Innovation, change, and order: Reflections on science and technology in India, China, and the United States

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A R T I C L E   I N F O

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A B S T R A C T

A comparative analysis of science and technology policies in China, India, and the United States shows striking similarities and sharp contrasts. These differences reveal much about the current problems and likely prospects in each country. This review distills the contributions of 15 distinguished leaders in science and technology who assess national goals and international ambitions. The review covers five themes: education, defense and space, R&D performers, science and technology in the economy, and governmental policies and funding. Other issues include: economic freedom, global competitiveness, energy and the environment, and population and demographic trends. Brief historical highlights provide context for understanding past trends in the present socioeconomic setting.

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1. Introduction

“The art of progress,” remarked Alfred North Whitehead “is to preserve order amid change and change amid order.” For India, the United States, and China, national debates about the paths for progress are often unsettling. One reason for this is that “progress” means different actions or implies different goals to different people. In any case, it is often uncertain and its pace is often unpredictable. For my purposes here, I loosely define progress in terms of the scientific and technological developments—creating innovations within the spirit of open inquiry—that enable economic growth. That growth and increased productivity yield higher standards of living. Research and development, narrowly conceived, like paths of progress, also have uncertain timetables and unforeseeable results. The purpose of this entire volume is to take stock of the arts of balancing science and technology in fostering national progress.

The future, we know, will bring surprises. Indeed, when comparing and contrasting the characteristics of the three nations, it is tempting to try to answer questions such as: Which firms and regions will thrive? Who will originate seminal innovations? Who will “win”? Win what? And why? To quench this temptation, recall Peter Drucker’s profoundly simple observation: “We know only two things about the future: it cannot be known, and it will be different from what exists now and from what we now expect.” Therefore, instead of hazard ing perilous conjectures, I will tackle three simpler tasks in this concluding Section:

- underscore common themes and concerns in the five clusters of papers;
- outline two major topics that received less attention; and
- highlight a few apercus about each country's capacity for innovation.

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2. The whole board

I will begin by taking a broader look; as in chess, it is wise to review the whole board before each move. Table 1 presents 2004–2007 data that characterize the economic and social conditions of the three countries:

These numerical indicators—look at them carefully, such as literacy and computers—confirm well-publicized images. My distinguished colleagues, J. Thomas Ratchford and William A. Blanpied, in their Introduction to this volume, have given a rich account of historical trends and accomplishments in each country. Here I briefly recall the familiar profiles in a qualitative way.

The United States has advanced for more than a century with successful industrialization, uses a great deal of energy, is rich, spends heavily on health care, fosters a dynamic business culture, and embraces a freewheeling ethos of individual rights and freedoms. Severe American problems span an equally large spectrum that the above data do not reveal: poor K-12 education, a deteriorating and aging infrastructure, inequitable and inefficient health delivery, severe fiscal pressures, and the strains of being at war.

China has accomplished absolutely unprecedented economic growth for more than a quarter century. It became the world’s second largest economy (PPP). Pulling tens of millions of citizens out of poverty and into literacy while evolving into a global manufacturing power, China became the world’s largest producer and consumer of steel. Yet China suffers pervasive and worsening environmental degradation with punishing effects on health, water, and air. Moreover, China fails to protect universally respected civil rights and freedoms.

India’s great talent and resilient democracy have been engaged for almost 20 years in successful and concerted efforts to muster higher growth rates, to free up the economy, and to pioneer communications and information services for the world. Recently, the manufacturing base has picked up steam, foreign investment continues to increase, and civil rights have begun to triumph after centuries of constrictions based on the caste system. Yet India’s low literacy rate, clogged and obsolete transportation system, together with lingering burdens of governmental regulation, impede its progress.

Now let us turn to the five principal themes of this volume. Because national security is the principal function of government, I will begin with defense and space.

3. Defense and space R&D

A “revolution in military affairs.”

This idea is more than a slogan; it drives future-oriented technological initiatives, and it is embedded in today’s military forces on the ground. Moreover, it takes a growing share of the defense budgets of major powers. In essence, the revolution is this: extraordinary information technology swept across military applications during the last quarter of the twentieth century, exploiting the speed and scope of computing and communications to enhance the accuracy and flexibility of warfare. Today the consequences of this powerful technology spark the imagination—and alter the doctrines of—national security planners.

Hermann, Erickson and Walsh, and Mallik, brilliantly assesses the American, Chinese, and Indian military and space programs. Each clarifies the situation with specificity and in depth. Hermann says, “the information system revolution ... changed what was possible for military and intelligence systems.” Erickson and Walsh point to China’s “fundamental change in strategic outlook.” This explains the 20% per year increases in Chinese defense budgets over many years in order to prepare for “local wars under high-tech conditions.” Such a “local war,” of course, could be about Taiwan. Looking at a
downside of these global technological trends, Mallik sees the “vulnerability of peaceful societies,” creating the challenge of how to ensure information security as India sets its military R&D priorities to take account of the sometimes threatening revolution in military affairs.

These waves of change have been underway for some time. Bruce Berkowitz neatly summarized the consensus: “Information technology has become so important in defining military power that it overwhelms everything else” [4, p. 2]. The 1991 Gulf War provided ample evidence, Berkowitz reminded us: “Americans could see at night, drive through the featureless desert without getting lost, and put a single smart bomb on a target with a 90% probability” [4, p. 5]. All nations noticed. Strategy, tactics, arms, all changed. Fifteen years later, the weapons and sensors are even smarter.

Yet the “art” of war—gaining and holding power—may not have changed over many centuries. As Sun Tzu put it, “All warfare is based on deception,” and “We cannot enter into alliances until we are acquainted with the designs of our neighbors” [p. 9,5,32] Given these venerable dicta, it is hardly surprising that the China, India, and the United States view each other warily. A recent American assessment said: “The outside world has limited knowledge of the motivations, decision making, and key capabilities supporting China’s military modernization”, and “This lack of transparency in China’s military affairs will naturally and understandably prompt international responses that hedge against the unknown” [6, p. 1]. For India, argues Mallik, in the “Asian triangle of China–India–Pakistan, the chances of border conflicts leading to short wars and even the lowering of nuclear thresholds are very real.”

A decade ago American analysts soberly observed that for China’s current rulers, informed by the nation’s history of the past 200 years, “security does not turn on interdependence,” and the “notions of building international norms and creating international regimes” are viewed with “deep distrust” [because] these are the disguised efforts of the dominant powers ... to bind weaker powers into systems that perpetuate the current global distribution of power and wealth” [7, p. 32]. In the spring of 2007, Harvard’s Ashton Carter and former US Defense Secretary William Perry incisively argued that America needs a “two-pronged policy. The first is to encourage China to become a ‘responsible stakeholder’ in the international community. The second is to hedge against competitive or aggressive behavior by China” [8]. Reliably reducing mutual suspicion, and gradually slowing any military buildup triggered by suspicion, will not be easy or quick.

Nonetheless, paradoxically, one tragic need encourages genuine hope for expanded cooperation among India, China, and America. That need is the global call to combat terrorism, a worldwide threat. As Hermann emphasizes, “modern industrial states ... have reason to cooperate to contain terrorist organizations and suppress their terrorist attacks.” Against the nightmarish threat of nuclear terrorism, for example, Council on Foreign Relations Science Fellow Michael Levi systematically showed how more can and must be done. More specific efforts, he argues, should begin with a better-coordinated, rigorous collaboration among the nine countries with nuclear arms “to support the strongest possible efforts to improve controls over nuclear weapons” [9,10].

The United States, China, and India are the most important subsets—in wealth, power, reach, and geography—of all the nuclear states. Despite the argument that, as Erickson and Walsh conclude, “technological cooperation (between the US and China) in the defense and space realms remains problematic in the near-term,” joint efforts against terrorists appear to be a shared objective, possibly even an imperative. US–China cooperation in the six-party talks about North Korean nuclear weapons shores up stability on the Korean peninsula. Such collaboration can be justified fully in terms of collective, reciprocal interests in the stability needed for the rising global trade that fosters economic growth. After all, a terrorist-caused economic depression in the US would quash the American market for exports from China and India. For India, too, as Mallik argues, “collective action [is] very necessary to address the new or non-traditional security issues—such as terrorism.”

Complicating the prospects for cooperation across most high-tech domains is the unavoidable spread and expanding application of “dual-use” technologies. Information technology, the true foundation of the “revolution in military affairs,” is also the crucial base for civilian and commercial success, lifting both domestic productivity and exports. Further, remarkable frontiers are crossed each year by life-scientists who are creating potent new tools in biotechnology; yet these are dual-use tools that could be exploited as weapons by nations or, quite possibly, terrorists. Indeed, the authors writing on how to advance national capability in defense and space—Hermann, Mallik, and Erickson and Walsh—agree on the importance of a “dual-use, integrated, civil-military strategy.” For aspiring nuclear states like North Korea and Iran (both currently in global disputes as this is written in early 2008), acute concerns about dual use create profound doubts about any nation’s claim that nuclear capacity will be used only to supply electricity. Since controls and non-proliferation treaties did not and cannot block the steady diffusion of dual-use knowledge, and since many countries can or soon will be able to build nuclear plants and weapons, this is a stark challenge for India, China, and the United States.

In closing this sketch, I must add a word about space programs. India and China have had exceptional accomplishments. Starting from scratch and without external assistance, India began with a civilian-observational program 40 years ago. It flourishes today. About 20 years ago, China transformed its older missile effort—founded with help from the former Soviet Union—into a satellite and space exploration program. Both China and India, with high morale and startling achievements, have set ambitious current goals. Competition with the US and Europe, as well as with each other, is vivid and occasionally tense.

American reactions to the Chinese space effort, and Chinese concerns about American capabilities, have ranged from cautious to vigilant. For example, the Pentagon issued this appraisal: “China’s counterspace program—punctuated by the January 2007 successful test of a direct-ascent, anti-satellite weapon—poses dangers to human space flight and puts at risk the assets of all spacefaring actions” [6]. Similar tones were apparent in exchanges that occurred in February 2008 when
the US Navy dramatically shot down a crippled American spy satellite. “This was uncharted territory … and the technical degree of difficulty was significant,” said General James Cartwright, Vice Chair of the US Joint Chiefs of Staff. Chinese Foreign Ministry spokesman Liu Jianchao soon warned: “China is continuously following closely the possible harm caused by the US action to outer space security and relevant countries” [11].

Could this exceptional space technology, in the hands of three nations that possess dual-use prowess, be transformed into a shared dedication to space exploration and exploitation for its own sake, for economic gain, and for scientific purposes? The authors here, all gifted technocrats, have their doubts.

4. Governmental science and technology policies

Writing in this issue, several experienced leaders each probed the broad theme of “Government: S&T Policies and Organization.” They outlined the critical points essential for understanding how the public sectors in China, India, and the United States have made significant changes in their S&T outlooks during recent decades. Each author gives a brief historical account as a prelude to a closer inspection of recent shifts in priorities.

C. N. R. Rao highlights, for instance, the Nobel Prize-earning research in physics of C.V. Raman during the 1920s and the founding of the Tata Institute in 1945. These and other examples reveal how Indian skill and a commitment to world-class science emerged long before the economic reforms of the 1980s and 1990s set the current pace for accelerated R&D. Song Jian documents the birth in the 1980s of major Chinese governmental R&D initiatives that created high-tech development zones and industries strong enough to penetrate international markets. Neal Lane analyzes the diverse post-World War II American R&D experience — characterized by periodic surges of funding, enormous organizational change, and, yes, occasional waste — with a sure and sophisticated grasp of the often-shifting priorities.

Government funding for R&D is rising in all three countries, especially in China (about 20% per year), but only slightly in the United States. In India, the most pressing needs are for more private investment and for better linkages among universities, firms, and public-sector S&T units. In the United States, the balance of federal support is beginning to shift again (after more than a decade of dizzying growth in the biomedical sciences) toward physics, chemistry, math, and related cross-disciplinary areas such as nanotechnology. However, the shift has been slow.

In all three countries, the more basic the research, the tougher the case for “selling” it to the government. Cosmology and neuroscience may be among the exceptions because of their extraordinary promise — the former for ancient reasons of deep-seated curiosity, the latter for urgent reasons of need in medicine. Lane correctly states: “Funding [in the US] for the core disciplines … has been eroding for decades.” Public officials in all the three countries claim a commitment to a strong base of science. Yet, they also know they must recognize social demands, and they always assert vigorous concern for more rapid commercialization of the fruits of research. This inconsistency confounds the traditional principles of balanced R&D management that should span a prudent and meritocratic mix of fundamental and applied work, close to frontiers and close, too, to markets.

Philip Auerswald and Lewis Branscomb point out in their assessment of the newer patterns of successful innovation that nationally oriented linear models — i.e., science leads to technology, which leads to new products or services — are becoming less apt and effective as the world of science and industry becomes vastly more networked, filled with alliances crossing disciplines and borders.

For many of the themes in this volume, the three countries are characterized as running three separate “experiments” in their respective government policies and models for public-sector S&T. One of the clearest examples of the variety of approaches is the degree of top-down or bottom-up processes. Overall, each government has taken a distinctive approach to S&T policymaking and to science advising, and to funding modes.

Rao notes that despite some liberalization, (Indian) “bureaucracy … continues to dominate … science and technology” [12]. He adds, icantly and ruefully, that the “formal science advisory mechanisms … are not working as well as one would like.” The American organization, with the White House Office of Science and Technology Policy (OSTP) at the pinnacle of government, has become fractionated. Defense and space S&T issues, central to OSTP over much of the past 50 years, have been mostly trimmed from OSTPs agenda. The mission agencies (e.g., Department of Defense, and National Aeronautics and Space Administration) argued for and won the case that their responsibilities should not be encumbered by much influential, independent advice on their programs offered directly to the President.

In the activities that fund research grants, the US system depends heavily on separate, bottom-up applications to, say, the National Institutes of Health or the National Science Foundation. These investigator-conceived requests then go to peer review in a competitive mode. China and India tend toward more top-down, nationally mandated programs. Although all three countries have hybrid systems for financial awards, the Asians seem to favor hierarchical guidelines.

International cooperation in strategies for research in many fields, as well as for missions such as health and the environment, are a rising priority in all three countries. Almost every author in this volume comments on this theme. Since “big science” is expensive, and scientists at the frontiers of their fields in every country pose many of the same deep questions, collaboration makes sense. And since goals such as dealing with HIV/AIDS and preparing for the almost inevitable flu pandemic are so significant everywhere, collaboration is compelling. Margaret Hamburg’s paper expertly documents the pivotal need for global coalitions — in research and in action — to deal with the likely new rounds of epidemics of infectious diseases.
Yet the question remains: will it happen? Will or can eminent S&T leaders stimulate a renewal of concerted international work over the next decade? Rao graciously recognizes the help India received in the past from many countries. He notes the “common goals in S&T” that can be addressed by “pooling both material and intellectual resources among nations,” and he singles out “mega-science” projects as desirable for participation among equal partners. Lane wisely asserts that US researchers will need to be “engaged in international collaborations at a level that is unprecedented in the nation’s history” [13]. Song’s closing words cite Deng Xiaoping’s advice: “in order to modernize the country, science and technology must go first,” and China has more than 500,000 students abroad along with large “foreign” S&T investments at home.

To deepen and replenish the reservoirs of basic knowledge, to ensure supplies of energy for economic goals, and to protect the environment and health of future generations, the international S&T system, such as it is, must be strengthened. An overarching need is for new architecture. That new architecture must be flexible enough to engage all three countries (and many others) and sturdy enough to accomplish tasks that earn the public’s respect, trust, and resources. This is a tall order, and the contributors here know that. The United States has had, beginning with Thomas Jefferson, a vibrant commitment to international collaboration. But that commitment, along with the resources and the reliability to pursue projects, such as for mega science in experimental physics has weakened. American professional societies, academies, foundations, government agencies, newer entities such as the US Civilian Research and Development Foundation—continually seek improved practices and compelling opportunities.

The next decade will be a challenging time to restore the vibrant S&T cooperation needed because global competition inexorably will increase.

5. Science, technology, and the economy

Before reviewing the observations of our authors on the roles and impacts of S&T in the economy, let us look at economic snapshots of China, India, and the United States (Table 2).

The pattern is crystal clear. The Chinese economy sustains its boom. The Indian economy continues to accelerate. The American economy advances despite teetering toward a recession in early 2008. Relentless competition drives innovation and trade. The welcome economic growth, with increased productivity, is difficult to manage. It disturbs the order, jobs change or disappear, markets tighten, technological change disrupts. A more complete picture emerges using World Bank data covering 1990–2004 (Table 3).

All three countries are becoming more high tech, more dependent on trade, more likely to rely on innovation to differentiate their products and services in typically cutthroat markets. Given these churning waves around the world, the analysts in this volume are cautious when assessing science and technology in each nation’s economy. One reason for caution is that, despite the apparently quickening pace of change, it often takes a long time for major innovations to gain and hold ground. Auerswald and Branscomb perceptively recall that “the most significant impacts on the growth of [American] R&D investments of the 1950s and 1960s did not come until the second half of the 1990s, when the widespread adoption of new information and communications technologies (ICTs) drove a surge in productivity.” They add: “today’s breakthroughs in nanotechnology and life sciences will take comparable periods of time to show up in national income accounts.”

Table 2
Output, prices and jobs—February 2008 (% change from one year ago)

<table>
<thead>
<tr>
<th></th>
<th>GDP</th>
<th>Industrial production</th>
<th>CPI</th>
<th>Unemployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>+8.9</td>
<td>+5.3</td>
<td>+5.5</td>
<td>7.2</td>
</tr>
<tr>
<td>China</td>
<td>+11.2</td>
<td>+17.4</td>
<td>+6.5</td>
<td>9.5</td>
</tr>
<tr>
<td>US</td>
<td>+2.5</td>
<td>+1.5</td>
<td>+4.1</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Source: [14].

Table 3
Selected economic changes, 1990–2004

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>India</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP Growth</td>
<td>3.8</td>
<td>10.1</td>
<td>5.8</td>
</tr>
<tr>
<td>Exports (% GDP)</td>
<td>19</td>
<td>34</td>
<td>7</td>
</tr>
<tr>
<td>Telephones (per 1000)</td>
<td>6</td>
<td>499</td>
<td>6</td>
</tr>
<tr>
<td>Hi-tech exports (% total)</td>
<td>6</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>Merchandise+trade (% GDP)</td>
<td>32</td>
<td>60</td>
<td>13</td>
</tr>
</tbody>
</table>

Source: [1].
From a different vantage point, Roddam Narasimha also emphasizes the lengthy times needed for most economic drivers of technology systems to mature and cause the desired effects. He says that despite increasing Indian public R&D investments, “the public S&T system has not been directly benefited yet by the [Indian] economic reforms.” He worries that “the shackles on education and R&D” suggest there is every likelihood of India remaining an efficient blue-collar S&T nation that serves more aggressive innovators elsewhere.

Mu Rongping’s highly quantitative and frank analysis notes: “the ratio of R&D/GDP in China has increased very fast since 2000, and reached 1.42% in 2006 … [which is] much higher than India in 2004 (0.71%) … [but] still a big gap [with the] United States at 2.68%.” Yet, even with this surging growth in Chinese R&D, Mu perceptively emphasizes that “the motivation for enterprises—with only 0.76% of total sales expended on R&D (much less than in US by most accounts)—to invest in innovation is still not strong because … there are many other opportunities to profit without innovation.”

Auerswald and Branscomb recall a key axiom of Joseph Schumpeter’s work: “creative destruction” of firms with obsolete products is a natural and necessary process of free market-oriented economic growth. This powerful idea remains valid. But they emphasize the surpassing successes in the US of “science-driven, small-firm innovation” following World War II, which contradicted Schumpeter’s prediction in 1928 that innovation would emerge mostly from large firms. A key argument in their case, noted earlier, is that the old paradigm of a linear invention-to-commercialization process is obsolete. They view “the global enterprise [as] increasingly a flexible assembly of [large and small] firms around the world, with skills and capacity that can be drawn upon for the most efficient combination of business processes.” In short, they argue that networking is the best method for producing innovation.

Tactfully agreeing with this economic model, Narasimha devotes much of his superb assessment to explaining why, in science and technology, “India’s performance is singularly uneven.” He shows why India’s achievement in organizing its aerospace program was so productive because it linked science to a clearly defined mission; also why the Indian IT industry had such “spectacular growth” (since it “never figured in the official five-year plans”); and why the clear notion of an innovation chain was barely understood in India during the past 40 years. Narasimha implies that India’s currently increasing support of S&T is not yet coherently and fully accepted as a national priority or as an essential component for India’s global competitiveness. A recent World Bank report affirms this conclusion: “…innovation remains concentrated in a small segment of the [Indian] economy. Roughly, 90% of the workforce is employed in the informal sector, characterized by low productivity and low-skill activities” [15, p.1].

For the future, Auerswald and Branscomb call for “recalibration of [US] policies and priorities” because they believe the “system of science-based innovation” is becoming “less national and the process of innovation is becoming less science-based.” Narasimha sees India as “predominantly a recipient rather than a source of technology,” and he is clearly saddened that “there is no pressure yet in the present economic system to create wealth through technology development and intellectual property generation.” These authors diverge in their outlooks simply because their nations are at such different stages.

Mu’s closing section is a meticulous and impressive review of the varied elements of China’s ambitious medium- and long-term Plan (adopted in January 2006) for building broader foundations for science and technology over the duration of the Plan from 2006–2020. His discussion covers tax incentives, governmental purchasing policy, “re-innovation” by assimilating foreign advanced technology, building up capacity for generating and protecting intellectual property rights, establishing national infrastructures for S&T, cultivating S&T talent, and special government financing measures—altogether a massively detailed strategy. Assuming China’s commitment to precise and consistent measurements, their future progress may well be available for the world to see.

What most nations leave out of their calculus for “what to do about S&T in the economy” is technology policy. The issue was an orphan, and is still highly charged, in the United States. The worldwide taunt is: can any government consistently pick winners? India is just beginning to deal with this knotty theme, and China’s new 2006–2020 Plan tried to come to terms with it in actions that evidently are to be coordinated centrally in order to fulfill national goals. The late D. Allan Bromley, White House S&T Advisor from 1989 to 1993, explored the topic with uncommon depth and experience in relation to his role in charting “the first formal US federal technology policy” [16].

Countries must solve the puzzle of building national S&T assets while contending with the riptides of both domestic politics and international trade. Adam Segal’s perceptive essay in this volume ably diagnoses these sometimes subtle and always stout forces affecting innovation throughout Asia.

6. Performers of research and development

Two excellent articles on this theme—one by Kathie Olsen et al., of the US, and the second by Zhu Zuoyan and Gong Xu from China—clarify with exhaustive data and citations to national policy papers the changing views on funding for basic research under the broad heading of R&D. Despite chronic difficulties in clearly distinguishing the categories of “basic” versus “applied” research, they carefully review the past 50 years of changing national patterns.

For instance, while the industry’s overall funding for R&D is up, its support for basic research is down; every firm’s time horizons must shorten to meet market pressures. Both sets of authors hint at the question I posed earlier, one that many observers ask: Who in the world should, or can, replenish the reservoirs of knowledge needed by all in order to continue generating innovation?
In China and the United States, the government is funding more, and usually the most basic, research at universities. In China, the institutes within the Academy of Sciences remain, for now, the most significant performer of fundamental work. But together with economic incentives and patent rights increasingly available to academic institutions and their faculties, an American research university model is an “answer” to serve China’s national and global aspirations. But it is hard to shake the idea that if the world had more diverse performers in fundamental science—that is, independent efforts by firms, by universities, and by public-sector labs—the diversity of talent and approach would spark even more innovation.

R. A. Mashelkar’s elegant review of the “changing landscape” in India explains what he sees as the “four pillars” underlying India’s science and technology goals: techno-nationalism, inclusive growth, techno-globalism, and global leadership. To illustrate, techno-nationalism became the driver when India was denied dual-use technologies. In response, India developed its own excellent technology for space and for nuclear systems. The fourth pillar—S&T for global leadership—Mashelkar says will “demand substantial improvement in the quality of India’s basic research, creating ‘innovation ecosystems’ comprised of forward-looking IP laws and venture capital. His ambition for India: “Tomorrow’s Silicon Valleys and Genome Valleys will be created in India.” This goal contrasts sharply with the recent past, Mashelkar concedes, when “Indian IQ has been used to create IP for foreign firms.”

The papers in this wide-ranging section converge on at least four points:

- the importance of equal access to, and bottom-up competition for, research funds, with awards granted on the basis of merit as judged fairly by peer review;
- the advantages of explicit policy guidance from the government on longer-range priorities for science and advanced education;
- the need for metrics about R&D activities, national trends, and international comparisons; and, not least; and
- a spirited commitment to more international collaboration in the future, along the lines mentioned earlier.

Consider each point briefly below.

6.1. Competition and peer review

Zhu and Gong compare China’s system “before the beginning of reform”—when funds were “allocated byadministrative means”—with the present mode of peer review, “relying on experts and developing democracy to select the best proposals for support in a fair and reasonable way.”

Olsen et al. recall that the US National Science Foundation’s first research grants, awarded in 1952, followed an “independent evaluation of [all] proposals.” Although there is a steady stream of Congressional appropriations with so-called “earmarks” for projects that are not competitively reviewed (and this is a glaring, much-criticized, chronic flaw in the American system), Olsen et al. are surely correct that the peer review system helps to “ensure quality and maximize potential payoff on a project-by-project basis.” But it does tend, as many observers claim, to be conservative in the sense of approving the best-justified plans and rejecting many high-risk ideas.

Mashelkar discusses the importance of pushing more competition in India to foster discovery. He uses recent examples ranging from pharmaceuticals and computers to bioinformatics—especially in applied research—to show why it will be crucial to induce competitive public–private partnerships that link universities, government laboratories, and industry.

6.2. Explicit governmental guidance

Olsen et al. review key American steps in government policy and funding over the past 150 years, beginning with the establishment of land grant universities in 1862 and 1890. Other critical steps included the National Defense Education Act in 1958, following Sputnik; the Bayh–Dole Act in 1980, which catalyzed universities to use the economic incentive of patent ownership; and the Small Business Innovation Research program started in 1982, which fosters commercialization of ideas and new partnerships to that end—these and other government actions have shaped the present scene in the US.

Similarly, Zhu and Gong trace their analysis of China’s acceleration of its R&D efforts: from the 1978 economic “opening up” by Deng Xioping (he also was responsible then for S&T) when he said “science and technology are the primary productive force,” to the impressive and sweeping recent “Guidelines” for S&T during 2006–2020. A riveting example of increasing convergence between the Chinese and American systems for performers of R&D is the ascending Chinese emphasis since 1985 on universities becoming a primary locus of basic research (although as mentioned above, the Chinese Academy of Science’s institutes still play a major role). This reverses a decades-long pattern of separating research and education into different institutions. By 2006, with encouragement from senior leaders, the new S&T guidelines set the goal that all national R&D spending (mostly by the government) should reach 2.5% of GDP by 2020, which would be about the same as the US and would entail sustained increases consistent with expected GDP growth.

According to Mashelkar’s forceful account, India “did not have any options” in its quest to obtain supercomputers. So it had to depend on a nationally mandated, top-down program to institute “its own technological preparedness.” Remarkably it did create its own globally competitive computer hardware. In this field, as in nuclear systems and space science, the government took the lead. Industry had been restrained over many decades: central economic planning and few market
incentives made innovation almost impossible. So government centers attempted to become world class and self-reliant, and India also succeeded in these activities. But the world has changed. For the future in India, will industrial and academic alliances actually replace government-directed self-reliance?

6.3. Metrics

Every country needs data to understand the status of its society and its position in the world. For the R&D enterprise, however, almost all data cover (a) the inputs of funding (for research, facilities, high-tech projects), and (b) the outputs of people and publications (K-12 students, engineers and scientists, patents, papers/citations). Many governmental and academic observers—and the authors in this section of the volume—find such data frustrating because they do not show how R&D produce, and/or connect directly to, specific innovations and concrete social and economic impacts. Hence, policy analysts investigate trends to discover better metrics that explain—or, possibly predict—meaningful relationships between S&T investments and national objectives. The literature is littered with failures to do this.

According to Zhu and Gong, one goal in China will be to show convincingly how rapidly rising investments in R&D (22% per year from 2000 to 2005) answered Deng Xioping’s strategy to “invigorate China through science and education.” Counting papers and patents is not a complete answer, of course, no matter how fast those outputs grow. The authors recall that in the 1950s and 1960s, some of China’s outputs were easy to understand: breakthroughs such as atomic and hydrogen bombs, the launch of satellites, and the discovery of continental oil deposits. For the future, equally convincing outputs—tangible, nationally relevant, and visible—will be demanded from the R&D system.

India is particularly proud of its number one world ranking on the scales of scientific publications/GDP/capita/year, and of citations/GDP/capita/year. Mashelkar’s calculations, using David King’s data, measure “the intellectual capital per dollar.” He knows the ranking will change over time as economic growth and income rise. But Mashelkar foresees that “as India becomes a great R&D web, the world’s best companies will be doing their most challenging R&D in India.” That will be hard to measure, but if it unfolds, the world will recognize it with little difficulty.

For more than 30 years, the US National Science Foundation has pioneered the development of “metrics describing the state of the US scientific enterprise in terms of global competition, national capacity, and institutional performance in contributing to national objectives” [Olsen et al.]. The NSF indicators have been a model for many countries. The OECD and UNESCO also have played vital roles in the effort to encourage and report accurate worldwide S&T/economic indicators. A new American program in the NSF, called “Science of Science and Innovation Policy,” aims to resolve the central issue, i.e., identifying the “process through which investments in science and engineering research are transformed into social and economic outcomes” [Olsen et al.].

6.4. International cooperation

Olsen et al., along with many other authors in this volume, converge on the proposition that “progress in the 21st century will ultimately depend on international cooperation and collaboration in science and engineering.” Zhu and Gong explain the urgency of “expanding international cooperation” through an explication of China’s aim to increase their own and tap into others’ basic research. Perhaps because of his emphasis on “techno-nationalism” and “global leadership,” Mashelkar leans toward India becoming a “model for other countries to emulate,” rather than a scientific partner, even though he has been and is a leader in many international cooperative initiatives.

Despite these commendable statements of principle, skeptics are aware of the “free rider” conundrum—the fact that everyone benefits from any research funding that is followed by open and timely publication of the results; hence, each firm or government might tend to let others finance research as a cost-effective tactic. Such a tactic, followed widely, would produce under-investment everywhere. Moreover, brisk market competition often blocks or confines plans for expanded cooperation. Open-ended (sometimes characterized as “academic”) scientific collaboration works best (and perhaps only) when a project can establish strong mutual intellectual interests, and comparatively weak commercial potential. In contrast, industrial firms frame their many R&D alliances for defined periods of time, based upon synergies among their expertise. But first they must clinch with precision a joint statement of clearly shared goals and timetables, often including acceptable exit strategies to give maneuvering room for changing circumstances.

Working scientists and engineers in every sector may be friends, to be sure, as well as competitors, but nations and firms have competing global interests that determine their budgetary commitments [17]. India, China, and the United States are exploring how to do this with each other. Investments and people going in all directions will begin to reveal the most successful patterns. As I mentioned earlier, the world needs new architecture for cooperation in order for the research enterprise to thrive.

7. Human resources and education

A truism: for science and technology, nothing is more important than human capital. Broadly speaking, the term encompasses the qualities of a nation’s educated people, along with the problems and prospects of the nation’s educational institutions. The Chinese, Indian, and American observers share three unmistakable characteristics: each is committed to
improvement, while being critically aware of current hurdles and inertia, and, in an admirable sense, patriotic. A striking feature in all the papers is a lack of explicit emphasis on the rising goals for women in science, engineering, mathematics, and technology. Perhaps every major country already has internalized this critical consideration; if not, they must do so.

Leon Lederman’s analysis captures a key general point: “The critical examination of a nation’s educational system is often a shock since education is deeply embedded in the culture of the nation ... other nations are rising to create educational systems that will place them at the lead over the entire spectrum of science and technology.” His summary of America’s problems covers many of themes probed by Raghavan for India, by Xu for China, and by Crow and Silver for the United States.

In China, Xu shows that although there have been “remarkable achievements in engineering education ... some “urgent problems [remain] to be settled so as to meet the demands of economic and social development.” His list of problems is daunting, and one that is all too familiar to the Americans trying to reform the US system. He deplores that, for instance, “the disciplinary integration is undesirable,” and “some outstanding teachers tend to focus on R&D projects, caring little for [engineering] education.”

It is much the same pattern in India. Raghavan explains that India “is trying to clear the disarray in its university system ... and many research institutes have shown accelerated aging.” In the lower grades of K-12, shortages of schools and faculty are severe; in rural areas, girls do not get the education they need and want.

Michael Crow and Mariko Silver undertake an extensive, panoramic review of US trends. They provide ample evidence for rapidly changing circumstances and they emphasize “transnational networks of prolific cooperation and intense competition that can ... transform national education policies and practices.”

All of the authors focus largely on contemporary circumstances, giving only hints about the historical backdrop. Yet is clear that, for instance, Confucian influences in China, British colonial actions in India, and the decentralized public/private base in the US, have both caused and constrained the current situation. Profound historical decisions and precedents have created rigidity. For example, John King Fairbank, discussing the long-standing traditions of “the scholar” in China, notes that “the Chinese student traditionally memorized the classics before he understood them” and that “people who worked with their hands [i.e., in technology] were not scholars” [18]. Percival Spear, outlining the early nineteenth-century birth of India’s educational system, emphasized that in 1835, “the decision to launch English education and Western knowledge into India (was) unique in colonial annals in Asia to that time” [19].

In the United States, many forces have affected the educational scene: Thomas Jefferson’s dedication to public education as the base for democracy; the 1862 law creating land grant universities; post-World War II decisions and post-Sputnik surges (as Lane outlines in his paper) in support of training graduate scientists and engineers; bristling critiques of America’s K-12 education system by national commissions during the 1980s and 1990s. Over time these powerful forces produced sprawling directions, multiple purposes, fractured governance, uneven standards, and, despite the cries, paradoxically the result has been descending performance of students—in short, a “rising tide of mediocrity,” in the words of a brilliant report of 25 years ago [20].

Readers should recall the enormous progress in China and India: the numbers of graduates at all levels have risen by large margins, high standards have been imposed, and world-class goals have been set for the next decade or two. Rapid economic growth continues to fuel increased investments in education as sharply rising demand for human capital accompanies modernization. In contrast, the United States has experienced, in Lederman’s words, “a colossal failure to implement” the astute recommendations offered over recent decades by leaders who assessed American failures in math, science, and engineering education. To be sure, innovations still abound in the US, productivity still rises, and Nobel prizes still come frequently. But complacency and routine seem to be replacing verve and competence in science education, especially in American elementary and secondary schools. Crow and Silver touch these past failures when they say, “the US has not adequately enhanced its math and science education standards in step with the technological advancements of the world.” Looking to the future of universities, they point to America’s international networking and the push “to establish [US] programs and facilities around the world on an unprecedented scale.” Hence, they imply a lower priority on national reform in the US, whereas the Chinese and Indian authors emphasize change and investment within their rapidly developing societies.

8. Two more perspectives

Inevitably, any multi-author ensemble accidentally shortchanges a few significant topics. I briefly outline two such subjects here: energy and the environment, and population growth and demographics. Each affects all three countries, and each challenges the global scientific and technological communities.

8.1. Energy and the environment

A summary from the OECD/IEA’s World Energy Outlook for 2007 is sobering:

China and India are the emerging giants of the world economy and international energy markets .... Current policies [mean that] the world’s energy needs would be well over 50% higher in 2030 than today .... These trends lead to increased reliance of consuming countries on imports of oil and gas—much of them from the Middle East and Russia
China, India, and the United States will continue to depend for a long time—yes, a very long time for sure—on fossil fuels to ensure their economic growth. Certainly, decades will pass before the stock of oil and coal-fired plants can turn over. And China and India are expected to account for about 45% of the estimated increase in global demand [21]. Moreover, consider the risks to the climate from carbon dioxide emissions [22]. Whatever degree of skepticism or conviction one holds with respect to the feasibility of soon mitigating the effects of the dire projections of global warming, one also knows that demands for energy will remain durably dominant, even if prices for oil, gas, and coal soar [23]. Even conservation has its limits.

Dampening economic growth by taxing or capping/trading carbon is daunting for politicians, and the general public, to consider; hence, so far, that path has been virtually intractable. For this reason, Europe and the United States are cautious. China and India care, in principle, about the future of their environments—and the world’s—but for now, their higher priority is economic development. They said so at Bali. Yvo de Boer, a UN official who helped to manage climate treaty negotiations in Bali, Indonesia, said: “Developing countries are making it very clear that it’s inconceivable for them to accept legally binding targets” [24]. Thus, global hopes for meeting energy demands appear to depend on hope for innovations coming from the S&T community. For example, can the nuclear industry attract the enormous capital and trained staff needed to affect a rescue? It would require ensuring effective designs, driving down construction costs, increasing operating reliability, and gaining public acceptance of waste disposal. At the moment, the obstacles to meeting those goals are formidable.

Along another line, can carbon sequestration technologies improve sufficiently, and soon enough, to enable cost-effective expansion and operation of new coal-fired plants? Renewables, as Jesse Ausubel discusses cogently, “are not green” because “to reach the scale at which they would contribute importantly to meeting global energy demand, ... wind, water, biomass cause serious environmental harm” [25].

Making things worse, collateral environmental damage is an enormous consequence of the pell-mell expansion of energy sources required for enhanced economic growth. Mark Schaefer’s paper considers the staggering demands for water as one example of a global environmental agenda that China, India, and America must face.

Urgent problems face China. Elizabeth Economy’s analysis of China’s so-called “Great Leap Backward” is blunt: “water pollution and water scarcity are burdening the economy; rising levels of air pollution are endangering the health of millions of Chinese, and much of the country’s land is rapidly turning into desert” [26, p. 38]. She adds that Pan Yue, Vice Minister of China’s State Environmental Protection Administration, is aware (as are most Chinese) that “the [economic] miracle will end soon because the environment can no longer keep pace” [p. 47,25,26]. For example, according to varied sets of data compiled by Economy, “Fully 190 million Chinese are sick from drinking contaminated water. All along China’s major rivers, villages report skyrocketing rates of diarrheal diseases, cancer ... and stunted growth” [p.47,26,27].

India has fewer such problems now. But as it drives ever faster in its industrialization—and burns ever more coal—the consequences observed in China now, and across the United States for the past century, are almost certain to emerge in India. A recent survey of cities said, for example, that “choking on fumes, Kolkata [India] faces a noxious future” [28]. Accordingly, environmental issues likely will become contentious in India’s fractious Parliament, and the S&T community will be called upon to help resolve them—just as such issues are already adding stress to Chinese politics.

### 8.2. Population and demography

Observers occasionally say, “demography is destiny.” Since talent presumably is distributed uniformly, China and India—each with roughly three times the population of the United States—are bound to develop genius in every field, and great innovators in science, engineering, mathematics, and medicine. What can be said about how demographic trends and governance might affect human capital vis-à-vis the vitality of a nation? The data in Table 4 trigger questions.

According to Nicholas Eberstadt, China’s draconian birth control policy—the “one-child policy” started in 1979—will lead to a “prolonged decline” in the number of 15 to 64-year olds beginning in 2015. He emphasizes “this presages a radical change in China’s growth environment from the past quarter century (1980–2005) when the country’s working age population expanded by over 55%” [30,31]. Moreover, there will be a dramatic increase in the number of senior citizens in China, “from about 100 million to 235 million or more,” says Eberstadt [30]. His estimates are not guesses; the trend seems

<table>
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<td><strong>Population demographics—2003–04</strong></td>
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<tr>
<td>Population under 15 (%)</td>
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<td>Population over 60 (%)</td>
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<td>Fertility rate (est)</td>
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Source: [29].
inevitable. And it will have implications—mostly, it seems, grave ones for the Chinese traditions of family and for China’s expectations of sustainable economic dynamism.

Chinese officials are aware of this trend. So exceptions to the “one-child policy” occur, permitting larger families in some places and experimenting with alternative policies on a pilot basis in other places. But the well-recognized effects of an aging workforce cannot be disregarded. The workforce probably will decline around 2020, and a broader welfare net will be needed for the elderly. Quite simply, all of this will have to be managed with fewer workers earning the funds to support the rising elderly population. Since pressures on the educational and environmental systems are already large, dealing with these rising social challenges would be even more burdensome should the child-limiting doctrine be relaxed substantially.

In contrast, India’s profile is that of a youthful population: 50% more people under 15, and 30% fewer over 60, compared with China; a higher (if declining) fertility rate; and an increasing workforce that receives more, albeit less universal and rigorous, education. For India, however, presently suffering from low literacy rates and concerns about employment for the under-skilled, its demographic trends are also worrisome. Capital-intensive industrialization in India evidently is not absorbing labor. Vast new investments in educational institutions, already underway, and reforms to create greater mobility of the labor force, will need to be a priority for decades in order for India to achieve higher productivity.

For the United States, trends in population distribution by age, and its bearing on prospects for economic vitality, do not seem to be on the cusp of immediate, large, and risky changes. Nonetheless, over the coming decades there will be controversy about reforms in the health care system (to reduce its share of the GDP), an overhang of large obligations to retired citizens, and persistent calls on the public sector to sustain America’s longstanding openness in immigration policy while enforcing border security. All these are hotly divisive topics in the 2008 presidential election campaign. Moreover, better education of a workforce—capable of competing globally—remains a dispiriting legacy of unmet hopes and a probably expensive imperative.

The changing size and composition of each nation’s population confront leaders with wrenching choices about how best to craft effective social and economic policies, short term and long. R&D and educational strategies always must be aimed at creating the means to achieve the goals set. For instance, biomedical research—perhaps in international projects—will produce new devices, new surgical interventions, and new drugs to maintain a healthy workforce and ease the burdens of aging populations.

9. Snapshots: society, culture, and innovation

Understanding history is difficult; making accurate global predictions is impossible. But a few conjectures are hard to resist. As a chronic (amateur) India-watcher and China-watcher for three decades, an S&T policy analyst, and an R&D executive, my aim here is to stimulate rather than pontificate.

One tough question, for example is it possible to fathom the ways in which different “cultures” nurture effective “innovation”? I surround both key words with quotation marks to give ample room for alternate definitions. Over several years, the World Economic Forum has assembled experts to combine 12 criteria—ranging from macroeconomic stability and higher education to technological readiness and business sophistication—to arrive at a single index of a nation’s competitiveness. Table 5 gives the resulting rank order for 2007–2008. In a comparable, yet distinctly independent assessment, the Heritage Foundation and the Wall Street Journal brought together specialists to use 10 measures—ranging from trade freedom and property rights to freedom from corruption and labor freedom—to create an index of a nation’s “economic freedom.” The table lists these rankings for 2007. For comparison, data for a few other countries also are provided.

These data back up widespread perceptions. Most observers regard the US as freer and more competitive than other countries (only Hong Kong, Singapore, and Australia rank higher on the Economic Freedom Index). And most observers see China as “more competitive” than India, and India “freer” than China.

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<tr>
<th>Table 5</th>
<th>Ranking countries by competitiveness and economic freedom</th>
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<tr>
<td>Global competitiveness index 2007–2008 Rank</td>
<td>Index of economic freedom—2007 Rank</td>
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<tr>
<td>US</td>
<td>1</td>
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<tr>
<td>India</td>
<td>48</td>
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<tr>
<td>China</td>
<td>34</td>
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<tr>
<td>United Kingdom</td>
<td>9</td>
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<tr>
<td>Japan</td>
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<td>Germany</td>
<td>5</td>
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<td>France</td>
<td>18</td>
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<tr>
<td>Mexico</td>
<td>52</td>
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<tr>
<td>Italy</td>
<td>46</td>
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<tr>
<td>Brazil</td>
<td>72</td>
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<td>Russia</td>
<td>58</td>
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Sources: [32,33].
These measures also help to document recent trends. For example, during the past 13 years, the Economic Freedom Index strongly suggests that “countries that increase their levels of freedom experience faster growth rates” [33, p. 6]. As China and India opened their economies during recent decades, their growth increased. Because this process is continuing, despite steep resistance in some instances, I believe that both countries will become even more competitive, and as part of their strategies, both will invest more in science and technology.

This is not the place, and I am not best qualified, to explore, using a combination of economic theory and empirical cases, the manifold dimensions of “competitiveness,” where it originates, and how it is nurtured or stifled. Nonetheless, in a volume such as this, which considers most perspectives on the three nations’ science and technology, I believe it is the place to emphasize that “the relative importance of technology adoption for national competitiveness has been growing in recent years, as progress in the dissemination of knowledge and the rising use of information and communications technologies have become increasingly widespread” [32, p. 5]. The American Council on Competitiveness prepares an index each year that monitors US trends and compares them with global data from many countries. Their path-breaking efforts have been a candid and quantitative wake-up call for government, labor, universities, and industry [34].

Many countries are struggling with questions of how to be more competitive as demand surges in the open marketplaces for knowledge, products, and services. In some countries, the question is: will there be enough freedom for talent to thrive in global scientific, engineering, and educational communities, and over many decades? Canadian Nobel Laureate chemist John C. Polanyi had this in mind on July 4, 1997—at the time of the turnover of Hong Kong to the China—when he told a Hong Kong audience, “Science is devoted to testing current orthodoxy in order to see whether it can be improved” [35]. Whenever centralized systems resist challenges to orthodoxy, when they block the nourishing flows of debate, innovation tends to be sluggish, threadbare.

Another “cultural” enemy of innovation is the headless nails (hard to remove!) of obsolete regulation, administered by a complacent and cocksure bureaucracy. This may be complicated or caused by a residue of fatalism or determinism having socio-religious roots. Nations then must wake up and then shake up their systems to combat these problems. India did this in 2007 when a distinguished national commission, after a self-study, decreed “excessive government regulation” and an inability to develop “a sustainable model for continuous innovation” [36].

Before closing these short notes on China and India, I must point to the value of appreciating a longer historical perspective. For instance, consider this striking comparison by Alex von Tunzelmann in the opening to her recent book on the end of the British Empire:

In the beginning there were two nations. One was a vast, mighty and magnificent empire, brilliantly organized and culturally unified, which dominated a massive swath of the earth. The other was an undeveloped, semi-feudal realm, driven by religious factionalism and barely able to feed its illiterate, diseased, and stinking masses. The first nation was India. The second was England. The year was 1577 .... [37].

Another vivid example concerns the morning of June 21, 1629 when an eclipse was expected. In China, the Imperial astronomers predicted that the eclipse would occur at 10:30 and would last for two hours. The Jesuits [in Peking] forecast that the eclipse would not come until 11:30 and would last only two minutes .... 10:30 came and the sun shone in full brilliance .... At 11:30, the eclipse began and lasted a brief two minutes .... [As a result], the door of China was opened to the science of the West.... At the very moment when, in Rome, Galileo was being tried by the Pope for his heresies, Jesuits in Peking were preaching the Galilean gospel. [38, p. 62]

Over several hundred years, national doors open and close, sometimes abruptly. Nations make choices about tradeoffs between change and order. Religious, political, and other restraints control the directions of change (“progress”) that tilts the balance. Neither inherent scientific capacity nor proud technological competence—alone or together—determines the long-range outcomes.

Now for snapshots of the United States. As I write this in February 2008, the country shows angst. For the public, perhaps foremost are bitter debates about the causes of economic downturn, the war in Iraq, jobs, health care, and increasing diminution of the world’s respect. A surprising number of Americans doubt the compelling evidence for the science of evolution; that attitude is impossible for scientists to swallow. Others question the value of the most basic research in, say, particle physics; that choice of spending the taxpayers’ money is certainly worth debating, but the public is not patient about listening to the rationale. Competition is up, and morale down, at many research universities; that is attributable mainly to the squeeze on talent and money.

But for much of industry and academe, the strategic issue is broader: “we fear the abruptness with which a lead in science and technology can be lost ....” and “the nation must prepare with great urgency to preserve its strategic and economic security” [39].² This persuasive call impelled President Bush and the Congress to craft large initiatives across the physical and engineering sciences. However, a suddenly crimped federal budget did not encompass the expected funding for 2008 and the anticipated funds may well not come in 2009 [40]. Recently, almost all significant, sweeping policy

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² This report, from the National Academies, along with earlier and later assessments by the Council on Competitiveness, led to President Bush signing HR 2272, the America Competes Act, on August 9, 2007. However, by January 2008 the funding had not been appropriated, as documented by the AAAS report of December 20, 2007.
recommendations, such as from a bipartisan commission proposing trenchant and urgent reforms in American foreign assistance, are on hold as the presidential campaign rolls into high gear [41]. Science and technology, in short, are often taken for granted in the US and likely will not be a central theme in the presidential debates.

The present American mood reflects an underlying ambivalence about global change. Was Samuel Huntington correct about the coming of a “clash of civilizations”? [42]. If so, could a hybrid form of isolationism (after all, this was the enduring value of America’s founders) become the national response? Could such a less active global role for the US be combined wisely with the necessities of international commerce and the urgencies of humanitarian actions? [43] How could such a hybrid be formed and sustained? Who would lead, when called, to protect global order with high-tech tools? What would be the future shape of scientific, political, and economic internationalism for America—still the sole superpower—as global challenges grow?

10. A final note

By 2008, nagging questions about China, as sharply posed by Sinologists a generation ago, have been answered. For example, Robert Oxnam, formerly President of the Asia Society in New York, asked a deep question in August 1977: “can the (Chinese) scientist be both ‘red and expert’? How extensive a scientific establishment does China really need to achieve basic modernization goals?” [44]. These pressing questions were puzzling during my first trip to China, not long after the Cultural Revolution ended and the Gang of Four fell. Today, those queries seem quaint. Decisions were made, and China’s determined answers are: expertise is indispensable, and ideology is (almost) irrelevant to economic development. The unprecedented success of the pragmatic commitments imposed 30 years ago sweeps away most doubters and dissenters.

Yet freedoms in China remain constrained. This constraint can be a major brake on discovery. My observation is not just technocratic, concerned only with science and technology or with the openness long proven to be the core of economic growth. The constraint carries moral weight. As Reinhold Niebuhr said: “Man’s capacity for justice makes democracy possible; but man’s inclination to injustice makes democracy necessary” [45]. Openness matters—in innovation, in education, in all realms of scholarship and the arts, and in debates about progress within politics. Ongoing Chinese experiments will reveal whether their distinctive adaptations are fruitful.

Similar crosscurrents buffet India. No longer frustrated by decades of doldrums characterized in the gritty humor about a “Hindu rate of growth” (1% or perhaps 3% per year in GDP), India is on a roll, emboldened by 8–10% GDP growth, and famous for the soaring success of its IT industry. Drawing on the power of economic liberalization introduced by Finance Minister (now Prime Minister) Singh and others in the mid-1980s and early 1990s, India has earned worldwide respect in many S&T-intensive fields. Yet, a recent OECD report on India, generally positive, emphasized that “social policies should be improved to better reach the poor and—given the importance of human capital—the education system also needs to be made more efficient” [46]. As noted above, the World Bank said, “despite pockets of innovative activities in both the formal and informal sectors, innovation remains concentrated in a small segment of the economy ...” [15].

Cynical observers say about the United States that “nothing recedes like success.” I do not agree. Pessimism does not dominate the American DNA. The US has a mobile workforce, remarkable productivity, great research universities, deep reservoirs of capital, unusual technological impatience—a formidable combination with which to navigate the 21st century’s global commons.

Any volume that aims to cover China, India, and the United States is brave—so brave as to seem rash. And I am keenly conscious of the limitations in my own contribution. Still, as the historian of India, Percival Spear, commented on his own voluminous work: recall the vicar who modestly said of his porridge, “It’s pretty good, what there is of it; and there’s quite a lot of it, such as it is.”

Acknowledgments

I thank George Schillinger, Managing Editor of this journal, for his generous and unflagging insight, grace, and efficiency in assembling this special issue with our resourceful and experienced colleagues, William Blanpied and J. Thomas Ratchford. I am also grateful for the patient and reliable assistance of Mary Jane Zimmermann and Mary Kate Zimmermann in preparing my manuscript. Finally, I wish to honor my friend and colleague, Joshua Lederberg, who passed away in February 2008 before he could complete a paper for this volume, and with whom I happily debated many issues of science and the world for the past 30 years.

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