing dependence on foreign technology; other policies encourage public procurement to strengthen domestic companies. Claims that FDI has been detrimental to the innovative capacity of Chinese firms have raised concerns among foreign firms in China of a backlash against them.[54] Prompted by these concerns, Chinese subsidiaries of European firms began a campaign titled "We are a Chinese company, too."[55]

Another defining feature is the plan's technical approach. For example, one target is that the contribution to China's future growth from innovations should be 50% larger than that from labor and capital inputs. This obsession with numbers and formulas is due in part to the composition of China's Politbureau: eight are engineers (and the ninth is a geologist).

In terms of the goals and instruments, China's latest plan for the development of technology and science is not novel. Compared to previous plans the level of ambition and determination to produce results (particularly with regard to the environment and energy supply) has increased considerably. Recent developments indicate a possible shift away from a science and technology policy focusing primarily on creating world-class high tech labs and scientists toward an innovation policy seeking to create an environment conducive to translating knowledge and ideas into economic and social gains.

Although China still works with long-term plans, they are not etched in stone. In the words of one government official, "just because we have set goals doesn't mean we can't change them."[56] The plan is best viewed as a dynamic instrument that allows for its interpretation, implementation, and even targets to be adapted over time.

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53 "The Problems of 'Independent Innovation,'" *IT Manager* [IT jingli shijie], November 5, 2006, 12 ~ http://www.ceocio.com.cn/store/detail/article.asp?articleId=8409&Columnid=2768&adId=10&view=.

54 Zhongping Lin, "The Influence of MNCs upon China's Independent Innovation Capacity," *Zhongguo keji touzi* [China Venture Capital], May 2006, 40–43, http://www.cvcht.com/.

55 See "We are a Chinese company, too—Request for Participation," European Union Chamber of Commerce in China website ~ http://www.europeanchamber.com.cn/events/news.php?id=320&PHPSESSID=9421b488dc268c28a6856a114c7a61f4.

56 Interview with government officials and experts, February–September 2006, Beijing.

POLICY ISSUES FOR OTHER COUNTRIES

China's development is part of a fundamental change currently transforming the global distribution of knowledge resources. State-of-the-art technology and world-class scientists are no longer the prerogative of the developed world. Developing countries are claiming increasing shares not only of world trade, manufacturing, and raw material consumption but also of global knowledge resources, both with regard to highly skilled labor and to corporate R&D. China is actively competing for these resources. The latest long-term plan reflects Beijing's desire both to address growing domestic social and environmental problems through science and technology and to become one of the world's knowledge hubs.

China's emergence as a magnet and now even producer of frontier-level science and high technology demands other countries formulate research and education strategies relating to China. Though facing considerable challenges in its quest to become a world leader in science and innovation, China offers significant opportunities both for mutually beneficial cooperation in research and education and for trade of knowledge-intensive goods and services. China's opening to the world, prioritization of science, education and innovation, and desire to acquire knowledge and technology provide important opportunities and vehicles for the international community to establish cooperation on issues of global relevance—including environmental protection and corporate social responsibility. Finally, by working with China, both bilaterally and within international forums, the international community might prevent techno-nationalistic tendencies from steering China toward isolationism or protectionism. For the international community, China's aspirations to become a global knowledge center could be a positive development providing opportunities rather than a threat.

To design constructive strategies appropriately responding to China's development, decisionmakers both in the public and private sector need to better understand the politics, economics, and culture of modern-day China.[57] ◈

[57] Currently, there is a shortage of such expertise, in academia and in policymaking, in a number of countries and international organizations. See David Shambaugh, "The New Strategic Triangle: U.S. and European Reactions to China's Rise," *Washington Quarterly* 28, No. 3 (Summer 2005): 7–25.

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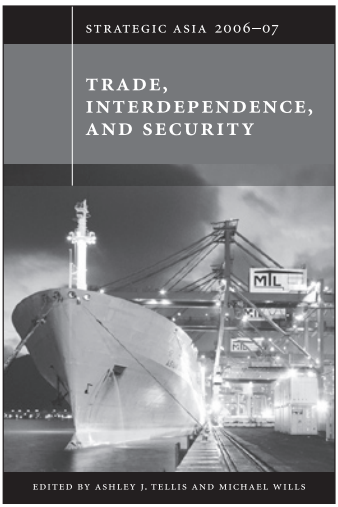

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