# Assessing China's Technology Potential

Richard P. Suttmeier

Given China's current role as both a legitimate economic force and uncertain politic entity, China's technological capacity has acquired a special importance in our assessments of the kind of nation China will be in the coming decades. The direction of China's science and technology (S&T) sector is of particular interest because it has considerable implications for international trade and security. There is little question that China is determined to secure its place as a scientific and technological powerhouse, as evidenced by its intensified research and development (R&D) efforts and new policies that promote innovation. But expert assessments of China's technological potential differ on the country's ability to mobilize its resources to this end, especially in the face of established global standards and tough competition. Therefore, in order to understand China's future international role, we need to learn how to ask the right questions about China's technolog ical development.

**Richard Suttmeier** is Professor of Political Science at the University of Oregon. He serves on the Department of Commerce Civil Industrial Technology Coordinating Committee for relations with the Chinese Ministry of Sci ence and Technology.

**International Attention.** Interest in China's technological capacity has grown markedly in recent years, both within China and among foreign observers. China's rapid economic growth over the past two decades has prompted questions about the extent to which future growth will be driven by technology-based productivity gains. China's rise as a great trading

nation has called attention to the chang ing composition of China's foreign trade and the extent to which China will be able to compete in international markets with knowledge-intensive, high value-added products. The large environmental costs associated with China's production sec tor heighten the need for new, environ mentally-friendly technologies that sup port sustainable development.

Interest in technological capabilities is also prominent in the context of China's military strength. Chinese political leaders and defense planners have become more concerned about their capacity for innovation in security technologies, as the nature and implications of high technology warfare have become evident over the past fifteen years. For foreign governments and foreign military analysts who are concerned about China's rising power, the increasing attention to technological capabilities by Chinese defense planners gives the issues of Chinese sci entific and technological development new strategic importance.

**Technological Innovation in a Global Economy.** Scientific discovery and technological changes in China, combined with economic globalization, are helping to create a new industrial revolution and promoting the emergence of a knowledge-based economy.[1] Chinese elites are highly sensitive to China's missed benefits of the last industrial revolution and want to be sure that China's place in the new one is assured. Success in scientific research and capacity for indigenous technological innovation are rightly seen to be essential for achieving these objectives. As a result, China has intensified its efforts to strengthen its national R&D and innovation systems. However, governmental efforts to encourage innovation also have to accommodate the strengths and weaknesses of domestic institutional legacies and the ongoing challenges and oppor tunities presented by the international environment, particularly in light of China's recent entry into the WTO. China's policies to build technological capabilities—through the reform of established institutions and the exploita tion of opportunities in international environment—are an attempt to navigate between these domestic and internation al realities. In a global economy that is increasingly characterized by trans-border technological innovation, any effort to develop a national innovation strategy and system that does conform to some degree to international trends invites frustrating failures. At the same time, sovereign nation states cannot readily cede control over the terms of their tech nological futures to transnational agents who operate without institutionalized responsibilities for national security and economic well-being. Creating a strategy for technological development remains a critical challenge for China; accordingly, Chinese technological development efforts reflect both the deeply felt pulls of techno-nationalism and the appeals of techno-globalism.

**Conflicting Interpretations of China's Technological Potential.** In light of the importance given to Chi na's technological development among both domestic and foreign observers, it is striking how diverse the assessments of Chinese technological capabilities are. These range from views that liken China to a threatening and unstoppable technological juggernaut to those that high light deep technological dependencies like those of most developing countries.[2]

In the former view, China is seen as having a highly developed and successful technology acquisition strategy that involves coercive technology transfer requirements for foreign investors, active espionage, and successful national R&D programs, such as China's National High Technology Program ("863"). Efforts to systematically compile indicators of high technology capabilitiesiv and assessments of technical progress in selected industriesv have found that China's growing technological power is unmistakable, although not yet the threatening juggernaut that some argue.[3]

There are good reasons for regarding China as a rising power in science and technology. China has the necessary national political will, trained human resources, and R&D infrastructure for research and innovation for it to emerge as a leader in scientific research and technological innovation during the coming decades. Measures of China's increasing technological capacity include: its large contingent of scientists and engineers working in R&D (810,000 in 2002) with a higher education system that regularly augments this already significant pool of talent; its R&D expenditures of US$18 billion (150 billion Yuan, or 1.32 percent of GDP), which, in PPP terms, is now third highest in the world after the United States and Japan; an acceleration of patenting activity; and its fifth place position in producing published papers for the world's international science and engineering journals. China's rising high technology exports exceeded US$100 billion in 2003 and accounted for one fourth of its total exports.[4] In addition, China is becoming an increasingly attractive site for multinational corporation (MNC) R&D activities.

This positive case can become misleading, however, if it is overstated or if the weaknesses of the Chinese national innovation system are overlooked. Thus, accurate evaluation of Chinese technological development requires carefully analyzing China's increasing R&D budget in a comparative perspective, recognizing the uneven quality and experience of China's large pool of scientists and engineers, and identifying and assessing the weaknesses in China's targeted national research and development programs. Moreover, China's technology acquisition strategy must be understood as having led to costly failures as well as successes, as much of its high technology export performance is from foreign invested firms, which employ managerial skills and proprietary technologies of MNCs.[5] The growth of MNC R&D centers is a particular source of concern in some quarters because it involves significant losses of technical talent—many of the best and brightest from the Chinese educational system—to foreign corporations.

**China has the necessary** national political will, trained human resources, and R&D infrastructure to emerge as a leader in scientific research and technological innovation.

Other recent studies of Chinese industrial development are far more dubious about the prospects for Chinese technological prowess. Peter Nolan's review of China's efforts to build up its "pillar industries" into internationally competitive firms points to the failure of Chinese technology and industrial policies.[6] Others see China's technology policies (portrayed so differently by the juggernaut discourses) as falling victim to a new complex international division of labor over which China has only limited control. These more skeptical interpretations have suggested that there are good reasons for doubting whether the firms that constitute China's industrial economy have the technological capacity to be internationally competitive. Chinese state-owned companies are still so mired in the practices of the past and still so subject to political influences that they will not be able to function successfully in an international capitalist economy for quite some time. Not surprisingly, the signs of technological progress in the industrial economy over the past two decades have generally highlighted the firms in the non-state sector. These include foreign invested firms and those Chinese companies which have broken from the state-owned enterprise mold to find new ownership and corporate governance arrangements as either private or collectively-owned companies. The projection for the future growth and development of such firms is an important factor in assessing China's prospects for technological development.

At the root of the more skeptical interpretations are serious doubts about the institutional structure, legal order, and business culture of the Chinese economy as these pertain to such high technology firms. In particular, concerns over intellectual property protection, financial markets, ownership, corruption, and the ability of Chinese enterprises to achieve a scale and size that would allow them to compete internationally all contribute to the skeptics' view. Finally, the skeptics call attention to the many problems that continue to exist in the R&D system, including difficulty achieving adequate funding levels and sensible funding strategies, difficulty securing an adequate number of suitably trained scientists and engineers in the right fields, continuing problems of linking research to production, and the uncertain ability of Chinese enterprises to become significant players in the nation's R&D activities.

**Are Chinese state-owned** companies still so subject to political influences that they will not be able to function successfully in an international capitalist economy?

There is thus a "half-full-half-empty" quality to foreign assessments of China's technological capability—an ambivalence that is evident among thoughtful observers in China as well. This is not surprising given the persistence of deep problems in the midst of significant

achievements. But, while the glass may be only "half-full" at present, the trends certainly suggest that the "levels" are rising, not falling. The critical questions may have more to do with the rates of change and possibilities for reversals. We will be in a much better position to address these questions if we understand the central importance of science and technology in globalization, the critical roles science and technology have played in China's response to globalization, and, notably, the assets and liabilities of China's national system of innovation. The latter are usually approached by asking whether the interactive effects of ongoing reforms, the pursuit of national program objectives in the face of China's changing position in the international division of labor, and the evolving role of science in Chinese society are producing a virtuous cycle of mutual reinforcement and development. We can better understand these questions by monitoring developments in the following areas.

**Critical Indicators.** *The Direction of Reforms.* Any assessment of where China is going with its science and technology must begin with recognition of the extensive, albeit painful reforms in China's science and technology system over the past two decades. Taken in concert with economic reforms, these have changed China's system of research and development institutions from one based on central planning, in which R&D were concentrated in government research institutes separated from industrial enterprises, 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 (up from 37 percent as recently as 1996). Now, activities of the research institutes of the Chinese Academy of Sciences and universities are connected to domestic and international companies in ways that would have been unimaginable twenty years ago.

The reform environment has stimulated the development of high technolo gy companies outside of the state-owned sector, some of which have become Chi na's better industrial performers. The existence of these firms and their struggle to succeed have introduced a new gov ernment-industry dynamic in which questions about the role of government strongly shape the reform agenda. This dynamic not only illustrates that it is difficult to wean Chinese officials away from interventionist inclinations, but also that nongovernmental enterprises themselves often seek continuing state support and sustenance. Thus, the inherited technical assets of the state remain important resources for those engaged in technological and institutional innovations out side the state sector.

Nowhere is this better exemplified than in the dynamism of the Zhongguan cun area of Beijing, where many of the more successful firms have relied on technologies developed by state entities. But, as recent studies of Zhongguancun illustrate, despite the entrepreneurial zeal and high concentration of intellectual prowess found in this area, the creation of China's "Silicon Valley" in Zhongguancun is still far from a reality.[7] Serious obstacles to a climate of innova tion persist and have eluded the govern ment's innovation strategy. These impediments include continuing uncer tainty over property rights arrangements and a critical lack of social trust, both of which work against the development of an effective, technologically advanced, networked economy. In addition, finding and developing high-level human

resources is a constant problem for small entrepreneurial firms. In the face of a rising demand for Chinese professional manpower from MNCs and the resulting rapid rates of employee turnover, small firms are reluctant to incur training costs. Competition for qualified professional labor will only increase as MNCs receive greater market access and China complies with the responsibilities of its accession to the WTO.

*National Programs.* Chinese science and technology policies reflect a certain ambiguity about the roles of market forces and government policies as drivers of technological development. In spite of marketizing reforms, the heavy influence of governmental direction on the nation's R&D is still evident in many national programs that have emerged over the past 20 years, including the "863" Program and programs in basic research. Members from China's technical community have questioned the effectiveness of these programs, complaining that top-down, bureaucratically directed programs, even when supported by expert advisory committees, have not served the development of Chinese science and technology as well as more investigator-driven, bottom-up programs might have.[8]

China's space program, which recently succeeded in its first manned mission, is a national program of a special sort . As a number of observers have noted, the space program provides China with a competitive commercial launch site, has important national security and commercial implications, and is an important driver of technological advance. Many have questioned the wisdom of committing the vast resources that this space program requires, comparing it to strategic weapons programs of the past, which also consumed scarce financial resources and China's best technical talent in pursuit of achievements that, while notable, were not at the international technological frontier.

Less noticed, however, is that the overall environment for today's space program is radically different from that of past strategic weapons programs. Whereas the latter were supported by research institutes and industrial enterprises operating in secret and cut off from both civilian economy and international technology flows, today's space program is supported by an innovation system with strong commercial orientations and vibrant links to global technology leaders. Whereas the old weapons programs displayed little sensitivity to the importance of a dynamic, civilian, high technology economy for national defense missions, this is no longer the case in today's China, where the importance of dual-use technologies has become deeply appreciated.

*China and the International Division of Labor.* China has arguably been one of the great beneficiaries of globalization. It has pursued opportunities to market its goods worldwide and has exploited opportunities created by globalization to acquire capital, managerial expertise, and advanced technology from the international system. In doing so, however, China has had to fit into global production networks established and created by others. Although China has moved up the value chain in these networks, it has remained subordinate to those who control the technical standards and intellectual property that define networks. China has realized absolute gains from its participation in

the global economy, but remains dissatisfied with its relative gains in comparison to those of global industry leaders. China sees itself, unhappily, as a rent payer rather than a the rent taker. As a result, in recent years China has initiated an aggressive new approach to setting its own national technical standards in order to capture greater value from its intellectual property and industrial activities.

China's standards policy is a high-risk endeavor that could harm many of its own companies that prosper under cur rent standards in the international division of labor. It could also lead to serious trade frictions affecting China's access to markets and to the flows of knowledge and financial resources from which it has benefited. The current dispute with the United States over China's attempt to establish a new encryption standard for wireless devices has already created tensions with the U.S. government and with U.S. high-technology firms, whose part nerships with China have contributed so much to the overall enhancement of Chinese technological capabilities. On the other hand, few countries are as well-placed as China to challenge the struc tural power of established production networks. The combination of China's market power and ability to harness an increasingly capable research system to its standards agenda gives China the opportunity to become an international stan dard setter and "rent taker."

*Science and Society.* Apart from the chal lenges China faces in developing work able mechanisms for its technological development, there is also a series of questions about the role of science, as opposed to technology, in a rapidly changing China. Perhaps most pressing is the challenge of developing a creative basic research tradition in an institutional environment hindered by a strong bureaucratic control of research agendas and scientific careers, a profound bias towards short-term commercial results and applications, and an environment that reflects a cultural predisposition of deference towards authority that may inhibit creativity.[9] Exploring the role that science plays in supporting China's over all development also involves grappling with the question of how to establish sci ence as an independent source of authority in a society that is increasingly complex and urgently requires sound technical judgments in its emerging regulatory policy, its environmental man agement, and, as the SARS outbreak highlighted, its public health policies. The new scientific revolution involving bio/nano/materials technologies and their synergies with information tech nology is already raising a series of unprecedented challenges of scientific understanding for the ethical governance of technology in China. The government is seeking to stimulate a much broader and deeper public understanding of sci ence, but, as in other countries, we do not know whether heightened public understanding of science will become a force that supports or opposes the development of the new technologies.

**The Challenges of State-Driven Technological Development.** The current interest in China's rapid development is reminiscent of the "Japan as Number One" mentality of the 1980s. Although there are profound differences between the Chinese and Japanese cases, foreign perceptions of them show important similarities. In both cases, foreign observers seemed genuinely surprised at

the development of sophisticated techno logical capabilities and commercial competitiveness in countries long thought to be "third tier." In both countries, the record of national policy intent and action in support of technological devel opment was available for any interested party to examine, but few foreign observers took the trouble to look. In both cases, therefore, when technological achievements began to appear, they gen erated a degree of alarm that produced both overstatements and understatements of state capabilities. These mistaken assessments were characterized by an under-appreciation of the states' real strengths, as well as an exaggeration of the deep structural and cultural problems affecting the states' innovative capabilities. Moreover, many miscalculations were due to misunderstandings of the role of the Chinese or Japanese state in fostering sci entific research and technological innovation, especially in the face of changing cir cumstances. Ultimately, any judgment about the initiation of that "virtuous cycle" in China must integrate an understanding of the Chinese government's role in driving forward its national program for technological development.

The Chinese government clearly is committed to a techno-nationalist vision of using political power to advance scien tific and technological development. At the same time, it has shown an increasingly sophisticated appreciation of how using political tools for this purpose can be ineffective. Although China's policy makers have certainly come to appreciate the importance of market forces as drivers of innovation, China's long tradition of state-directed research predisposes the government towards using national programs (now including the space program) as innovation drivers as well. A major challenge facing China's policy makers as they attempt to harness the energy of the state structure to promote national innovation and techno logical development is finding a workable balance between market forces and national programs in its technology policy. Here, in spite of sharp policy differences in China and often contradictory policy consequences, China is beginning to find this balance.

**A major challenge** facing China's policymakers is finding a workable balance between market forces and national programs in its technolgy policy.

The more difficult problem in considering the role of the state and China's potential for dynamic technological growth is one that touches upon the very nature of the Chinese political system. Here the questions pertain to the rule of law, relative policy neutrality in the management of financial institutions, liberal understandings of the roles and flows of information in society, and encouragement of the kind of pluralism that would foster far greater autonomy and self-governance in the technical community. Redefining the state's role with reference to these issues draws out underlying considerations of political reform and, ulti-

mately, raises the question of whether China's position as a leader in the new technological revolution can be assured independent of such fundamental reform.

## NOTES

1 See The RAND Corporation, *The Global Technological Revolution: Bio/Nano/Materials Trends and Their Synergies with Information Technology by 2015* (Santa Monica: The RAND Corporation, 2001).

2 See Pat Choate, Charles Mcmillion, and Edward Miller, "An Analysis of the U.S. Industrial Base and the People's Republic of China," U.S. Defense Industrial Base, June 2002; Charles Mcmillion, "China's Very Rapid Economic, Industrial and Technological Emergence," U.S. Defense Industrial Base, July 2002; Yuko Arayama and Panos Mourdoukoutas, *China Against Herself: Innovation or Imitation in Global Business?* (Westport: Quorum Books, 2002).

4 Xinhua News Agency, "Rapid Progress in Scientific Development: Minister," 22 February 2003, China Internet Information Center, Internet, http://www.china.com.cn/english/scitech/88099.htm, and Ministry of Science and Technology, *China Science and Technology Statistics. Data Book* (Beijing: Ministry of Science and Technology, 2003).

5 Daniel H. Rosen, "Low-Tech Bed, High-Tech Dreams," *China Economic Quarterly* Q4 (2003): 20–40.

6 Peter Nolan, "China and the Global Business Revolution," *Cambridge Journal of Economics* 26 (2002): 119–137.

7 Wang Jici and Tong Xin, "Industrial Clusters in China: Alternative Pathways Towards Global-local Linkages," *Innovation Systems In Developing Countries* (Maastrict: UNU/INTECH, forthcoming). See also, Cong Cao, "Zhongguancun: China's Silicon Valley," *China Business Review* 28, no. 3 (2001): 38–41.

8 Carl Dahlman and Jean-Eric Aubert, *China and the Knowledge Economy: Seizing the 21st Century* (Washington D.C.: The World Bank, 2001).

9 See Nature, 428 (2004): 203ff.; especially, Mu-Ming Poo, "Cultural Reflections," 204–5.