

Executive Summary

India is increasingly becoming a top global innovator for high-tech products and services. Still, the country is underperforming relative to its innovation potential—with direct implications for long-term industrial competitiveness and economic growth. About 90 percent of Indian workers are employed in the informal sector, and this sector is often characterized by underemployment, as well as low-productivity and low-skill activities. Although India has the benefit of a dynamic young population—with more than half of the country’s population under 25 years old—only 17 percent of people in their mid-20s and older have a secondary education. To sustain rapid growth and help alleviate poverty, India needs to aggressively harness its innovation potential, relying on innovation-led, rapid, and inclusive growth to achieve economic and social transformation.

One of the unique features of this book is its focus on inclusive innovation—that is, knowledge creation and absorption efforts most relevant to the needs of the poor in India. This is in addition to the book’s emphasis on how faster growth can be facilitated by promoting “new to the world” knowledge creation and commercialization—the traditional understanding of the term *innovation*—as well as through often underappreciated but even higher-impact “new to the market” diffusion and absorption of existing knowledge.

To unleash its innovation potential, India needs to develop a three-pronged strategy:

1. India would benefit from increasing competition as part of efforts to improve the investment climate, supported by stronger skills, better information infrastructure, and more finance—public and private.
 - *Competition is vital to unleash innovation.* India must encourage stronger competition among enterprises. Since the Indian economy was opened up in 1991, the private sector has invested the most in research and development (R&D) in the sectors most open to competition. In 2004, enterprise R&D was more than seven times higher than in 1991. Recommended actions to spur competition include removing nonessential regulations and applying essential ones more transparently in product, land, labor, capital, and infrastructure services markets—for example, easing limits on small industries, restrictions on foreign direct investment (FDI), and barriers to import competition, as well as introducing bankruptcy reforms and modernizing the Industrial Disputes Act.

- *Limited skills and training are a major bottleneck.* Only 16 percent of Indian manufacturing firms offer in-service training, compared with 92 percent in China and 42 percent in the Republic of Korea. The Indian firms that provide in-service training are 23–28 percent more productive than those that do not. Moreover, gross enrollment in higher education is only 12 percent in India, compared with 90 percent in Korea and 68 percent in the Russian Federation. The skills bottleneck could be unblocked by providing public matching funds for firms to invest in training, increasing the fiscal and managerial autonomy of universities and colleges, and increasing private participation in higher education.
 - *Better information flows are needed.* India is already the world’s fastest-growing market for mobile phones, with the number of wireless subscribers jumping 55 percent in 2006. However, disparity persists between rural and urban areas: teledensity is 40 percent in urban areas and just 4 percent in rural areas. And while high-speed national research and education networks accelerate the pace of new discoveries and the expansion of knowledge, India’s connectivity is less than 1 percent of China, Korea, the United States, and European Union countries. Information-related actions could include expediting the allocation of radio and wireless broadband spectrums, increasing targeted subsidies for rolling out rural mobile and broadband, and agreeing on an organizational structure to deploy and manage a national research and education network.
 - *More early-stage funding is needed.* In 2005, just 13 percent of deals by venture capital and private equity providers were for early-stage funding. In dollar terms, early-stage deals accounted for even less of such investments: 4–6 percent. Cumulative start-up capital provided for seed financing in India is estimated to be \$25 million–\$35 million—enough for 75–100 start-ups, many fewer than the 450–600 start-ups needed. Finance-related actions could include facilitating regulations for early-stage venture capital investments, and government provision of leveraged returns for private investments in innovation areas overlooked by the market (such as rural industry and pro-poor, grassroots innovations) by creating a fund of funds—with distinct windows for pro-growth innovations and inclusive innovations—with venture capital funds managed by the private sector.
2. India would benefit from strengthening efforts to create and commercialize knowledge, as well as better diffuse existing global and local knowledge and increase the capacity of smaller enterprises to absorb it. If all enterprises could costlessly achieve national best practices based on knowledge already in use in India, economic output could more than quintuple.
- *Variations in productivity highlight the need for better knowledge diffusion.* Average enterprise productivity in finance, insurance, and real estate companies is nearly 23 times that in agriculture. But these industries account for only

1.3 percent of employment, while agriculture accounts for 60 percent. Actions to better diffuse existing knowledge could include increasing openness to trade and FDI, coupled with strengthening and expanding public support for technology at the cluster level and modernizing infrastructure for metrology, standards, testing, and quality (especially metrology). India could also consider strengthening its support infrastructure for technology licensing by creating a public-private technology acquisition fund, building on intellectual property that is already locally available.

- *Private enterprises need to increase R&D spending.* Aggregate domestic R&D spending has never exceeded 1 percent of GDP, and 75–80 percent comes from the public sector. However, between 1998 and 2003, multinational corporations spent \$1.3 billion on R&D in India—showing that its valuable assets could be exploited more effectively. Actions to spur private R&D could include consolidating and expanding public early-stage technology development programs, as well as developing a policy and action plan to use public procurement to promote innovation. Reforms to existing early-stage technology development programs could include establishing a streamlined matching grant program building on India’s Sponsored Research and Development program and Small Business Innovation Research Initiative—targeted mainly at smaller enterprises and promoting more collaboration.
- *New domestic knowledge needs to be converted to commercial use.* Of the top 50 applicants for patents in India between 1995 and 2005, 44 were foreign firms. Only six were Indian; three of these were public institutions and one, a public corporation. Just two were private Indian firms, both in the pharmaceutical industry. Actions to promote commercialization and strengthen links among industry, universities, and public laboratories could include providing support to technology transfer offices, creating a patent management corporation, developing technology parks and incubators, and improving India’s regime for intellectual property rights. India should also consider enhancing support for higher-risk technology R&D and commercialization by strengthening its New Millennium Indian Technology Leadership Initiative—including by opening the program to international collaboration and giving grants to both research institutions and private enterprises, with sharing of any resulting royalties. To further spur international collaboration, India could create a Global Research and Industrial Partnership program to promote advanced R&D and commercialization efforts conducted jointly by domestic and foreign enterprises.
- *The diaspora needs to be tapped more effectively.* About 2 percent of India’s population—20 million people—live abroad, where they earn the equivalent of two-thirds of India’s GDP. Actions to more effectively tap India’s overseas talent could include supporting a larger diaspora network, building on existing groups that aggregate this population’s talent and capital for use in India.

3. India would benefit from fostering more inclusive innovation—by promoting more formal R&D efforts for poor people and more creative grassroots efforts by them, and by improving the ability of informal enterprises to exploit existing knowledge. *Existing pro-poor initiatives need to be scaled up.* Inclusive innovation can play a critical role in lowering the costs of goods and services and in creating income-earning opportunities for poor people. The Council of Scientific and Industrial Research has developed technology applications for rural India, and university and formal private initiatives (such as e-Choupal and Amida’s Simputer) have delivered benefits. The National Innovation Foundation has a repository of more than 50,000 grassroots innovations and traditional knowledge practices. And a number of initiatives exist to help the informal sector better absorb knowledge. More favorable matching grant support for pro-poor early-stage technology development could significantly increase collaboration among public R&D entities, universities, nongovernmental organizations, national industries, and global networks. Increased support for grassroots innovators could be provided to the National Innovation Foundation to scale up impact. To leverage traditional knowledge into revenue, a policy-oriented intellectual property rights think tank could propose how to implement a cheaper intellectual property regime. Finally, successful technology upgrading programs could be extended to help informal and rural enterprises make better use of existing knowledge.

The action-oriented recommendations that form part of this volume’s three-pronged innovation strategy require a realistic, time-bound implementation plan. This may best be accomplished through a consensus-building process that includes a task force of Indian policy makers working with business and social leaders—who would be in the best position to set priorities among the recommendations and develop an appropriate sequencing of activities. To help capture the nation’s imagination, it may be desirable to focus on “grand challenges” such as access to clean water throughout the country or mitigating road congestion in cities. A light-touch public-private oversight mechanism may be required to evaluate and address the fragmentation of India’s current innovation system; encourage collaboration and facilitate streamlining of the system’s constituent programs, using public-private partnerships wherever appropriate; and monitor the achievement of realistic targets, with periodic international benchmarking as India’s innovation potential is unleashed. India’s successes with inclusive innovation will be of particular interest to other developing and emerging market economies also seeking to harness innovation for poverty reduction and economic development.

Overview: Toward an Action Agenda for Innovation

Mark A. Dutz

India's recent growth has been impressive, with real GDP rising by over 8 percent a year since 2004—accompanied by a jump in innovative activities. Growth has been driven by rapid expansion in export-oriented, skill-intensive manufacturing and, especially, skill-intensive services. For example, pharmaceutical firms such as Dr. Reddy's Lab have been pursuing a twin strategy of profiting from the production of generic drugs and investing in research and development (R&D) to discover new ones. Growth has also been fueled by increased local demand, backed by rising urban and rural incomes, and a sharp rise in savings and investment rates. Indian manufacturers have focused on delivering low-cost products to previously untapped markets by innovating to lower costs and create new delivery mechanisms—as with Tata Motors, which has promised to deliver a car, geared toward India's middle class, priced at less than \$3,000. Thanks to its innovations in outsourcing, Bharti Tele-Ventures offers some of the world's lowest telephone prices. And innovations in supply chains have integrated those at the bottom of India's economic pyramid, as exemplified by e-Choupals. These cyber kiosks, established in thousands of villages, have given farmers the power of information—eliminating middlemen and resulting in higher productivity and better prices for farmers.

Growth, accompanied by innovations, has been associated with rising living standards and a reduced number of poor people. However, despite pockets of innovative activities in both the formal and informal sectors, innovation remains concentrated in a small segment of the economy. Roughly 90 percent of the workforce is employed in the informal sector, which is often characterized by low-productivity and low-skill activities. Productivity is also low in most formal enterprises. Given this dualism in the economy, what can be done to strengthen the likelihood of sustained high growth rates and, in particular, to address the unmet needs of the informal sector and the poor? Innovation is crucial for increasing growth and can also help reduce

poverty. By applying knowledge in new ways to production processes, better and previously unavailable products can be produced with the same or fewer inputs—to meet the needs of all sections of Indian society.

This book provides action-oriented recommendations for India to unleash existing capabilities and build on its innovation potential, to help meet the dual challenges of sustained and inclusive growth. Sustaining growth is a challenge because of both intensified external competition brought on by information and communication technology (ICT)—spurred globalization and internal pressures linked to skill shortages. As a basis for its recommendations, the volume examines the extent to which Indian enterprises are undertaking innovative activities and analyzes their enabling environment.

Given the dualism of the Indian economy, innovation is broadly defined to include “new to the world” knowledge creation and commercialization as well as “new to the market” knowledge diffusion and absorption. This second type of innovative activities involves enterprises applying existing technologies in new locations and product areas. Both types of activities seek to provide better, cheaper products in response to consumer needs—creating more and higher-paying jobs. Although both types of innovation activities are essential, India stands to gain more from catching up to the global frontier of knowledge through increased absorption than from trying to push out the frontier through creation. An enormous amount of existing global knowledge is not yet fully used in India. A 2006 World Bank Enterprise Survey of roughly 2,300 manufacturing enterprises in 16 Indian states found that applying existing technology in new settings is more likely to be associated with increases in productivity than are efforts to create new knowledge. In addition, given the overriding need to better address the needs of the poor in India, knowledge creation and absorption efforts most relevant for the poor are indicated by the term “inclusive innovation.”

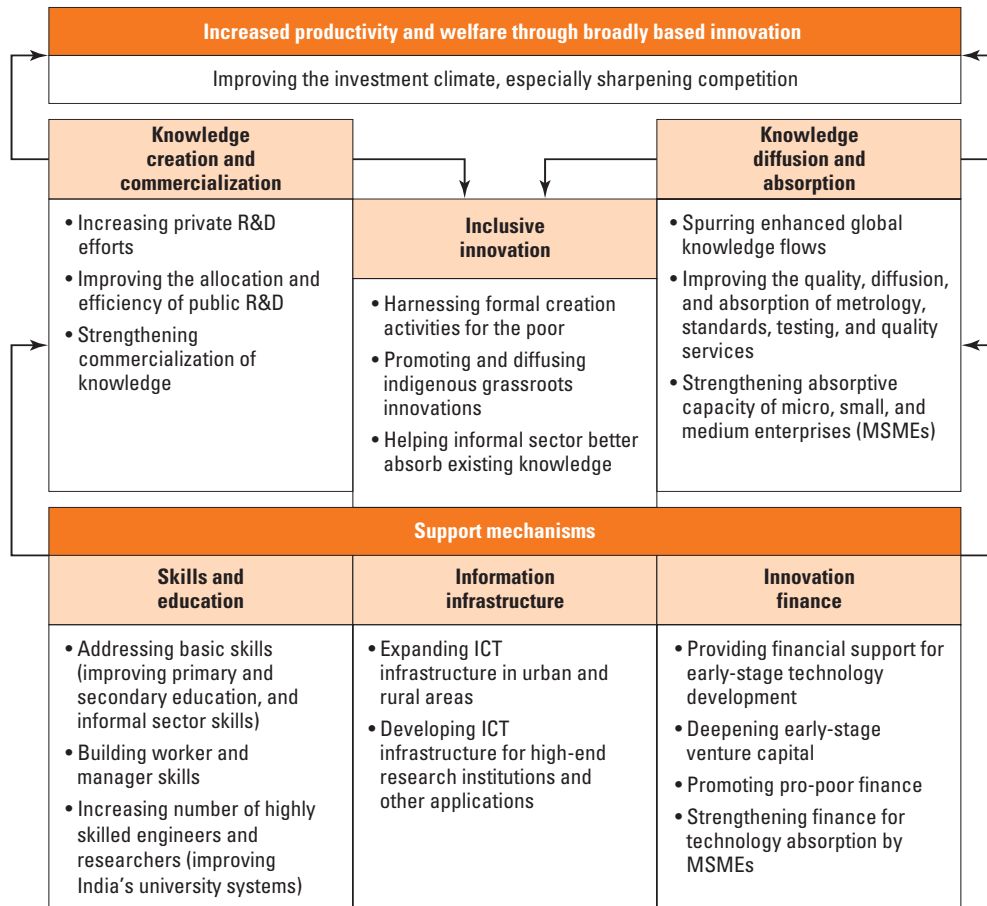
This book has three main messages (figure O.1 shows how they are interrelated). To unleash its innovation potential, India needs to develop a strategy that does the following:

- Focuses on increasing competition as part of improving its investment climate, supported by stronger skills, better information infrastructure, and more finance—public and private.
- Strengthens its efforts to create and commercialize knowledge, as well as better diffuse existing global and local knowledge and increase the capacity of smaller enterprises to absorb it—if all enterprises could costlessly achieve national best practice based on knowledge already used in India, the output of the economy could increase more than fivefold.
- Fosters more inclusive innovation—by promoting more formal R&D efforts for poor people and more creative grassroots efforts by them, and by improving the ability of informal enterprises to exploit existing knowledge.

Recognizing the importance of generating, commercializing, and absorbing R&D, in recent years the government has created a number of support programs—but they



Figure 0.1 Unleashing India's Innovation Potential



Source: Author.

could be more effective. Public programs supporting innovation have achieved significant successes. Still, their outcomes have not been commensurate with the needs of the Indian economy or the resources invested in them. This imbalance reflects many missed opportunities. Most of the programs have been run by government institutions; private sector involvement has been minimal. The public systems, not only in India but across the globe, especially where investments are to be made, normally go through a very long and elaborate decision-making process and are generally risk averse. This bureaucratic, rigid nature—and lack of risk taking—typical of government institutions, limits the effectiveness of these programs. These programs should be subjected to regular, independent performance evaluations and international benchmarking.

A new approach is needed—one that leverages the strengths of the public and private sectors in designing and operating innovation support programs, with a greater focus on inclusive innovation. The government's role should be to provide

a policy and regulatory framework that encourages the private sector to undertake riskier initiatives that are economically beneficial but that firms would not normally undertake. Removing nonessential regulations and facilitating more transparent application of essential ones in product, land, labor, capital, and infrastructure services markets—thereby promoting fairer and more intense competition—are critical to spurring innovation efforts. Reforms that enhance genuine competition are essential. This framework should be complemented by financial support where needed, with significantly more for pro-poor innovation. The private sector should be called on to manage such programs, with appropriate checks and balances as well as performance standards and monitoring. Moreover, all public support programs should periodically receive thorough reviews by independent experts, including international ones as appropriate. Based on these evaluations and international benchmarking, public support programs should be expanded, restructured, or closed.

India could benefit from an explicit, multipronged innovation strategy—building on existing private and public innovation efforts. This volume examines key issues and offers recommendations in six areas, in addition to an initial discussion of the Indian context and enabling environment. It argues that India's innovation strategy should build on the complementarities between knowledge creation and commercialization (that is, more state-of-the-art innovation), knowledge diffusion and absorption (greater acquisition and use of existing knowledge), and more explicit promotion of inclusive innovation—all supported by strengthened skills, upgraded information infrastructure, and enhanced innovation finance. The book is structured as follows:

- Chapter 1 reviews the Indian context and enabling environment.
- Chapter 2 analyzes knowledge creation and commercialization.
- Chapter 3 discusses knowledge diffusion and absorption.
- Chapter 4 encourages inclusive, pro-poor innovation.
- Chapter 5 addresses the need for stronger skills and education for innovation.
- Chapter 6 examines ways of improving information infrastructure.
- Chapter 7 suggests approaches to enhance innovation finance.

The recommendations that form this book's multipronged innovation strategy need to be prioritized and molded into an action plan—ideally through a collaborative process. Innovation is a broad topic that cuts across government ministries and economic sectors, and affects all Indians. It requires both private and public commitments and efforts—especially collaboration between partners with different perspectives. At the government level, some policy elements and investment decisions will be federal, while others will be more state responsibilities. This volume offers a number of recommendations, many with sizable cost implications, for implementation by the government, private entities, and civil society. The Ministry

of Science and Technology is beginning to prepare a national innovation program to scale up or modify some of the ongoing initiatives discussed in this book and introduce others. In addition, India would benefit from a broader complementary effort—including representatives from government, academia, the private sector, and civil society who are in a good position to set priorities among the recommendations and consider appropriate sequencing of activities, with a possible focus on national “grand challenges” such as road transport congestion in cities or access to clean water. A bold implementation approach emanating from such a consensus-building process would then benefit from a “light” public-private oversight mechanism—one that helps address the fragmentation of the current innovation system and tracks the achievement of realistic targets, with continuous feedback and periodic international benchmarking as the program evolves.

The Indian Context and Enabling Environment

The now-famous “Dabbawala” (literally, lunchbox-carrier) system is an innovative business process that allows 4,500–5,000 semiliterate Dabbawalas to deliver almost 200,000 lunches to workers every day in Mumbai. The Dabbawalas reportedly make one mistake per 6 million deliveries. So remarkable is this delivery network that international business schools have studied the work flows of the Dabbawala system to understand the key to its stellar performance rating.

In chapter 1, Mark A. Dutz and Carl Dahlman discuss the “dualism” of the Indian economy. India’s heterogeneity—with dispersion in enterprise productivity even wider within than across economic sectors—calls for support to create and commercialize new knowledge as well as to diffuse and absorb existing knowledge, with greater emphasis on inclusive innovation. Indicators of India’s innovation capacity highlight its innovation potential. Still, India is behind the global frontier in most sectors of the economy. Thus, innovation in India should not be thought of as simply pushing out the global technological frontier in a few areas, but as improving practices across the whole economy. More inclusive innovation efforts are especially important for poor people and informal enterprises. This chapter discusses

- relevant structural features of the Indian economy;
- the book’s definition of broadly based innovation, aggregate indicators of innovation, and links between innovation and productivity; and
- the enabling environment for innovation, including the centrality of competition as the key stimulus for innovation and the need for agreed on principles for coordinating innovation support programs.

India is a heterogeneous economy, with productivity dispersion even wider within than across sectors. On the one hand, India is the world’s fourth-largest economy in purchasing power parity (PPP) as well as nuclear and space power. Moreover, it is increasingly becoming a top global innovation player in biotechnology,

pharmaceuticals, automotive parts and assembly, information technology (IT), software, and IT-enabled services (ITES).

On the other hand, India is still a largely subsistence economy, with illiteracy rates of 46 percent among women and 25 percent among men, and about a quarter of its population living below the national poverty line, with significant spatial variance across and within states. Less than 3 percent of the Indian workforce is in the modern private sector, while roughly 90 percent is in the informal sector. This heterogeneity translates into a wide dispersion in productivity levels. Productivity dispersion of formal enterprises in manufacturing sectors is wider in India than in all other major comparator countries (Brazil, China, the Republic of Korea, Mexico, the Russian Federation) except Brazil. And India's productivity dispersion is wide across both formal and informal sectors of the economy. The average productivity of finance-related businesses is 23 times that of agricultural activities. Productivity dispersion is even wider within sectors, suggesting a strong potential for productivity improvement. The least productive formal enterprises in auto components and textiles are hundreds of times less productive than the most productive firms in those sectors within the country. Such differences are even starker among informal enterprises.

The heterogeneity of the Indian economy calls for a broader definition of innovation—one that distinguishes between “new to the world” innovation (creation and commercialization), “new to the market” knowledge (diffusion and absorption), and explicit promotion of innovation to reduce poverty (inclusive innovation). India has many islands of excellence. Still, it falls behind the global frontier in most sectors of its economy. Thus, innovation in India should not be thought of as simply shifting outward the global technological frontier, but as improving practices across the entire economy. Innovative activities are not restricted to new products but include innovations in processes and organizational models. Though the recommendations have broader applicability, this volume focuses on central government support for industrial innovation—not agricultural, medical, or other innovations, or state-level support. Though based on the best available comparable data, given the pace of change in this area, reported statistics may have been overtaken by recent developments.

Indicators of India's capacity for innovation highlight its potential and the links among innovation, productivity, and competitiveness. India's stock of scientists and engineers engaged in R&D is among the largest in the world. But another critical innovation input is domestic R&D spending, which in India has never exceeded 1 percent of GDP. However, the sizable increase in R&D activity by multinational corporations (MNCs) in India since 2002 has had a significant impact on total R&D spending. Moreover, acquiring new technology has a stronger correlation with productivity than does R&D spending. By far the most important channel for absorbing knowledge is through the use of new machinery and equipment. India has a strong record in producing basic knowledge, as proxied by internationally refereed scientific and technical publications. It has also experienced a significant increase in patent applications. Overall, India appears better at producing basic rather than commercializable knowledge. Still, the efficiency of its R&D spending, as measured

by the relative costs of a scientific publication or a U.S. patent, appears higher than in comparator countries.

India's enabling environment for innovation consists of policies, institutions, and capabilities that support the creation and commercialization of new knowledge, and the diffusion and absorption of existing knowledge—for both formal and informal sectors of the economy. India could gain from incentives that encourage stronger competition among enterprises and a national mind-set that values innovation. Since the 1991 liberalization, the private sector invested the most in R&D in the sectors most open to competition. Enterprise R&D spending as a share of sales increased more than sevenfold between 1991 and 2004. However, domestic innovation efforts, R&D spending, and diffusion and absorption efforts remain low largely because competition pressures—although strengthening—are not sufficiently widespread throughout the economy. Two reforms are crucial:

- *Sharpening competition among enterprises so that innovation becomes a necessity*—for example, by reducing entry and expansion barriers such as limits on small-scale industries, and remaining restrictions on foreign direct investment (FDI) and barriers to import competition. In addition, reallocation of capital should be eased through bankruptcy reforms and modernization of the Industrial Disputes Act.
- *Strengthening innovation-friendly sociocultural norms.* To help solidify a mind-set for nationwide innovation, more resources are required to raise awareness about the high social value of business and social innovation and commercial success, to disseminate success stories highlighting the achievements of techno-entrepreneurs, and to provide high-profile innovation awards and prizes—including for creative teachers.

Creating and Commercializing Knowledge

Once characterized as producing outdated 1940s models referred to as “fossils on wheels,” the Indian automobile industry—with FDI allowed up to 100 percent and no minimum investment requirements for new entrants—now accounts for more than \$13.5 billion in investments and employs 500,000 workers directly and 10 million indirectly. India is emerging as a global center of innovative automotive design. Mahindra & Mahindra spent only \$120 million to develop its fast-selling Scorpio model—one-fifth of what it would cost in Detroit. Tata Motors recouped its development costs within a year on the Ace, a small truck that costs about \$2,500.

In chapter 2, authors Carl Dahlman, Mark A. Dutz, and Vinod K. Goel discuss the tremendous potential of India's efforts to expand knowledge and commercialization through formal R&D and to move ideas from laboratories to markets. The world has acknowledged India's R&D potential. More than 300 MNCs have set up R&D and technical centers in India. But despite their recent increases in R&D spending, national corporations and other domestic enterprises are not

systematically exploiting this potential to India's advantage. Indigenous R&D spending as a share of GDP remains low and dominated by the public sector. Furthermore, much of the knowledge that is created—especially by the public sector—is not commercialized. To fully exploit India's R&D potential, the government must take three key steps:

- increase private R&D efforts
- increase the impact of public R&D
- strengthen commercialization of knowledge.

Private R&D could be increased by enhancing support for early-stage technology development (ESTD) programs. During 2006, R&D spending by roughly 300 MNCs in research labs in India appears to have significantly surpassed spending by India's private sector. Although the growth of MNC R&D provides valuable training for Indian scientists and engineers, possible negative externalities in the short term include the diversion of researchers' focus from domestic to MNC issues and increased salaries that may make it difficult for universities and public labs to compete for needed talent. India's large demographic dividend should lead to a sharp supply response over the longer term with appropriate incentives for the development of higher-end skills, with likely enormous longer-term benefits to the Indian economy from greater exposure to MNCs. Two areas need reform:

- *Studying MNC spillovers and adjusting incentives.* A study on the externalities of MNC R&D centers would help indicate how best to adjust existing incentives, including how to ensure that small and medium enterprises (SMEs) can still employ competent technical personnel as the talent gap is being addressed.
- *Consolidating and expanding ESTD programs, and developing pro-innovation public procurement policies.* To support private R&D more effectively, the government should conduct an independent review of ESTD programs with international benchmarking. Based on such a review, programmatic reforms could include establishing a matching grant program building on India's Sponsored Research and Development (SPREAD) and Small Business Innovation Research Initiative (SBIRI) programs, targeted largely at smaller enterprises. The government also should consider developing a national policy and action plan to more effectively use public procurement as an effective policy instrument to promote innovation.

To improve the impact of public R&D, India should consider allocating more resources to productive and social applications. Less than 20 percent of public support for R&D is allocated to civilian applications: 8 percent goes to the 38 labs under the Council of Scientific and Industrial Research (CSIR), 4 percent to Indian Council of Agricultural Research (ICAR) institutions, 4 percent to the applied research programs of the Department of Science and Technology, and 1 percent to the Indian Council of Medical Research (ICMR). India should consider the following:

- *Increasing resources for civilian research.* CSIR was restructured in the 1990s to focus on more market-driven R&D; further restructuring is ongoing. Still, the

public R&D system would benefit from independent evaluation and restructuring across the three main central government research agency networks (CSIR, ICAR, ICMR). Such actions would increase cross-institutional synergies and their focus on commercialization. A systemwide action plan would also consolidate and transfer some R&D labs to the private sector, so that their work becomes fully market driven.

- *Providing more support for university R&D.* Basic science and engineering research of a public goods character can probably be better supported through competitive grants along the lines of the U.S. National Science Foundation, as contemplated in the planned National Science and Engineering Foundation, as well as through greater partnerships and researcher exchanges with international research laboratories.
- *Strengthening support for R&D for high-risk technologies through the New Millennium Indian Technology Leadership Initiative (NMITLI).* Though young, the NMITLI has a number of impressive precommercialization accomplishments. CSIR plans an independent evaluation of the program with international benchmarking. Plans for scaling up the NMITLI include supporting pre- and post-NMITLI activities, opening the program to international collaboration, and giving grants to both research institutions and private enterprises, with success royalties to be shared.

Fostering increased collaboration among R&D institutes, universities, and private firms would help strengthen commercialization of knowledge. The Indian private sector has little interaction with public R&D. Possible areas of reform include the following:

- *Strengthening incentives to commercialize publicly funded R&D.* The U.S. Bayh-Dole Act (1980) encouraged university professors and students to commercialize their intellectual property. India should consider strengthening incentives to commercialize publicly funded R&D by passing legislation inspired by the Bayh-Dole Act but appropriate to the Indian context. India's situation differs from that in the United States in 1980 in that India has no law prohibiting patenting development and commercialization derived from using public research funds. Still, there would be a signaling benefit from clarifying India's legal framework along the lines of the CSIR and Patent Facilitation Center guidelines in force at some ministries. Any new law should promote an entrepreneurial spirit on campuses and at research institutes—including the freedom to negotiate deals with private partners, and rewards for labs and individuals who contribute to revenues.
- *Improving support infrastructure for India's regime for intellectual property rights (IPR).* India's legal framework for IPR has been modernized with the 2005 amendments that brought its patent laws into full compliance with the World Trade Organization (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). However, India should consider addressing outstanding IPR implementation issues. The drive to modernize India's IPR implementation

system is already under way. In addition, the government is expediting plans, among others, to upgrade Indian Patent Offices and expand support for individuals and organizations seeking to patent in India and abroad through an enhanced patent facilitation center. For the longer term, the government is considering creating a special court of appeals for IPR. Finally, to provide country-strategic policy advice on complex IPR-related issues such as technology advances and ensure that they are resolved in India's interest, the government is considering creating a policy-oriented think tank on outstanding intellectual property (IP) issues.

- *Supporting technology transfer offices and a patent management corporation.* Legislation should require government agencies that issue research grants to motivate universities, research institutes, and their individual researchers to seek and exploit patents and engage in technology transfer programs with industrial concerns. A patent management corporation structured as a public-private partnership and as a replacement for or restructuring of the National Research Development Corporation (NRDC) could play a useful role by managing the patent portfolios from CSIR and other public labs and universities, and facilitating their commercial exploitation—as well as provide strategic down-to-earth IP guidance to SMEs.
- *Promoting greater mobility.* Mobility of personnel among public R&D labs, universities, and industry should be encouraged through competitive awards with generous stipends, both within India and within an international context.
- *Expanding technology parks and incubators.* Technology parks and incubators should be expanded with government support and private finance, and management should be based on international best practice. Spin-offs from universities and public research labs should also be encouraged, to create new companies. Scientists should be allowed to start spin-offs while holding their current jobs.
- *Broadening SPREAD.* SPREAD's success as the first formal program to encourage collaboration between Indian technology institutes and firms should be broadened, with a likely focus on SMEs. Its expansion should be based on international benchmarking—including the U.S. Small Business Technology Transfer program, which provides matching grants and requires collaborative commercialization.
- *Creating a Global Research and Industrial Partnership (GRIP) program.* To spur greater international collaboration, the government plans to set up a GRIP program. Inspired by the Israeli-U.S. Binational Research and Development Fund, India's program will support advanced R&D and commercialization carried out jointly by Indian enterprises and those from specific countries, such as Canada, Israel, Russia, and the United States.

Diffusing and Absorbing Knowledge

The Central Leather Research Institute, the largest such institute in the world, implements the Mission for Leather, with the goal of spreading and sustaining a technology culture in India's leather sector. The institute trains workers in all areas, from flayers and

those engaged in collecting raw materials to designers. The global leather industry sources manpower from the supply of trained Indians.

In chapter 3, authors Vinod K. Goel, Carl Dahlman, and Mark A. Dutz discuss how India stands to gain tremendously from increased diffusion and absorption of existing national and global knowledge. Reaping the large, enterprise-based productivity returns from better knowledge diffusion and absorption requires

- spurring flows of global knowledge;
- improving the diffusion and absorption of metrology, standards, testing, and quality (MSTQ) services; and
- strengthening the absorptive capacity of small enterprises.

A range of factors can be strengthened to enable enterprises to absorb knowledge for increased productivity. This book focuses on enhancing global knowledge flows; improving MSTQ services; and strengthening the absorptive capacity of small enterprises. A number of factors help enterprises absorb local and global knowledge. Vigorous competition from local and international rivals is the most important—not only to create and commercialize new knowledge, but also to scour the world for appropriate knowledge, buy it, adapt it for local use, and integrate it in production processes. Other factors include ease of access for acquiring technology (wherever it was developed); sufficient managerial, organizational, and technical capacities within enterprises to use more advanced knowledge; dense links among MSMEs and with dynamic larger enterprises; and sophisticated, demanding local customers. This volume focuses on a few areas with significant scope to build on the progress that has been made in recent years.

By building on its liberalization efforts and further facilitating global knowledge flows, India could help enterprises better absorb knowledge of best practices. India's liberalization of flows of goods and services, capital, technology, and people has had a tremendously positive impact on its economy. The spectacular development of auto components and assembly is perhaps the best illustration of the benefits of a more open business environment. However, India should do more on trade and FDI openness to help its enterprises remain competitive relative to those in comparator countries. Three action areas follow:

- *Increase openness to trade and FDI.* Although India has liberalized many of its trade and FDI policies, implementation remains a problem. Recommendations for increased trade integration include expediting trade liberalization—including the short-run priorities of extending duty drawbacks on imported inputs for exporters, strengthening export promotion for entry into global supply networks, and reducing procedural requirements for both exporting and importing. Recommendations for increased FDI include opening remaining eligible sectors to FDI and setting up a one-stop shop for foreign investors. Longer-term goals should include increasing India's attractiveness to foreign investors by significantly enhancing the efficiency of contract enforcement.

- *Ease technology transfers and set up a technology acquisition fund.* Although India has significantly liberalized its technology transfer regulations in recent years, there is scope to further reduce barriers to technology licensing contracts. The government also may want to consider strengthening support infrastructure for technology licensing by setting up a technology acquisition fund on a public-private partnership basis.
- *Leverage the talents of the diaspora.* Some 2 percent of India's population lives abroad. Their aggregate incomes are roughly equal to two-thirds of India's GDP. India can do a lot more to leverage its large diaspora pool of entrepreneurs and technologists. Initiatives could include supporting a more formal diaspora network, building on existing groups that aggregate diaspora talent and capital for use in India—one that locates individuals to enhance innovation policy and evaluation; enrich the management of scientific institutions and programs; provide teaching, consultancy, and mentoring resources for Indian innovators; and help commercialize Indian intellectual property domestically and abroad.

Improving MSTQ services would help diffuse quality standards and their absorption by enterprises. Standards and quality are closely linked to innovation and productivity. But relative to comparator countries, the absorption of quality in India and the use of its MSTQ system appear low. India's standards and quality system is fairly well developed, but it is dominated by the public sector. A key action area is to *create a world-class, demand-responsive MSTQ infrastructure*. In addition to the need for increased competition as a stimulus for quality upgrading, India should modernize its MSTQ infrastructure, especially metrology, to international standards. Modernization should start with a review of MSTQ programs—examining their governance, management structures, and effectiveness to maximize synergies among initiatives by various ministries and private actors.

Expanding support programs for MSMEs would help increase their absorptive capacity. The skewed distribution of enterprise productivity by sector, with smaller enterprises furthest from top local performers, indicates low absorption of existing knowledge by most enterprises, especially smaller ones. But this skewed distribution also indicates the potentially large productivity and output increases from diffusion and absorption of available national and global knowledge. A key action area is to *strengthen knowledge upgrading initiatives, including technology support at the cluster level and softer organizational capabilities*. Key inputs to enterprises' absorptive capacity are sufficient managerial, organizational, and technical skills. Although the government has a range of policies and programs to promote technology absorption by smaller enterprises, the Ministries of Science and Technology and Small Scale Industries have to do more analysis of how effective they have been. In particular, support for cluster development deserves careful assessment. There is enormous potential for enterprises to absorb knowledge from vertical links with larger, more competitive firms and from horizontal links with enterprises facing similar challenges. The concerned ministries should thoroughly assess existing programs. Based

on this assessment, the government should strengthen and expand effective programs and discontinue or modify ineffective ones.

Promoting Inclusive Innovation

The Honey Bee Network consists of innovators (individuals, farmers, entrepreneurs), policy makers, academics, and nongovernmental organizations (NGOs) committed to recognizing and rewarding innovative ideas and traditional knowledge produced at the grassroots level, using local language interfaces. The network has, in the National Innovation Foundation repository, more than 50,000 innovations and traditional knowledge practices from over 400 districts of India. The related Society for Research and Initiatives for Sustainable Technologies and Institutions has, among other activities, organized biodiversity contests and supported the grassroots development of botanical pesticides and health care products.

The authors of chapter 4, Anuja Utz and Carl Dahlman, suggest that India needs to focus more on promoting inclusive innovation. A three-pronged strategy could make India's innovation system better meet the needs of the economically weaker sections of Indian society:

- Harnessing, increasing, and redirecting formal creation efforts
- Promoting and diffusing innovations by grassroots entrepreneurs
- Helping informal enterprises better absorb existing knowledge.

The main recommendation of this chapter is to create incentives for pro-poor early-stage technology development (ESTD) and commercialization by the formal sector, possibly by providing more preferential matching grants to collaborations among public R&D entities, industry, universities, NGOs, and global poverty alleviation networks. In addition, grassroots innovation networks should be formally evaluated and supported. Finally, government programs should promote knowledge absorption in the productive sector and extend the reach of markets to the common man.

Public policy needs to play a bigger role in increasing India's innovation efforts to address the needs of the poorer segments of the informal sector, in both urban and rural areas. Unless more efforts are made to address the needs of the poor, the growing divergence in productivity between agriculture and knowledge-intensive manufacturing and services will lead to higher income inequality. Innovative activities can play a critical role in reducing the costs of goods and services and in creating sustainable income-earning opportunities for the poor. To bolster inclusive innovations, India would benefit from a crosscutting strategy that harnesses formal creation efforts for the poor; promotes, diffuses, and commercializes grassroots innovations; and helps the informal sector better absorb existing knowledge.

By building on public R&D and university initiatives and encouraging private and global initiatives, India could harness creation and commercialization efforts by

the formal innovation system for poor people. Public research for development and university initiatives have generated benefits in several pro-poor directions. These include the preparation of more than 2,000 groundwater prospect maps, the discovery of a new antituberculosis molecule, and the incubation of n-Logue Internet rural service centers. Private initiatives include the solar power pilot program for poor rural households in Karnataka by the United Nations Environment Program with the Shell Foundation and ultra-low-cost mobile handsets produced by Nokia. Still, formal R&D to meet the needs of the poor has been too low. A key action area is to *provide additional matching grants for pro-poor ESTD followed by commercialization*. More favorable support for pro-poor ESTD could spur a significant increase in collaborative projects among public R&D entities, universities, NGOs, national industry, and global networks. Approaches could include providing more preferential matching grant terms for formal sector activities that alleviate poverty under a consolidated ESTD program.

Deepening grassroots networks and strengthening IPR for traditional knowledge would promote and diffuse grassroots innovation. A number of efforts support grassroots innovation. Nongovernmental initiatives include the Honey Bee Network, which recognizes innovative ideas produced by individuals and communities at the grassroots level, and the Society for Research and Initiatives for Sustainable Technologies and Institutions, which provides financial and institutional backing to the Honey Bee Network. Government initiatives include the Grassroots Innovation Augmentation Network, which functions as an incubator, and the National Innovation Foundation, set up by the Department of Science and Technology to document grassroots innovations. The government also set up a Traditional Knowledge Digital Library to create a database of indigenous knowledge related to medicinal plants. These initiatives have to be independently evaluated for reach and effectiveness. Areas requiring change follow:

- *Deepen financial support for grassroots innovators.* More concessional matching grants for ESTD should be given to grassroots innovators. An example is the harnessing of formal creation efforts for the poor as part of a consolidated and expanded SPREAD/SBIRI program. Once prototypes are developed, they would become candidates for the fund-of-funds window, which considers pro-poor grassroots innovation. Moreover, the National Innovation Foundation should be expanded in ways that enhance and scale up measurable impact.
- *Strengthen IPR for traditional knowledge.* Recommendations to strengthen IPR for traditional knowledge focus, first, on charging the policy-oriented IPR think tank (proposed above) with completing the Traditional Knowledge Digital Library to prevent international patenting of India-based traditional knowledge. Second, the think tank would assess the costs and benefits associated with moving forward with an IPR regime to leverage traditional knowledge into revenue streams.

To help the informal sector absorb knowledge, the government should extend to the informal and rural segments of the economy support programs to strengthen the

absorptive capacity of smaller enterprises. A range of support networks—research institutions, corporations, trader-entrepreneurs, NGOs—try to reach the poor, with unrealized synergies. Those efforts to promote the diffusion and absorption of knowledge in the informal sector appear ineffective, especially given the scale of the challenge. A key action is to *extend technology upgrading programs to informal and rural sectors*. As with support to strengthen the absorptive capacity of smaller formal enterprises, it is essential to undertake a thorough assessment of the reach and effectiveness of existing programs. Based on this assessment, effective programs should be strengthened or new programs introduced to develop a more formal, programmatic approach to this critical but underserved area.

Strengthening Skills and Education for Innovation

The National Association of Software and Service Companies (NASSCOM) has introduced a national assessment of competence for IT and business process outsourcing workers. This test (covering communication, analytical, and keyboard skills) is a market opportunity for private training institutes, spurring them to adapt and increase the market relevance of their courses—helping transform the trainable workforce into an employable workforce.

In chapter 5, authors Isak Froumin, Shanthi Divakaran, Hong Tan, and Yevgeniya Savchenko discuss that India needs to transform its immense young labor pool into a skilled workforce able to take advantage of new and existing knowledge. To fully unleash India's potential as an innovation economy, the government needs to

- improve the delivery of basic skills to both the formal and informal sectors;
- strengthen enterprise-based training and vocational education and training; and
- increase the transfer of market-relevant knowledge-creation skills in higher education, particularly by universities not in the top tier.

India must convert its youth into a skilled workforce. More than 500 million Indians are younger than 25. By 2050 India is expected to overtake China as the world's most populous nation, and over the next five years will be responsible for nearly a quarter of the increase in the world's working-age population. Already, India has almost a third of the available labor supply in low-cost countries.

These figures represent an enormous competitive advantage for India in its emergence as an innovation economy, including as a supplier of skills to the world. However, the widespread perception that it has unlimited employable human resources has changed. India has a growing shortage of skilled workers—caused largely by workforce development and education systems that do not respond adequately to the economy's needs. To fully unleash its potential, India must address three constraints that prevent many of its workers from acquiring the skills needed to contribute to the innovation economy: inadequate delivery of basic skills to both formal and informal sectors; underinvestment in enterprise-based training and inadequate quality of vocational education and training; and insufficient transfer of

market-relevant knowledge creation skills at the higher education level, particularly by universities not in the top tier.

To increase productivity in both the formal and informal sectors, increased efforts are needed to combat illiteracy and provide basic skills. India's high illiteracy limits the population's capacity to acquire the basic skills needed for an innovation economy and curbs the productivity potential of the informal and lower-skill sectors. Reading and writing skills are low even among the literate population. Low worker education contributes to low firm productivity. The country has taken significant steps to reach its high enrollment rate of 94 percent in elementary education, though quality continues to suffer. In contrast, secondary education (grades 9–12) enrollment remains low, at 38 percent. This low secondary education enrollment creates a bottleneck impeding the supply of students for tertiary education. A focus on memorization, use of outdated curricula, and chronic teacher absenteeism have led to an education system that does not prepare students for a market that increasingly rewards problem solving, communication skills, teamwork, and self-learning. Despite a variety of programs to develop skills in the informal sector, the resources directed to the sector are not aligned with its size and the diversity of skills needed. Two actions needed are the following:

- *Use innovative approaches to improve the quality of primary and secondary education.* The government should revamp the primary and secondary education system by modernizing curricula and creating a more flexible, market-responsive education system. New approaches must be experimented with to address existing problems.
- *Strengthen basic skills for the informal sector.* The government should continue to invest in programs that combat illiteracy. It also should facilitate transfer of skills to the informal sector by supporting NGOs that provide training to meet the needs of the informal economy. These skills include training instructors, developing curricula, and encouraging external financing of informal training programs.

Enterprises need stronger incentives to invest in worker training and in vocational education and training that better meet market needs. Indian employers' underinvestment in worker training places India at a competitive disadvantage. A firm's capacity to create or absorb knowledge depends on the skills and training of its workforce. Yet only 16 percent of Indian manufacturing firms provide in-service training, either in-house or external—compared with 92 percent in China. Two recommendations follow:

- *Strengthen enterprise-based training.* The government should help ensure that the benefits of in-service training are widely recognized by enterprises while also providing strong financial incentives—such as matching funds—for firms to invest in such training.
- *Improve vocational training.* India's vocational education and training systems have been unsuccessful in producing graduates able to meet market needs, particularly because of a lack of interaction with industry in curriculum development. Aligning these systems with market needs requires restructuring—including private participation in the management of systems, curriculum development,

and system financing; and stronger performance incentives for vocational education and training institutions.

India's higher education system needs to produce more scientists, engineers, and other Masters and PhD graduates with skills matched to the needs of the innovation economy. Universities are the cradle for sustained creativity and innovation. But India's demand for highly educated, skilled workers outstrips its supply. The high demand is fueled partly by India's popularity as an R&D destination for multinational corporations luring away domestic talent, and partly by the blossoming of India's IT and ITES sectors. To maintain its share of global knowledge services, India will need 2.3 million knowledge professionals by 2010. Instead, it may face a deficit of up to 0.5 million workers. Despite the prestigious standing of several Indian institutions of higher learning, the education system's output remains uneven. Quality training continues to concentrate on islands of excellence: 80 percent of doctorates in engineering are awarded by 20 leading institutions, and 65 percent of doctorates in sciences come from 30 institutions. India produces fewer than 7,000 PhDs a year in the faculties of science, engineering, and technology.

The lack of skilled researchers and knowledge creators is manifested in low output of high-quality scientific research. Furthermore, weak links with industry have created a mismatch between the needs of the market and the skills of the highly educated workforce. Only 10–25 percent of general college graduates are suitable for employment. In addition, India has a small number of high-quality management programs, and even they are inadequate to support the growing need for management and supervisory skills in both knowledge-intensive and lower-skills sectors. Two key action areas follow:

- *Increase private participation in higher education.* To address the growing supply constraint of high-quality education institutions, India requires stronger incentives to attract domestic and foreign private participation in higher education and its financing. The November 2006 agreement by the government to allow FDI in higher education and foreign universities to set up campuses in India is a positive step in this direction.
- *Raise fiscal and managerial autonomy of universities and colleges.* A drastic increase in joint training programs with industry would help ensure that university curricula reflect market needs. Competitive grants for academic innovations and performance-based incentives for professors would also foster a more dynamic academic environment—one better aligned with India's growth in knowledge-intensive sectors.

Upgrading the Information Infrastructure

After mobile phones were made available to fishermen in Kerala, they were able to call several markets and agree on selling prices before landing their fish. Within a few weeks the dispersion in fish prices fell and there was no more wastage. The profits of fishermen

increased 9 percent while the average price of fish fell 4 percent—to the delight of customers.

In chapter 6, authors Shanthi Divakaran, Anil Srivastava, and Mark Williams conclude that India needs to improve the ease and cost of accessing and sharing information and knowledge among enterprises, knowledge workers, and researchers. Upgrading the information infrastructure for innovation requires

- making information and communication technology (ICT) more available to both rural and urban users, and
- strengthening India's National Research and Education Network (NREN) infrastructure for high-end research institutions.

The creation of new ideas and dissemination of ideas between firms and countries are strongly influenced by the availability of information, cost of obtaining it, and ease with which it is passed on. Electronic communications systems lie at the heart of this information transfer process. Investment in ICT services is one way to stimulate growth in national innovation and productivity. India's ICT sector has grown rapidly over the past 20 years. The IT industry, for instance, is becoming an increasingly important part of the economy. High investment in ICT services, increased competition, and low equipment prices have raised teledensity and driven down prices—to the point that Indian consumers now enjoy some of the world's lowest charges for telephones. At year-end 2006, India had roughly 41 million wireline subscribers, 150 million wireless subscribers, and over 1.8 million broadband subscribers. Rapid growth in penetration rates has reduced the price of information for individuals and businesses. However, this growth must continue and reach all segments of the economy to fully support the development of an innovation economy. To do so, the government must address a number of policy issues.

India has made rapid progress in improving access to telecommunications services, but urban teledensity still lags behind international comparators, and rural access remains insufficient. Households and small enterprises worldwide use basic ICT services to better organize their economic activities and marketing. China's penetration of broadband access is 30 times greater than India's. Teledensity in India in urban areas is 40 percent, compared with 2 percent in rural areas. Only 30 percent of India's population is covered by a mobile signal, versus more than 90 percent in China and South Africa. The value of ICT infrastructure to Indians and the lack of alternatives in rural areas are shown by the speed at which phone services are taken up when made available. Using ICT can spur institutional innovations to improve public service delivery in sectors such as health, education, energy, and transport. Two recommended actions, both benefiting from increased competition, follow:

- *Expand infrastructure for rural access.* By freeing more radio spectrum and making it available to operators of voice and data services, the government can reduce rollout costs and operators can accelerate the provision of services—including

broadband wireless services in rural areas. The government should also provide targeted subsidies for rural mobile and broadband rollout in a way that rewards efficiency, maximizes private investment, and does not distort competition.

- *Deepen infrastructure for urban access, especially broadband services.* India's success in expanding the supply of narrowband (that is, voice) communications infrastructure must be replicated for high-speed data services. Increased access to broadband networks will involve faster allocation of spectrum for wireless broadband rollout and revision of the policy definition of broadband to speeds higher than 256 kilobits per second.

A high-speed national research and education network would enable Indian scientists and researchers to work with the global scientific community and remain at the global frontier of science. Although there is widening awareness that network-enabled collaboration accelerates the pace of new discoveries and the expansion of knowledge, India is significantly behind global comparators in high-speed networking for research and academic institutions. NRENs have become an essential part of national R&D infrastructure. More than 70 countries connect researchers and scientists through high-speed networks, with the emerging standard for connectivity at 10 gigabits per second.

In contrast, most Indian scientists and researchers are not connected to high-speed networks. NRENs' main impact on an innovation economy is their potential for more productive research through formal, high-speed mechanisms that create and absorb knowledge by tapping into global networks. The case for NRENs also includes improved broader access to information, increased opportunities for collaboration, expansion of distance education at lower cost, and opportunities to participate in innovative research on the future of NRENs. Investment in shared cyber infrastructure by the U.S. National Science Foundation and similar institutions in Europe reflects the growing importance of NRENs. The main responsibilities of a typically nonprofit NREN entity are to mobilize and aggregate demand, manage underlying infrastructure, and deliver services—including connections to global high-speed networks at agreed standards. No single entity in India is entrusted with these responsibilities; the result is parallel high-speed networking efforts with duplicated resources. Indian policy makers recognize the importance of advanced networks for the knowledge economy. They should explore the cost of NREN infrastructure and the appropriate organizational structure to deploy and manage the network. A key action is to *upgrade India's NREN*. India should quickly agree on the appropriate NREN entity structure to manage the network, aggregating available infrastructure and building on it as needed. Programmatic rollout would include a prototype phase to test the selected management model and partnership arrangements, a decision on the right own or lease model for wider outreach, and phasing of connectivity to user research and education institutions. Demand could be ensured by subsidizing academic institutions for their required local network investments and ensuring that institutional incentives foster collaboration and network activity.

Enhancing Innovation Finance

The Acumen Fund, a nonprofit venture capital fund, takes a market approach to combat poverty, focusing on both opening markets and making goods and services more accessible to the poor. Acumen has taken a \$1 million equity stake in and loaned \$600,000 to Drishtee.com—an e-kiosk that gives rural poor people access to Internet services—to help build more kiosks and add new services, including online health care. However, the fund pulled out of a fluoride filtration company when the entrepreneur changed strategy and started pursuing subsidized government contracts.

Chapter 7, by Inderbir Singh Dhingra, discusses how India can meet the final challenge—enhancing public finance for innovation, which is essential to enabling more state-of-the-art innovation, increasing the use of existing knowledge by enterprises, and promoting inclusive innovation. Areas of support include

- providing financing for ESTD;
- deepening early-stage venture capital; and
- strengthening finance for technology absorption by MSMEs.

Among these, addressing the ESTD funding gap is the top priority because the early-stage venture capital gap will probably narrow over time through market forces, while the ESTD funding gap will not.

The government should expand financial support for ESTD. This requires multi-pronged reforms to improve the enabling environment for innovation. These should include increasing the scale and scope of public support for private R&D and strengthening incentives for research and commercialization through more incubators, technology parks, and spin-offs. Any interventions supporting venture capital need to be preceded or complemented by interventions that address the ESTD funding gap.

To deepen early-stage venture capital, India should consider both supply- and demand-side reforms. On the demand side, besides increasing ESTD, more efforts need to be undertaken to increase techno-entrepreneurship. Entrepreneurship training should be incorporated more systematically into engineering training. Greater incentives should be provided to young scientists, engineers, MBAs, and other professionals to launch technology-based companies. On the supply side, despite a significant number of major venture capital funds being created in India in the past 12–18 months, biases remain toward larger funds, the IT sector, and more proven business models. New efforts in seed and angel funding trying to fill the gap are insufficient. Taking into account the amount of funding available at the post-early-stage phase, the total funding available at the seed and early stage, especially under \$2 million, is a serious bottleneck. This lack of funding is even more of a constraint because early-stage financiers provide not only capital but also management support, advice, reputation, and other forms of mentoring critical to

successful commercialization. Two reforms would increase the supply of early-stage venture capital:

- *Introduce facilitating regulations.* Measures should make it more attractive for wealthy individuals to invest in venture capital funds. This can be done through tax incentives and changes in the Securities and Exchange Board of India rules to allow tax pass-through benefits for “accredited” angel investors. The investment guidelines of pension and insurance funds could also be relaxed to increase their investments in early-stage ventures.
- *Create a fund of funds.* Also crucial is the creation of a fund of funds, where the government would provide leveraged returns to private investors by increasing potential returns or reducing potential risks. The fund could cover innovations in areas overlooked by the market, including agro-industry, rural industry, pro-poor grassroots industries, and start-ups where companies need to advance an innovation. The fund should have two distinct windows: one focused on pro-growth innovations, the other on inclusive innovations. Governance of the fund-of-funds is perhaps the most critical factor for success, so that selection of fund managers and program control are professional, free from bureaucratic burdens, and independent of political interference. The individual venture capital funds should be managed by the private sector.

Finally, the government should implement measures to improve access to finance for innovative MSMEs upgrading their technology. Although no official data exist on the magnitude of the finance gap facing MSMEs wishing to absorb technology, the general constraints that they face in financing investments suggest that it is significant. There is evidence that access to funding for absorption of innovative practices is a more serious problem in India than in most other developing countries in Asia and Latin America, and more constrained for smaller enterprises and those operating in traditional industries. India should *strengthen finance for technology absorption by MSMEs*. Possible measures for government action include improving credit information on MSMEs to reduce transaction costs—thereby lowering lending rates, addressing the problem of collateral and reducing default risk by lenders, and establishing a policy and regulatory framework to foster the development of leasing finance as an instrument to finance small, innovative enterprises.