The Indian Technology Century – How Close is it to Happening?

Invited Paper

Thirtieth Annual AAAS Forum on
Science and Technology Policy
Washington, DC
21 – 22 April 2005

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I would like to thank AAAS for giving me the opportunity to address the Thirtieth Annual AAAS Forum on Science and Technology Policy
on what I believe is an exhilarating topic: The Indian Technology Century – How close is it to happening? We have already caught glimpses, in yesterday's sessions, of some of the issues I will be dealing with today.

You are leaders, actors, and spectators in the drama of global change. China and India, as you shall see from my presentation, may soon be lead locations where this drama will play out.

We are witnessing an unprecedented autocatalytic economic rise in East and South Asia. India is perfecting "knowledge process outsourcing" or KPO as a revolutionary work paradigm. Industrialization is well under way in China, which now sustains double-digit economic growth.

A December 2004 National Intelligence Council's 2020 Project Report titled "Mapping the Global Future" indicated some of the demographic trends in the world at large. One may ask: Where will 100 average global dwellers in the year 2020 come from?

56 will come from Asia with 19 Chinese, and 17 Indian,
16 will come from Africa with 13 from Sub-Saharan Africa,
7 will come from the "New" Europe and from the former Soviet Union,
5 will come from "Old" Europe,
3 will come from the Middle East, and,
13 will come from the Western Hemisphere with only 4 from the U.S.!

The numbers speak for themselves. Aging and slow growth populations challenge countries with heretofore-strong economies. Billion-plus demographics and economic growth, coupled with global connectivity suggest a possible China and India global economic leadership that will make the rise of Japan, Taiwan, and Korea pale in comparison. Moreover, substantial migrations have already seeded the world with Asian business acumen.

I have had the good fortune to view first hand the Chinese and Indian economies, from a science and technology, environment and health perspective. I served in China from 1993 to 1997 as Science Counselor at the U.S. Embassy in Beijing. Since 2000, I have been the Science Counselor at the U.S. Embassy in New Delhi, India.

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Some folks predict the 21st century will be the Indian Technology Century. Is it happening? Can this really happen? Does India have the ability to make it happen?

China and India dominated world trade up to the early nineteenth century. British mercantilism, the Industrial Revolution and Victorian quest for empire brought their dominance to a close. In addition, domestic political turmoil, misguided policies and cultural resistance suppressed S&T and economic development in China and India. Thus, one and a half century of gradual impoverishment followed.

In China, a one and a half century hiatus began with the Opium War and ended with the economic reforms spearheaded by Deng Xiao Ping in the 1980s. In India, over the past two centuries, colonial rule and post-Independence Indian policies that favored autarchism stunted India's development.

In the 16th century, Babar, the first Mughal Emperor and a descendant of Genghis Khan declared: "India is a populous country with a large number of people who go to the market place where everyone is innovatively engaged in a creative pursuit to make, build or sell products." This reference underscores the fact that India has ingrained in its society the very pillars of successful business enterprises and the ingredients of a vibrant economy: making, building and selling.

Why then is India still poor, with about 300 million of its people living on less than one dollar a day, and an additional 300 million living on less than two dollars a day? Is it a fallacy to think that India could lead a technology century under such circumstances?

Looking deeper, there is perhaps a missing variable in Indian earnings that the calculation on poverty does not include. Such a variable would embody the villages of India. There, wealth is still counted as animal herds or stored grain in household granaries. Work performed is still paid "in kind" rather than in rupees or dollar bills.

Besides, there are vibrant, self-sustaining entrepreneurs in India that prolifically develop cheap ingenious technological solutions to everyday problems. These entrepreneurs buffer those who we perceive in India as poor. Assessing a value to the contributions of these entrepreneurs to the Indian economy is exceedingly complex. Thus, there exists a severe mismatch between quality of life as perceived in rural India and the definitions of poverty as we dollarize them. Let me add a corollary trait that Babar did not mention: the Indian ability, driven by necessity, to constantly improvise and fix.

For the first forty years after independence in 1947, India developed a self-reliant, import-independent, and export-indifferent economy. By the late eighties, India achieved food self-sufficiency and developed space and nuclear technologies. India also laid the foundation for pockets of excellence in higher education. Institutions nurtured during this period produced well-trained graduates in engineering, science and medicine who could compete globally.

These strong institutional frameworks, and the large intellectual capital that they produced, which by and large the Indian economy could not absorb in the early days of the republic, would serve India well in the post-1991 reform period.

In the name of self-reliance, during these first forty years, the state parceled out quasi-monopolies to state enterprises and industrialist families. With little or no competition to improve product quality, innovation in India ceased. Without innovation, the Indian economy could not grow. Thus, the Indian economy could not fully absorb the graduates that the educational system was producing. This led to a wave of migration of top-notch graduates from Indian universities mainly to the U.S., the U.K., and Canada.

Many of these graduates were destined to become top producers and leaders in their fields. As the bulk of creativity often resides in the minds of a few talented individuals, this mass migration of talent intellectually impoverished India and enriched principally the United States. This migration of Indian science and technology talent may have contributed in a significant measure to the dramatic increases of productivity the U.S. witnessed in the 1990s.

In the auto sector, modernity lay dormant in India during the self-reliant economy period. Indian customers had no opportunity to question the design or performance of India's beloved icon: the Hindustan Motors "Ambassador" car, a derivative of the Morris Oxford. Padmini taxis that still ply Mumbai roads derive from a late- 50s Fiat 1100 model. The mid-50s Willys CJ-5 Jeep, produced by the Mahindra clan, is still a ubiquitous workhorse on rural Indian roads.

The 1959 Datsun 310 Bluebird was a breakthrough model for Japan's Nissan Motors in the U.S. market. Ironically, it had the same Morris Oxford ancestry as the Ambassador car in India! The power of markets to drive product improvements is so large that the evolutionary gap between the slick descendants of the Datsun 310 Bluebird and Ambassador became unbridgeable.

In May of 1991, Prime Minister Rajiv Gandhi was assassinated. Narasimha Rao, the new Prime Minister, and Manmohan Singh, his Finance Minister, (who also happens to be India's current Prime Minister), introduced rupee convertibility, liberalized trade restrictions, broadly liberalized foreign and domestic investment, and raised ceilings on foreign equity holdings and technology licensing. These revolutionary measures revitalized a broken and stagnant economy. They reduced costs for consumers, reduced input costs to industry, reduced production bottlenecks, and above all, increased competition.

Singh's iconoclastic and sweeping economic reforms benefited the automotive sector first. Foreign Direct Investment (FDI) and the opening of markets to imports (albeit with high tariffs) triggered dramatic improvements in Indian automotive technology. Innovation, competition and variety added dynamism to the marketplace. Local manufacturers learned new skills and raised standards.

In India, just like in China, foreign auto manufacturers soon discovered that despite small internal markets, new designs and know-how allowed domestic component manufacturers to supply better components, at lower costs. In this manner, FDI-investing manufacturers roped high quality, low-cost, domestic component suppliers into their global supply chain.

Locally manufactured foreign brands (Ford, Suzuki, Hyundai, Honda, for example) raised the standards of the Indian former automotive monopolies. India's Tata Motors, a monopoly truck manufacturer, now produces sub-compacts that are competitive internationally. Ford India exports the Ikon, which was originally intended for the Indian market only. Even the "new" Ambassador now meets customer demand for a quaint, nostalgic yet modern, retro look.

Market integration has spawned new relationships. In August 2002, in preparation for production, Chang'An Ford in Chongqing, China began importing components from Ford India suppliers. To start up manufacturing operations in February 2003, Chang'An Ford trained Chinese workers on its Ford India production lines in Madras.

Cummins Inc., the Columbus, Indiana-based diesel engine maker, recently opened a product research center in Pune, India. There, Indian engineers work on complex 3-D models to analyze ways to make more efficient combustion systems in engines that meet tightened emission standards. While Cummins carries out engine design in Columbus, Indian engineers in Pune optimize performance through computer analysis. In the words of a business reporter, "For companies like Cummins, the ability to use computers to streamline operations, speed product design and improve technical communications, may spell the difference between success and failure in the information age."

India was a country that until the early nineties could only produce road dinosaurs that were available to those who were fortunate enough to join a queue and wait. In just a decade, India became a full partner in the development of cutting edge technology for internal combustion engines. Such engines power eighteen-wheelers on American roads and Indian small cars are now ready to ply global roads.

How did this happen?

During the 1990s, a quirk in the development of technology turned the earlier loss of intellectual capital into a deferred intellectual capital gain. As U.S. industry scrambled to make legacy computer programs Y2K compliant, the bright emigrant minds that had reached positions of authority in U.S. enterprises quickly began taking advantage of the ability of Indians to produce and fix things at home. Indian engineers began to produce quality software patches in a timely and cost effective manner to keep those U.S. legacy systems running beyond Y2K.

Thus India, who unlike China had not yet become a manufacturing base in the 1990's, quickly became a competitive source of intellectual content, through production of unbranded software components for export.

India had stumbled into a new production model for intellectual goods that gave rise to a reconfiguration of the global economy.

A combination of benign neglect and active encouragement from a traditionally intrusive government helped. A steady, annual supply of 120,000 science and engineering college graduates from the more progressive and business friendly western and southern regions of the country provided the human capital for the natural growth of the Indian software component industry.

An explosive implementation of intercontinental fiber optic links and protocols for efficient, error free point-to-point transfer of vast amounts of compressed data files held the key to this reconfiguration. The cost of transferring data now is a minute fraction of the value of the product the data represents. Thus, this work methodology, for the first time in human history, allowed multiple minds across different continents to simultaneously add intellectual value to a product.

Leading innovation firms that control the intellectual property, standards, and technological architecture of high value added products in the international economy then coordinate and integrate these components electronically.

Jack Welch, the General Electric (GE) CEO realized that abundant talent in India could provide GE with more intellectual capital per dollar, just as it did for software enterprises in the U.S. Welch thus established a research laboratory in Bangalore, India at the turn of the millennium. This 2,300-employee laboratory, now known as the John F. Welch Technology Center, is GE's largest multidisciplinary R&D location in the world. In China, GE is not far behind as it launched a GE China Technology Center in Shanghai in late October 2003

About 700 employees joined GE Bangalore after working in the U.S. for three or four years. The GE Bangalore laboratory thus represents India's hope that its educated diaspora may return home. These returnees may encourage other talented individuals to remain in India rather than emigrate. Should a rapid expansion of India's industrial base take place, laboratories such as the GE Bangalore operation could become a cradle for further professional development of highly trained and highly disciplined personnel. These personnel could spread innovation to every corner of India, just as GE executives populated the leadership ranks of corporations in the U.S.

GE and Cummins are not alone in their desire to tap Indian talent within India. Other companies, including IBM, Oracle and Microsoft, are following in their footsteps in the search for global competitiveness. By improving corporate global reach and productivity, companies can sustain profits and position themselves to support higher paid employment in the United States.

Can satellite research and development facilities, tens of thousands of miles away from production plants, maintain vitality? Much will depend on the ability of India's physical and intellectual infrastructure to sustain an exponential growth of the global collaborative enterprise. India is at the very end of a long supply chain. Thus, management of complex experimental and production technology research and development, where not only ideas and data but also equipment and people must be mobile, will be a challenge.

Engineering design and project implementing companies like Fluor and Bechtel, for example, have been engaged in distributed execution of complex designs long before the concept globalization gained currency. The experience of these companies is that it is economically equally challenging to manufacture or erect an Indian design in the U.S. as a U.S. design in India. Why? Because costs of labor and capital, skill set, tooling, and capitalization of industrial facilities differ widely. The same applies to product designs that incorporate vendor-supplied components. In these designs, optimization of product cost depends on component performance, cost, and availability. In assessing all these issues localization is the key.

Let us now turn briefly to biomedicine.

In biomedicine, more so than in other fields, the 'brain drain era' of Indian expatriate scientists quickly became a "core" which played a key role in the development of Indian scientific institutions. There are now multiple centers of excellence in India where scientists conduct molecular, biological, immunological, and clinical investigations in infectious and chronic diseases, many in state-of-the art laboratories. India's biotechnology industries are engaged in developing indigenous vaccines, monoclonal antibodies and other biological products for human and veterinary use.

More than 300 college level educational and training institutes offer biotechnology, bioinformatics, and biological sciences instruction. India graduates annually 500,000 students in these disciplines. 100 medical colleges churn out 17,000 medical practitioners per year. India produces about 300,000 post-graduates and about 1,500 PhDs who qualify in the bioscience disciplines.

India's pharmaceutical industry has witnessed phenomenal growth. The Indian Patent Act of 1970, which excluded patents on products such as pharmaceuticals and foods, fueled this growth. Virtually freed from Intellectual Property Rights protection restraints, Indian firms began producing large volumes of pharmaceutical products for domestic Indian markets that incorporated intellectual property belonging to others. India's industrial base began supplying specialty chemicals, pharmaceutical compound precursors, and eventually reverse-engineered "generics" to the rest of the world.

The IT industry, the automotive sector and industrial research centers, are examples of innovation that the biotechnology and pharmaceutical sectors in India want to emulate. These sectors view themselves as the source of enabling technologies that can transform agriculture, health care, industrial processing and environmental sustainability.

Success will depend on India's implementation of the 2001 TRIPS agreement. WTO signatory countries must now provide patent protection in all fields of technology, to products as well as processes, and establish a uniform 20-year term for all patents, regardless of the social cost and benefit from the patented innovation. To comply by January 1, 2005, India promulgated a Patent Ordinance on 27 December 2004, and the Patents (Amendment) Act, 2005 on 4 April 2005.

These policy developments, combined with a wealth of intellectual capital, may position India to become a global partner in the development and testing of drugs, vaccines, diagnostic products, and devices for infectious and chronic diseases.

There is an expectation that after full compliance with WTO obligations under the TRIPS agreement, India will attract and earn one billion dollars from clinical trials in the next five years. New drug discoveries may very well follow.

However, success of the freewheeling IT sector may be harder to reproduce. The economic potential of Genetically Modified Organisms places a premium on intellectual property protection in academic collaborations. Such premium may cause friction in academic settings and slow down the pace of scientific research. Concepts that once were the domain of academic departments now have become the domain of business development cells of U.S. universities and some research institutions in India. At a minimum, the concept of the VIP (vials-in-pocket) scientist is quickly becoming a thing of the past.

In addition, biotechnology and drug product development require capital-intensive laboratory and production facilities. Reliable power is not universally available in India. Field trials are expensive. The health infrastructure to support them, while improving, remains inadequate. Environmental contamination in India challenges "clean" facilities. Thus, large-scale diffusion of biotechnology and nanotechnology, which requires capital in a global scale, is likely to remain out of reach in India, except for a very limited number of enterprises that have the deep pockets to afford it.

International collaboration in science, as a public good, is a key component to dynamic knowledge creation. This collaboration still constitutes an enabling share of scientific research. Science remains a tool to improve international relations and, increasingly, foreign policy has a scientific bent as science becomes more international in its research interests and practices.

While I touch upon international collaboration in science and its role in India's ascent to technological competence, perhaps I should draw your attention to the historical role U.S. PL-480 funds played during the last three decades of the 20th century. These funds, proceeds from the sale of excess agricultural commodities to India, provided a strong foundation for Indian science. Often during my mission in India I have heard: "Anybody who is somebody in contemporary Indian science, at one time or another has been touched by PL-480 science funding." Perhaps a laboratory? Some equipment? A teacher? A collaborator? A travel grant?

The Indo – U.S. Science and Technology Forum (Forum), a progeny of PL-480 science funding, is the standard-bearer of the 21st century U.S. – India bilateral science relationship.

The Forum's mission is to underwrite the wow!! in U.S. - India science collaborations. This mission is quite similar to the mission of NSF in the U.S. With a bottoms-up approach, the Forum can choose and fund exciting collaborations. Thus, the Forum supports shared partnerships that encourage long-term bonds between scientists and institutions in India and the U.S. The Forum nurtures contacts between young and mid-career scientists so they can generate exciting, sustainable follow-on scientific collaborations. The Forum extends selective travel support to Indian and U.S. experts to attend invited international scientific events and for exploratory missions in either country.

Secretary of State Condoleezza Rice, in her March 2005 visit to India, conveyed to Indian Prime Minister Manmohan Singh that the United States would help India become a major world power. This marks the transformation of the U.S. – India bilateral relationship into a true strategic partnership. A new U.S. – India bilateral science and technology agreement is in the cards. The hope is that, in the not too distant future, a U.S. – India Bi-National Science Foundation will be in place, which will nurture the embryos of scientific collaboration conceived at Forum events. It too will be the descendant of the PL-480 program.

U.S. universities and institutions have touched the lives of many Indians, who have become leaders in their own fields. The current Indian President, A. P. J. Abdul Kalam, is one of them. The Institute of International Education tells us there are now about 80,000 Indian students and 70,000 Chinese students enrolled in US universities. Asian students so far have been better prepared and more motivated to undertake technical training in the U.S.

The future aspirations of these students are difficult to predict. A more robust "second wave" – back to their country of origin is very possible. Such U.S.-educated returnees might, just as their predecessors, have absorbed skills and, more important, values from us. With instant connectivity, returnees to India will be catalysts for even faster transformation of Indian society. They will also make India more competitive and faster, in a world that is already globalized.

A trickle of Indians returning from the U.S. has already set up their own firms. Will the trickle turn into a tide like it did in Taiwan and Korea? Very much will depend on the business environment and infrastructure that welcomes them and the degree to which the India body politic can bring vitality-sapping corruption under control.

Open innovation where ideas, people and products flow across national boundaries, company boundaries, and universities, could lead to a crisis or bring about new opportunities for U.S. industries. Innovation is a sport, global in character – set by rules that envisage cooperation as well as competition among firms and nations.

In open innovation successful companies that once ran their own research laboratories and spurned ideas developed elsewhere, now are collaborating and working well with others. The Web, e-mail and even toll-free calls now allow companies to listen to customers who come up with new products or new ways to use old products. Just as economies in the era of globalization depend for their health on a steady exchange of ideas and resources, so must big companies in the era of innovation. In this new era many of these inputs may come from India and China. Just think, development of software for avionics and heads up displays for U.S. fighter aircraft under contract in India? What was unthinkable maybe 5 years back is happening now. Just ask Honeywell, Boeing, Rockwell Automation, or Hamilton-Sundstrand.

The Indian Technology Century – How close is it? We have heard already about Thomas L. Friedman's book "It's a Flat World, After All." Friedman suggests that the world is now a "level playing field" and geo-economics are reshaping our lives – much faster than many people realize. How has all this been made possible? To quote Friedman, "Because we built this ocean crosser, called fiber-optic cable and now, you can plug into the world from India. … India could never have afforded to pay for the bandwidth to connect brainy India with high-tech America, so American investors paid for it."

The production revolution that is currently under way is perhaps just as significant as the Industrial Revolution. Microprocessors today are the steam engines of the 19th century. But, unlike the Industrial Revolution that left billions untouched in China and India for the better part of two centuries, this production revolution now has a global reach. The U.S., India and China are now on board the innovation train.

The President of India himself has addressed Indian audiences in a manner that befits a recent business school graduate. Addressing the PMI-Asia Pacific conference in Hyderabad, on April 15, 2005, President Kalam extolled the virtues of competitiveness, knowledge power, investment, return on investment, revenue, repeat sales, customer satisfaction, value of products, productivity, innovation, employee loyalty, sound project management and creative leadership. What a contrast with the India of Ambassador days!

In 2020, only 4 out of 100 world citizens will come from the U.S. Thus, the U.S. economy will have to find ways to run faster and better, just to remain in the race. The irony is that we may need to turn to India and China for help to accomplish this goal.

Will India and China be content to remain as building block suppliers? Or will they stake territory in innovation just like the Japanese, and now the Koreans have already in many technology endeavors? If one listens to President Kalam, it may be the latter. What would the consequence be if India were to provide China with the same level of knowledge process outsourcing as India now is providing US companies?

Could world trade dominance revert to Asia after an absence of two centuries? I would not discount it. Just remember how the manufacturing and innovation wildfire spread from Japan, to Taiwan, to Korea and mainland China. India's intellectual fuel contribution, coupled with a leadership of India commitment to innovation, could spread this wildfire throughout continental Asia.

Thank you for allowing me to share my thoughts with you.[2]

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[2] I gratefully acknowledge Dr. Nirupa Sen, a Foreign Service National colleague at our Embassy in New Delhi, for her contributions to this presentation. Dr. Sen, an astute observer of the Indian science and technology scene, has been my sounding board for many of the assessments I voice in this paper. AAAS provided a travel grant so I could present this paper in Washington. Jo Villemarette in the Science Office at our Embassy, MAH, and SAS wielded the editing scalpel with much skill and little compassion