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Innovation Systems, Radical Transformation, Step-by-Step

India in Light of China

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Abstract

The paper introduces a reform trajectory we call 'revolutionary incrementalism' in which partial and incremental measures add up to profound transformation.

Recent advances in economic theory demonstrate that growth is not hard to start: it almost starts itself, somewhere, sometimes. But keeping it going is not easy: doing so requires attention to the context of growth-binding constraints and situation-specific ways to resolve them. The same goes for institutions: it is almost always possible to find some that are working. The issue is using the ones that work to improve those that don't. The thrust of the proposal is to rely on variation within existing institutions as the 'Archimedean lever' with which to leverage reform and change. India's public sector record for implementing and coordinating innovation efforts can be notoriously fragmented and inefficient but there are some parts that perform better than others, and there are recognized pockets of excellence virtually within every ministry or public sector organization. The same internal diversity is even more visible in the private sector. Importantly from a policy perspective, better performing segments of public sector and better performing segments of productive sector are beginning to join forces in a variety of search

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Keywords: innovation systems, heterogeneity of institutions, radical incrementalism, search networks, open economy industrial policy

JEL classification: O32, O38

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networks—private-public partnerships and programmes to unblock binding constraints and to advance reforms. From this perspective, India's unparalleled heterogeneity is its most beneficial aspect. But to leverage internal diversity, the already vibrant search networks have to develop a systematic procedure of assessing the constraints and of developing 'next step' measures to relax them.

All too often, reform is conceived as a comprehensive blueprint consisting of many desirable changes. Neat in theory, but such blueprints tend to become mere 'wish lists' in practice because of a myriad of implementation constraints. The consensus is that while India needs a profound modification of its innovation and higher education system, reforms are blocked because of vested interests and significant political economy constraints. Revolutionary incrementalism perspective developed in the paper dispenses with blueprints and 'wish lists'. Instead, it proposes a series of strategic pilots, each addressing binding constraints in its own way, and a procedure to evaluate these as a way to reform. The proposal draws on lessons from China, a recognized paragon of revolutionary incrementalism.

The paper is addressed primarily to policymakers. It will also be of use to economists with an interest in institutional design of innovation policies.

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Acronyms
Acronyms are given at the end of the paper.

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1 The jigsaw puzzle of the innovation system

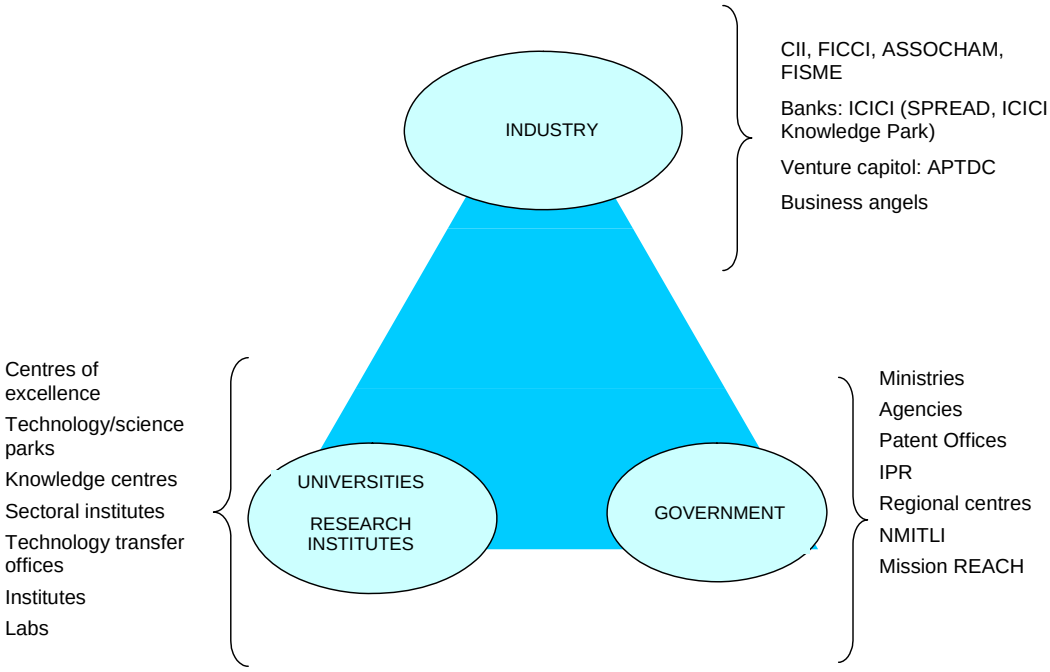
As is well known, an innovation system consists of a network of organizations, rules, and procedures that affects how a country acquires, creates, disseminates, and uses knowledge. Key organizations for the creation and diffusion of knowledge include universities, public and private research centres, and policy thinktanks. Private firms are at the centre of the innovation system. If the private sector has little demand for knowledge, the innovation system cannot be effective. Effective R&D-industry linkages are vital for transforming knowledge into wealth. Therefore, networking and interaction among the different organizations, firms, and individuals are critically

The main idea behind the concept of an innovation system is one of synergy: an idea of the so-called triple helix which conveys a synergy between three major players: industry, the government, and universities and research institutes (Figure1). However, the reality of all countries which engineered rapid catch-up in the post-war years was anything but triple helix. A more accurate characterization is three ivory towers—of the government, research creation organizations, and industry—each having little incentive to interact with one another. Why has the problem of crossing-boundaries, interaction and university-industry linkages proven so difficult everywhere? The following three issues are responsible:

Very long gestation period between research input and actual impact on societal needs

Figure 1 breaks down this long gestation period from the time of research input to its societal impact (as demonstrated by market shares from the perspective of industry and improvement of social indicators from the perspective of society) into specific components. In biotechnology, for instance, this period is thirty years or more (more

Figure 1
India's innovation environment: towards the triple helix



Source: Compiled by the author

than a generation!). But governments, as a rule, do not have such long planning horizons: exigencies of electoral cycle, for instance, impose their own logic, which makes accountability for the allocation of resources particularly difficult.

Non-linearity of interaction among major players

The problem of the long gestation period is compounded by the fact that research production function—transformation of inputs (funding of programmes) into research impact is not a linear process as the figure suggests. *The linear innovation model* emphasizes technological opportunities, science push, and well-defined stages (discovery, invention, innovation, diffusion). The development, production, and marketing of new technologies all take place within a well-defined time sequence that originates in research activities, then through a product development phase which ultimately leads to production and eventual commercialization. It is elegant and neat but it is manifestly false.[1] In the non-linear model, research (including fundamental) has to proceed in constant interaction with industry, with feedback flowing both ways and in a way that tolerates the unavoidable failures and uncertainty.

Political economy problem: management of entrenched interests

Last but not the least is the fact that changing the incentives of major players to make them more amenable to interaction and collaboration in joint projects proved notoriously difficult. Harvard University is the richest in the world, with an endowment and budget which dwarf the India R&D budget. Yet its rector Larry Summers has been forced to resign. The job of rector is to assure an intricate balance between many stakeholders: the interests of alumni (who contribute to environment), students (concerned about job placement), professors and research (focused in peer-reviewed publications), industry (interested in commercialization of research), governments (which finance fundamental research) and other stakeholders. A change that is too swift—or to be precise, is *perceived* to be too swift—results in elimination of the driver of the change, and this is what happened even with the well-connected Harvard' rector.[2]

This problem of entrenched interests is truly ubiquitous and is central in the management of innovation. By all accounts, the Korea innovation system is exemplary. The private sector performs 75 per cent of total R&D, which justifies the high 2.8 per cent of GNP expenditure on R&D. But a closer look reveals that the country has about 30 government research institutes which were created in the 1970s with a clear mission to conduct public research and promote industry when private sector had not performed any R&D. Thirty years later and in a radically different environment, this system of government research institutes remains largely unreformed. In the 1990s the government established public venture funds as a way to promote venture capital industry. Fifteen years later and with a vibrant private venture capital industry, public

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1 Agricultural extension is one exception where the linear model seems to be a fairly good approximation of reality. In a basic model of agriculture extension, applied research is diffused from the source (the agricultural extension unit) to the recipient (agents of the rural economy) and this is one reason why agricultural extension proved relatively successful.

2 There is little doubt that the motives for resignation of the Harvard rector were many, that they were complex and that they surely went beyond the entrenched interests we emphasize here. This example should be viewed as a parable reminding of the power of a status quo in world-class organizations, which are typically very conservative, their excellence non-withstanding.

venture capital industry—an oxymoron—still exists. Duplication and inefficiencies are rampant, a fact which shed a new light on the enviably high share of R&D (is this because the government is unable to downsize the less efficient segments of public R&D?) and even more enviable share of privately executed R&D (is it because *chaebols* prefer to perform all the R&D in-house rather than in collaboration with universities and public research institutes?). Far from being a triple helix, the Korea innovation system resembles a jigsaw puzzle. Many elements of the jigsaw puzzle (public research institutes, vibrant private sector, rapidly growing venture capital industry, etc.) already exist. The problem is how to pull the elements together in a coherent whole.

This paper is about a process of how to pull together—gradually and incrementally—the jigsaw puzzle that constitutes India's innovation system from the many pieces that already exist. This paper conveys the following three messages about the process.

First, collaboration between major players is largely about conducive microeconomic incentives of such players, not about top-down coordination. The myriad of R&D programmes and projects is so clearly inefficient that a well-making policymaker attempts to coordinate them in a top-down fashion, by creating inter-ministerial councils or a super-ministry of innovation. Good intentions not withstanding, this largely fails. Inter-ministerial committees become cartels of established interests while the super-ministry becomes super-efficient in creating and defending its own turf. The drive for top-down coordination is in itself a symptom that something is wrong with incentives of agents.

Top-down coordination used to work in economies with exceptional government capabilities such as the Asian tigers, but as the complexity of the economy increases, it is failing even there. Korea is a useful benchmark of what a central authority can and cannot do in assuring coherence of national innovation system.

Second, while India needs a profound change in incentives, the actual process of changing the incentive structure has to be gradual and step-by-step. 'We don't even mention the word "reform" until it is underway and cannot be stifled'—this rule of thumb from Chile (another useful benchmark for India)—is a must in avoiding the fate of hurried reformers, as a parable of Larry Summers suggests.

Third, incrementalism and pragmatism should not be confused with muddling through. We make a sharp dichotomy between ad hoc incrementalism (taking advantage of the windows of opportunities in a sporadic way) and strategic incrementalism (gradual reform which adds up and results in a dramatic, even revolutionary change). India's innovation system is characterized by tremendous heterogeneity: better-performing segments (such as Council of Scientific Industrial Research, CSIR) coexist with poorly performing ones. So far, the progress in reform has been possible due to ad hoc incrementalism, a system characterized by the following features:

- Gradual but significant introduction of a new incentive structure which not so much fights vested interests but accommodates and transforms them by finding new roles for potential losers of the reform. Such was the reform of CSIR, supported by the Bank's project in the 1980s.

- Ability to ‘get around’ the constraints: creativity and ingenuity in tackling many unavoidable problems on the path of reform. Constraints are redefined by ‘out of the box’ solutions and by forging new alliances. This feature makes a detailed blueprint of the end state—the ideal one hopes to achieve—not a particularly useful guide for action. In other words, the blueprint for change is useful only to the extent that it is changed, adapted, and adopted on a continuous basis.

- Reliance on key individual champions which stake their credibility and reputation on the outcomes of reform. This creates fragility when the key champions change or retire.

- Reliance on organizational spinoffs to diffuse and spearhead the reform. For instance, New Millennium Indian Technology Leadership Initiative (NMITLI) was created as an organizational spinoff as a reformed CSIR, and shares its organizational culture of accountability for results, sensitivity to the needs of society, and the like.

Ad hoc incrementalism has been proven to be efficacious in its ability to carry reform forward in the difficult Indian environment, but it has serious limitations. The main limitation is that the changes and new programmes being introduced in the name of reform and enhancement do not necessarily add up: ad hoc incrementalism could degenerate into muddling through. As its main recommendation, this paper proposes *strategic incrementalism*, reforming the Indian innovation system with an approach that would combine gradual change (which seems the only viable alternative, anyway) with a focus on strategic goals of dramatic reform.

Strategic incrementalism retains all the features of ad hoc incrementalism but relies on the following additional three features:

- Continuous monitoring of the progress of reform and benchmarking of what is feasible: continuous and informed discussion of the ‘next steps’ for reform. An informal group should be established to consist of national champions of reform, members of the diaspora and international experts to examine further possibilities for reform and the steps necessary for achieving them. Consolidation of such continuous discussions was arguably the most valuable value added of the Bank’s recent innovation project and the most useful contribution of a new innovation operation which is under consideration. International benchmarks could include countries as diverse as China, Ireland and Chile, all of which have made progress in transforming their innovation systems, although each in its own way.

- Introduction of a diverse portfolio of strategic pilot projects and initiatives, to test what is feasible, along with a rigorous evaluation to learn from the pilots. National benchmarks should come from carefully monitored pilots, and a system which would allow for ranking them. As the ranking, not piloting, is the central issue, the selection of pilots should be based on their scalability and diffusion, as it is done in China; hence, the name strategic pilots.

- Introduction of formal procedures of programme evaluation (to establish benchmarks for accountability) and innovation foresight processes (to link possibilities from science with the needs of society). This is another dimension

which allows many discrete and gradual actions to be coalesced into a coherent innovation system. Institutionalized evaluation provides a feedback from the past to present-day decisions, and it introduces accountability for past decisions. A process of innovation foresight allows us to map future needs of the society with tools and opportunities presented by science. It is a feedback loop from the future to inform present-day decisions.

The logic of our argument is as follows. Section 2 sets the stage by describing the uniqueness of India's innovation system. Since there is no 'one-size-fits-all' solution, understanding the sources and implication of this uniqueness is a starting point of any discussion of whatever strategic changes are required. To it put another way; uniqueness becomes a major asset to be leveraged rather than yet another vexing complication of the jigsaw puzzle. Section 3 is a snapshot of the successful episodes of reform of India's innovation system introduced through incremental changes. Section 4 discusses how incremental reforms transformed China's innovation system, and offers lessons for India. Section 5 provides detailed suggestions of the measures needed to transform the current ad hoc incremental reforms into strategic incrementalism. The concluding section 6 distils the main principles of the policymaking art of combining ambitious reform objectives with gradual step-by-step means of its implementation.

2 Starting point for reform: leveraging the uniqueness of India's innovation system

The uniqueness of India's innovation system stems from a combination of at least four features.

2.1 Heterogeneity of the economy

The first is the unusually large heterogeneity of the economy: the co-existence of high-productivity and state-of-the-art segments and low-productivity informal sector. Because of this heterogeneity, the Indian economy cannot be accurately compared to any single economy (even to an economy as large and diverse as the US economy) but rather to the world economy as a whole. There are only two other economies in the world that are considered world-economies in microcosm—the former USSR and China. The USSR broke up because of its inability to manage this heterogeneity while China is an exemplary case of huge heterogeneity being leveraged into spectacular growth. Both cases are telling benchmarks for India.

By heterogeneity we mean not just high-productivity modern sectors, such as knowledge process outsourcing, co-existing with low-productivity informal sectors but heterogeneity running through each sector and indeed through each sphere and walk of life. An example is the garments industry. Much of it is conducted in informal shops, yet in the state of Tamil Nadu there are also modern factories that are on the cutting edge of design and manufacturing. In fact, thanks to a global advantage in warehousing, logistics management, and just-in-time delivery, they have become competitive globally and have been integrated forward by buying garment designers from Italy. In this case, knowledge not only flows from OECD economies to India but also vice versa (Tewari 2003). In spite of the fact that India has pioneered such a forward integration in the

developing world, it remains an exception within the country and relatively unknown. Access to knowledge is as much about access to national best-practices as it is about access to best-practices on the international scene.

The creation of diversity in performance is a key function of the market. Yet the market also levels out the differential through labour and factor markets. A defining feature of India's particularly large heterogeneity (as is the case of China and former USSR) is the existence of many internal barriers to level out the differentials. Internal migration is the most widespread instrument of transfer of national best practices: people migrate to expanding regions, and transfer in this way their knowledge from an environment of low productivity to one of high productivity. Yet Clark and Wolcott (2003) find that migration rates among Indian states are surprisingly small because of tradition, underdeveloped housing markets, and other problems. As a consequence, knowledge poles such as Mumbai and Bangalore are underperforming because pervasive infrastructure and housing bottlenecks severely impede their capacity to grow.

Flexibility of the US economy and of its innovation system is assisted by two important shock absorbers. On the low end, there is a reserve army of cheap, low-productivity labour from Mexico and the rest of Latin America that exerts downward pressure on wages for unskilled labour. On the higher end, there is an even larger reserve of global talent, not the least from India and China, to higher productivity jobs. The reality of India is such that *both* of these 'reserve armies' exist within the country itself, making a truly unique microcosm of the world economy. For its neighbouring states, Bihar in India is precisely what Mexico and Central America are for the USA, while India's highly successful talent abroad (along with the talent which is yet to leave India) is a potential to be tapped for domestic innovation. The jigsaw puzzle of India's innovation system is about leveraging (partly through the lessons learnt from China) its heterogeneity and untapped potential.

2.2 India's high-productivity segments

The second characteristic that makes India's innovation system unique is the unsustainability of the peculiar way in which the country has been creating its high-productivity segments such as the Indian institutes of technology (IITs) (Box 1) and Indian Institute of Science (IISc) (Box 2). The high-productivity segments were deliberately created as institutional enclaves, with rules and procedures separate from the rest of the economy (highly competitive examinations, meritocratic promotion). IIT could be characterized more accurately as an *exclave*—a home-grown extension of global knowledge economy, as it bears more similarities with global knowledge leaders like MIT rather than the typical, underfunded and understaffed public college in India. This hypothesis is corroborated by the fact that India's diaspora of talent is emerging in no small numbers among those who failed to be admitted into IIT and had to accept enrolment in a western university as consolation.

The creation of institutional enclaves—islands of excellence amid the sea of entrenched interests that defend inefficiency—is a common strategy. The emerging global education leaders such as the Monterrey Institute of Technology (see below for more details), Korean KAIST and POSCO universities are examples of this strategy. The crucial issue is whether society can tolerate such an emphasis on elite organizations and for how long these elite organizations can remain insulated from the pressures common

to the rest of the system. There is an indication (as demonstrated, for instance, by the recent attempt to increase a mandatory quota of admittance for scheduled castes) for the elite organizations of having to open up, and becoming more transparent and accountable. This could mean that they would lose their elite status and stellar performance. But the whole innovation strategy of India, its global success so far, has been based on the ability of the elite organizations to produce high-productivity output (mainly graduates) in large numbers, quantities that are not matched by any other developing or transition economy. There is considerable tension which calls for elite organizations to cater to mass markets that are elite and mass market at the same time—an organizational hybrid which is yet to be discovered. One of the strategic pilots suggested in section 6.4 proposes such a pilot spinoff of IIT to introduce low-costs high-quality higher education.

Box 1
Indian institutes of technology (IITs)

IITs are the elite of technical education in India. They command an unprecedented reputation for excellence in technical education globally. The origin of IITs goes back 60 years, to pre-independence India, when the British government set up a committee to plan higher technical institutions in India, which were conceived along the lines of MIT in the United States, training not only undergraduates but research scientists and technical teachers as well. Five of the IITs were set up in the 1950s and early 1960s and the sixth in the northeastern part of the country in 1995, and the seventh in 2001, by converting India's oldest-engineering college to an IIT.

With aggregate faculty strength of around 2,400 in the seven IITs, the teacher-student ratio is around 1:10. The brand equity of IITs is due to the excellence of their undergraduate education programme arising out of the selection of the best brains of India through one of the most rigorous testing systems in the world. A mere 2 per cent of India's elite school graduates get into the IITs. The same is not true of the postgraduate programmes, as a large number of PhD candidates drop out midway and a very small percentage of the undergraduate IITians seek to pursue postgraduate studies at the IITs. Presently, around 30 per cent (down from 50 per cent a decade ago) of the undergraduates migrate abroad after successful completion of their studies. The IITs have been increasing their research focus recently. All the IITs have also established industrial research and consultancy offices (albeit with differing names) to promote, facilitate and manage institute-industry interaction activities through the usual mechanisms and instrumentalities. Four of the IITs have also established campus-based 'incubators'. Amongst the academia, IITs in India have the best interaction with industry largely due to the organic linkages to its alumni who command leadership positions in the industry. ITT Bombay is a good example. In 1999 it established an incubator to promote technology transfer to new ventures by IIT students and faculty. Initially, the funding came from the alumni. Later, with funding provided by the department of science and technology and ministry of information and communication, IIT Bombay set up an autonomous society SINE (Society for Innovation & Entrepreneurship) to manage the incubator programme. Besides providing office space and technical guidance, facilities and infrastructure of the IIT, the programme offers supports through grant/loan/equity ventures. IIT Bombay houses 15 incubators.

Source: Bhojwani (2006: 37).

Box 2
Indian Institute of Science (IISc)

The IISc enjoys a prestigious pedigree. Started nearly a century ago, in 1909, through the pioneering vision of India's industrialist J. N. Tata, it has grown into a premier institution of research and advanced instruction. The institute is neither a national laboratory like the CSIR research institutes, which concentrate solely on research and applied work; nor is it a conventional university that mainly concerns itself with undergraduate teaching such as the IITs and most other universities. Instead, the institute focuses on research in frontier areas and education in current technologically important fields at the postgraduate and doctorate levels. Total postgraduate and PhD students number around 2,000 with faculty strength of around 450. Over the years, the institute has pioneered in many fields of educational programmes such as aerospace, communications, electronics, automation, biochemistry, biophysics, materials science and solid state & structural chemistry, space sciences and technology, environmental and atmospheric sciences, genetic engineering, etc. Its faculty and alumni have been a reservoir of high-class talent from which leaders for the national R&D and the industrial R&D systems are drawn. Now with Bangalore developing as a global R&D hub, its manpower is highly valued and in great demand by the multinational corporations (MNCs) as well.

The Union Finance Minister in his 2005 budget speech announced a special budget allocation of RS 100 crore as a grant to help make the IIS a university that would rank alongside Oxford and Cambridge or Harvard.

The overall annual budget of the institution is around Rs 225 crore of which around 50 per cent is met through government budgetary support; the rest is generated through various externally funded projects and schemes. The institute's Center for Scientific & Industrial Consultancy and Society for Innovation and Development provide the interface and interaction with external customers and collaborators. It allows and helps staff and students to establish 'start-ups' through flexible incubation facilities. The institute has also established an S&T park where it has been able to attract several well-known Indian and international companies to organize joint research centres and undertake collaborative projects. As a result, the institute boasts of some of the best R&D facilities in the India and has developed tenable linkages with its customers. In short, the success of IISc as the power house of innovation and scientific excellence in a difficult Indian milieu, is testimony to its persistent and consistent adherence to excellence arising out of the autonomy it enjoys in academic, human and financial matters which is lacking in state run and/or assisted universities.

Source: Bhojwani (2006).

2.3 India, the largest democracy in the world

The third feature, and one which occupies the limelight of discussions, is of course that India is the biggest democracy in the world. More to the point, it is the biggest democracy characterized by an inefficient public sector.[3] This particular combination makes collective action extremely difficult: the more stakeholders are involved, the slower the pace of reform. Since stakeholders involved in innovation reforms are particularly numerous and diverse (recall our Larry Summers parable for a gist of

3 See World Bank (2006) on problems and solutions on India public service delivery.

diversity), the relevant reforms move with glacial speed or worse, come to a complete standstill.

If the stakeholders' interests prove so cumbersome at the national level management and if government's involvement in innovation is questionable because bureaucracy is a problem rather than a solution, can we propose a mode of government involvement in innovation that takes these two particular features into account? A strategic pilot called India Fund (modelled after Foundation Chile) explores mezzo-level (lower than national but higher than micro-level) level of coordination of multiple stakeholders' interests. To address the problem of pervasive bureaucracy, it piloted a model of private-public partnership where the government puts seed money into a privately-led foundation, but then entrusts its share to a private, professional management team with clear performance criteria.

2.4 Challenges unique to India

The final factor of India's innovation system is that it must face major challenges that are unique to India. How will India meet its transportation needs in 20-30 years from now? Can it simply mimic Western-style reliance on cars? How will it meet the country's energy needs in the same timeframe? Clean energy technologies will have to dominate the energy system, but how to develop such technologies? How to accelerate India's transition to high-value added agriculture (with all the necessary technologies such as weather forecasting available to farmers on just-in-time and continuous basis)? These are just some of the issues on which India's innovation efforts have to focus. In each of these examples (transportation, clean energy, value-added agriculture), India needs to develop its own technological solutions drawing, naturally, on the global cutting-edge in science and technology. For a lack of a better term, this agenda can be called 'appropriate technology agenda of the global economy' with obvious similarities with the familiar appropriate technology agenda of import substitution, but also with key differences.

Although many elements of the relevant technological systems exist and many are available off the shelf, more need to be developed, and crucially, to be put together in a coherent whole. Experience shows that such a complex task of design and implementation cannot be accomplished in a top-down fashion (insistence on top-down blueprints is one reason why the traditional appropriate technology agenda largely failed). The modern view is that Toyota-style design and implementation (benchmarking of options and alternative simultaneous designs, etc.) is the only practical way to design and implement the complex and open-ended technology systems India requires for high and sustainable growth.[4]

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4 One, arguably very controversial idea in this regard, is to explore the creation of an Indian DARPA as a scaled-up extension of the NMTLI programme. Indian DARPA, however, is to be private sector led in the sense that it will follow a venture philanthropy approach when high-net worth individuals (super achievers) transfer managerial experience and personal net worth for resolving major social challenges. Indian DARPA should be an institutionalized alliance between the Bill and Melinda Gates Foundation, super-achievers of India diaspora, the private sector, and the NMTLI programme. The key objective of such an alliance is to design mid-level technologies: open-ended technoeconomic systems providing functional fit between the unique characteristics of India's growth and cutting-edge technologies available in the world.

Any proposal to reform India's innovation system should take into account not only the uniqueness of the country, but also leverage its unique features. The remainder of the paper introduces a reform proposal for leveraging the uniqueness of India's innovation system.

3 Changing the incentive structure gradually: ad hoc incrementalism

Successful implement of innovation reform in India has followed an ad hoc incrementalism strategy. For example, the Council of Scientific Industrial Research (CSIR) has been restructured from an organization based on autarkic technological development for self-reliance to a model based on internationally competitive market driven R&D.

Originally set up in 1942, the CSIR was modelled after the Department of Scientific and Industrial Research in the UK. It predated most other specialized R&D institutes in India and had a wide range of functions, ranging from the promotion of scientific research to establishing R&D institutions and collecting and disseminating data on research and industry. After India's independence in 1947, the CSIR was set up as an independent society under the prime minister. In the first two decades after independence it focused on building up an extensive R&D infrastructure from metrology to R&D for a wide range of industries, with a strong focus on supporting emerging industries, especially small and medium enterprises.

The global energy shock of the early 1970s coincided with three consecutive years of drought in India. In the pursuit of Indian self-reliance, CSIR concentrated on reverse engineering products and process technology primarily in pharmaceuticals and chemicals, glass, and other import-substituting industries; and in adding value to technologies, using domestic resources such as high ash coal, small-scale cement plants, medicinal and aromatic plants.

When after the 1991 crisis India shifted from an inward-oriented development strategy to a more outward and market-driven economy, the focus of CSIR also changed. With the liberalization of trade and industrial policy, firms began to feel more pressure from international competition. CSIR was criticized as being unwieldy and not very effective at converting scientific results achieved in the laboratories to technology for industrial production, and of spending too much effort in 'reinventing the wheel' by focusing unduly on known processes. The demands of the crisis lead to self-examination and a radical change in CSIR's role from technological self-reliance to 'R&D' as its operational model, and to a focus responding to the needs of a more competitive market with world class industrial R&D. Increased emphasis was placed on output and performance, and on issues that were relevant for the income-earning productive sectors. Each laboratory was considered a subsidiary corporate entity; incentives and rewards for meeting targets were introduced, and laboratories were given operational autonomy in relation to how well they delivered on committed output and deliverables. In addition, there have been continuous efforts on further streamlining to improve effectiveness and efficiency.

Although CSIR is going through further restructuring, the results to date have been quite impressive, highlighting the kind of impact a change in the direction and incentive regime of even a very large public research system can have. Between 1997 and 2002,

CSIR reduced number of its laboratories from 40 to 38 and manpower from 24,000 to 20,000. At the same time there was a noticeable increase in output. Technical and scientific publications in internationally recognized journals tracked by the science citation index increased from 1,576 in 1995 to 2,900 in 2005; and their average impact factor increased from 1.5 to 2.2. Patent filings in India increased from 264 in 1997-98 to 418 in 2004-05, while patents abroad increased from 94 in 1997-88 to 500 in 2004-55. CSIR accounted for around 50-60 per cent of all US patents granted to resident Indian inventors. In addition CSIR has increased its earnings from outside income from 1.8 billion rupees in 1995-96 to 3.1 billion rupees in 2005-06 (about US$65 million) from this contract work. Today it has 4,700 active scientists and technologists in 37 research laboratories supported by a scientific and technical personnel of 8,500. Its government grant budget has roughly doubled between 1997 and today, to 15 billion rupees (about US$325 million), so its earnings account for about 20 per cent of its grant budget (based on Bhojwani 2006).

Importantly, New Millennium Indian Technology Leadership Initiative (NMITLI) was launched in 2001 by CSIR as its organizational spinoff. It was to catalyze innovation-

Box 3
Inter-organizational collaboration: examples of successful NMITLI projects

Over the last five years, NMITLI has supported 42 projects involving over 65 industry partners and 222 R&D institutions in India with an estimated outlay of about Rs 300 crore (US$65 million). Some of the key successes and highly visible products:

Successes of NMITLI

- Bio-suite: A versatile, portable software suits for bioinformatics; a multiple tool for carrying out diverse bio analyses. Team India efforts of TCS and ten institutional partners
- Tuberculosis breakthrough: Reduces treatment duration from 6 to 2 months. Team India effort involves one industrial and twelve institutional partners
- Psoriasis: A single plant-based oral herbal formulation. Project network involves two institutional and one industrial partners
- Others: Breakthrough technologies on leather, cost-effective simple office computing platform (softcomp); monsoon-related predictions; mesoscale modelling; lysostaphin; novel biotherapeutic molecule, baggasse

Source: Bhojwani (2006).

Examples of NMITLI programmes

Docosahexaenoic acid (DHA)

Vital nutrients for babies and aged persons

- Reduction in uptake due to food habits
- Identified thraustochytrid strain producing high amount of DHA
- Fermentation process up scaled
- Battery of genes identified and transferred in yeast
- Transfer of genes into sunflower and brassica standardized
- Novel positive selection markers developed
- 16 patents portfolio created

Health care: addresses diseases of the poor, special Indian needs, unmet medical needs; degenerative disorders; life-style diseases; leveraging Indian traditional knowledge space

Towards Indian leadership: tuberculosis, psoriasis, lysostaphin, arthritis/diabetes/hepatoprotectives, eye&vision, and cancer

led development aimed at achieving a global leadership position in a few selected niche areas. The programme aims to turn sound technological ideas into a reality through the systematic development of innovative projects.

NMITLI supports R&D commercialization at the 'proof of concept' stage, by granting financial assistance to institutional partners and soft loans (3 per cent interest) to industrial partners. NMITLI has carved out a unique niche in the innovation space in India and has developed a favourable 'brand image'. Projects predominantly have been in the broad area of biotechnology (40 per cent) and in drugs and pharmaceuticals and chemicals (15 per cent each)—areas in which CSIR has recognized core competence. (see Box 3). NMITLI projects, which are totally government-funded, enjoy an average of about Rs 7 crore per project, the highest of all government technology development programmes. NMITLI projects are carefully monitored and discontinued, if progress is unsatisfactory.

The NMITLI concept should now be scaled up by broadening its scope to extend support for pre- and post-NMITLI programmes, including those beyond national boundaries. Financing pre- and post-activities would help to generate better technology project ideas and accelerate the process of bringing products to market. Opening the programme to international collaboration would help leverage the best minds and facilities within India and beyond, thus enhancing outcomes and returns. Further, the programme should provide grants (currently grants are provided to institutions, but soft loans to private firms) to research institutions as well as private enterprises, thus providing a level playing field in exchange for a share of royalty revenues from successful projects. Further, an independent evaluation should be undertaken by a committee that includes members of the international community. Based on such a review, appropriate changes in the management as well as monitoring of the programme should be introduced.

Indeed, the reformed CSIR and its organizational spinoffs—such as the NMTLI—illustrate that incrementalism has proven to be a successful reform approach which relies on and leverages the unique features of India's innovation system. The challenge is to combine ad hoc incrementalism (taking sporadic advantage of the windows of opportunity) and strategic incrementalism (gradual reform that builds up and culminates in a dramatic change).

4 Undertaking reform by growing: lessons from China

By 1980, China had developed a massive but largely incoherent R&D-system, with 4,690 research institutes affiliated to administrative bodies above the 'county' level, i.e., central, provincial, and regional/city governments, and some additional 3,000 institutes at the county level. Personnel consisted of 323,000 scientists and engineers working in these institutes. The share of R&D expenditures was more than 1 per cent of GDP, a level higher than in any country at a comparable income level.[5]

5 The first three paragraphs of this section draw on Gu (2006).

The reform programme initiated in 1985 had two prongs. On the one hand, 'technology markets' were established to align R&D institutes with the needs of industry, while on the other hand, operational subsidies from the government were gradually reduced. Autonomy in various degrees was introduced to the R&D institutes (in terms of personnel, research projects, and acceptance and use of contractual fees). The *technology market* solution, central in the initial design, had largely failed. Both buyers and sellers faced difficulties in engaging in market transactions: buyers were unable to absorb the transferred technology, while those selling it could not earn enough to secure their R&D institutes because the market was too small.

In response to this drawback, reform policy in 1987 began to promote the *merger of R&D institutes* into existing enterprises or enterprise groups. The merger approach was also largely a failure. Huge gaps between the consolidated institutes, ranging from differences in work culture to administrative affiliations, were hard to overcome. Yet, the drastically reduced R&D subsidies and the resultant budget constrains (recall the second prong of 1985 reform) opened the policy space which facilitated a variety of spinoffs, first by individuals (scientists and engineers creating a spinoff from the 'mother' institute) and later by organizations. In 1988, the Torch Programme was launched to encourage *spinoff enterprises*—called new technology enterprises (NTEs)—from existing R&D institutes and universities.

NTEs became the institutional vehicle to bring together the most dynamic segments of R&D establishment: R&D institutes, universities, S&T staff, and local governments. Local governments contributed to invest in the 'new and high-tech industry zones' as supporting institutions of the NTEs. Scientists and engineers, often in affiliation with their parent institutions, focused on the commercial application of their inventions and expertise.

The strategy of concurrently freeing up policy space for new dynamic elements (from this perspective, the draconian reduction in subsidies was paramount, as it motivated research and experimentation), and introducing explicit measures to encourage the diversity of pilots and organizational spinoffs worked well because it was almost ideally suited for exploiting the tremendous heterogeneity of the Chinese economy and its innovation system.

Freeing up policy space to existing players through the gradual reduction of subsidies provided motivation to search for new solutions and approaches. Explicit measures to promote spinoffs served to create and institutionalize search networks of diverse individuals and organizations looking for new options. In the case of NTEs, search networks brought together federal government officials (who monitored the results of the experiment), industry, R&D institutes, and local governments (who contributed the critically needed resources such as high-tech industry zones, but who also reaped the rewards of high growth).

The result was 'double transformation':[6] high *growth* resulting from self-discovery and the diffusion of new segments of economy, and *reform* of the established structures

6 Note the marked contrast here with Polanyi (1944). His 'double transformation' argued for a need to create social institutions to correct for the alarming consequences of growth under capitalism. In our view, the generalized spinoff dynamics illustrated here with the transformation of China' innovation system has, given adequate monitoring from stakeholders, the capacity to create necessary

supporting them. Another example of such double transformation, taken from another end of the heterogeneity spectrum, is the transformation of rural industries and role of the SPARK programme in this process (Box 4).

To illustrate double transformation, we refer to the birth of a 'new' information and communications industry (ITC), and its economy-wide contribution through the application of powerful information and communications technology (Gu 1996; Gu and Steinmueller 1996/2000). Table 1 illustrates double transformation.

To underline the innovative procedure of new organizations emerging as spinoffs of entrenched structures, Gu and Steinmueller (1996/2000) conceptualize the dynamics as the recombination of capabilities. In our view, however, the process is deeper and more profound. Dramatic reform occurs as new incentives are introduced and institutionalized. Yet, such dramatic revolutionary reform evolves gradually, step-by-step. The recombination of capabilities was exhausted in China by the end of the 1990s and other more coordinated reform approaches became necessary. Yet, 'double transformation' continues.

Double transformation generates a wide range of gradual step-by-step reforms leading to extraordinary changes. The cascade of institutional changes began in the 1970s with agricultural reform that recognized peasants' control over the plots they currently worked, and permitted farmers to sell any surplus over target levels at market prices and for their own account. The result was a sustained increase in agricultural productivity and a rise in rural incomes. In the 1980s another wave of reform allowed the proceeds

Table 1
Double transformation' of China's innovation system

	ICT industry	Machinery	Textile
Growth dimension: Technological gaps	Product architecture	Design engineering Production engineering	Design International marketing
Means of filling the gaps	Application and sales of advanced products	Technology licensing	Access to global knowledge and capital goods
Accumulated capabilities	Design Testing R&D Production	Design Testing Production	Production
Reform dimension: Organizational restructuring	Spectacular spinoff dynamics	Transformation of R&D institutes Transformation of state enterprises	Export-production zones Joint ventures Small local startups

Source: Adopted from Gu (2006).

institutions of growth through expansion. On a central similarity between this perspective on institutional formation and Toyota-style industrial system, see Sabel (2006). On spinoff dynamics, see Ellerman (2005).

Box 4

Harnessing the heterogeneity of China's rural industry and agricultural research system: the SPARK programme

With the emergence of a rapidly growing and dynamic rural non-state enterprise sector in the early 1980s, and with the Chinese government's determination to utilize more actively the science and technology developed in the country in the real sector, the ministry of science and technology initiated the nationwide SPARK programme in 1986. Its overall objective was to help transfer technological and managerial knowledge from the more advanced sectors to rural enterprises to support continued growth and development in the non-state rural enterprise sector, mostly in the TVEs and to help increase output and employment. The programme has now spread to virtually every province and has helped develop 66,700 projects and many more individual enterprises within these. Some 20 million people have found employment in rural areas. Possibly the greatest impact has been the increase in annual per capita income of the rural population in those areas where the SPARK programme has been active. In one TVE in Jingyang County in Shaanxi, there has been almost a threefold increase in per capita income of the county population over the previous five years.

Under SPARK, courses were conducted for trainees, modern training centres were established with modern equipment in computer, video production facilities, language and scientific laboratories. The TVE sector demanded training for rural enterprises, and SPARK responded according, using appropriate methodologies, such as instructional packages, teaching materials, curriculum, and audio/video productions. A computerized technical information system was also set up, with thousands of technical databases for rural enterprises. These network systems provide technical, economic, marketing, and sales channel information to TVEs. Broadcast-quality videos of 'SPARK science and technology' programmes were also developed with a specific target to TVEs and farmers. The project offered technical evaluation training to staff in national, provincial and local SPARK programme offices so as to approach SPARK project evaluation systematically, and to equip them with analytical techniques and sources of information in order to be able to offer quality help to rural enterprises. Another major objective of the national SPARK programme was the diffusion of technical and managerial knowledge from successful projects to non-project beneficiaries.

The most dynamic segments of China's rural industries are drawn to the SPARK programme to increase their productivity and help them expand. SPARK's most successful projects have become pillar industries in their respective 'SPARK intensive' areas, leading to vertical and horizontal integration of related industries either in their own localities or extended to other provinces. SPARK provides a tool for diffusing and scaling-up local success stories. In other words, SPARK is able to harness the enormous heterogeneity of China's rural economy: it not only amplifies the better performing segments but links them to the less advanced areas by assembling packages of managerial, marketing and technical services.

The same heterogeneity principle applies to the transformation of China's agricultural research system. SPARK has become a focal point for drawing and leveraging the best and the most relevant properties from this massive but not particularly efficient system. In this manner, the agricultural research system reorients its staff's incentives towards research programmes that service the needs of rural clients.

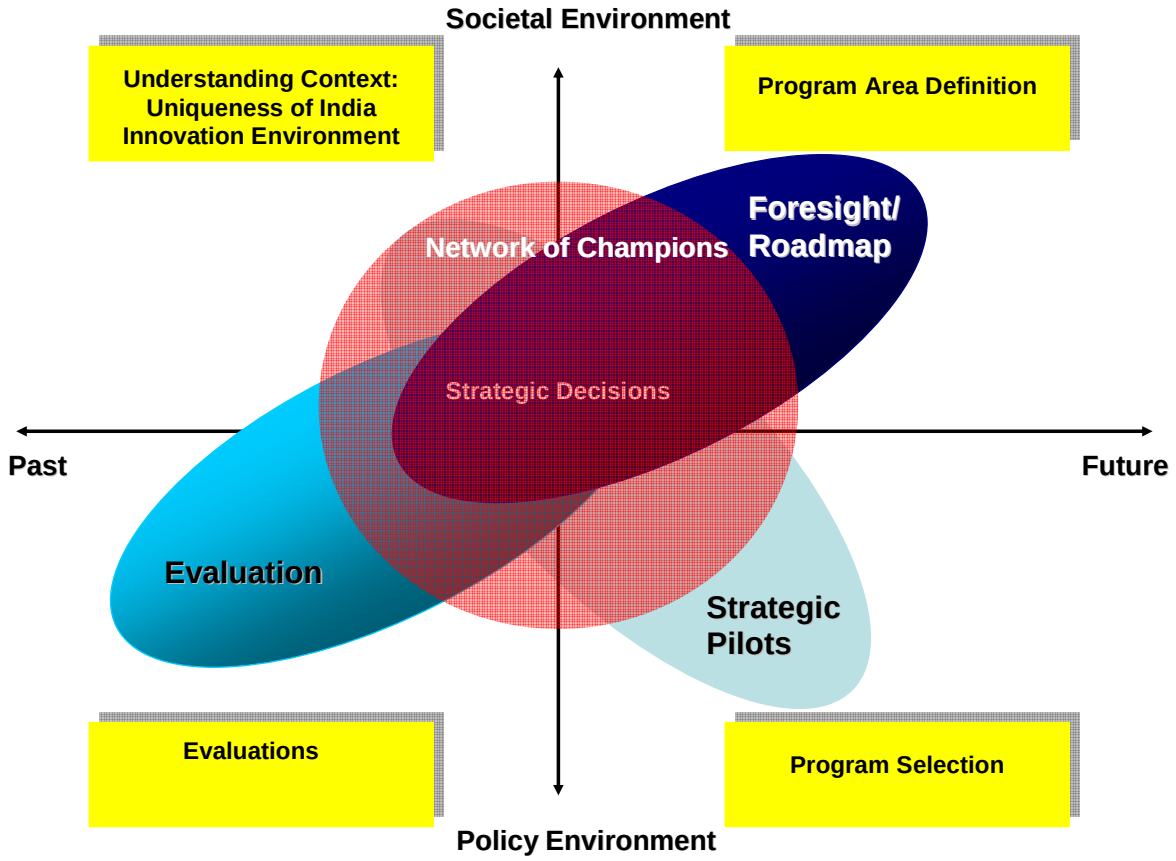
Source: Written on the basis of World Bank (1998); and Huang et al. (2004).

of improved agriculture to be invested in town and village enterprises (TVEs), i.e., municipality-owned manufacturing firms or those co-owned with private parties, with production targeted for both domestic and export markets. Again, proceeds after tax obligations were retained by the enterprise and made available to its stakeholders. The TVEs continued to expand through the mid 1990s, competing with state-owned firms and adding to the modest pressure exerted by the central state for their reform. The TVEs unleashed creativity in China's rural industry, the lower end of the heterogeneity scale. Measures to promote search networks to bring together dynamic segments from diverse fields were important (Box 4).

Changes around the middle of the heterogeneity scale were accompanied and accelerated by partial reforms of the financial system, the opening of export-processing enclaves to foreign firms and joint ventures. At the higher-end of the productivity spectrum, reforming the innovation system through recombination resulted in dramatic changes.

The outcome is a profusion of new institutions that promote investment incentives and efficiency-enhancing behaviour in various domains without ever creating what, from a consensus view, seems to be the essentials of a capitalist economy: China is privatizing state firms very haltingly, has only recently recognized private corporate property as a distinct legal category, and makes little pretence of an independent judiciary.

Figure 2
Elements of strategic incrementalism



Source: Compiled by the author.

5 Strategic changes through incremental steps: strategic incrementalism

Can India learn from China's experience in harnessing its heterogeneity and creating new institutions, promoting growth and undertaking reforms? Building on developments in ad hoc incrementalism, we propose the following for India:

- institutionalizing search networks of champions: continuous monitoring of the progress of reform and benchmarking of what is feasible;
- systematically evaluating programmes and projects;
- designing and implementing a portfolio of strategic pilots that probe economic potentials and establishing benchmarks for action; and
- instigating an innovation foresight process as a deliberative evaluation of the future.

Next, we consider each of these components in turn.

5.1 Institutionalization of search networks of champions

Everywhere, including India, change is driven by champions, individuals willing to risk their reputation on the results of reform. Such an informal group of leaders of key innovation organizations clearly already exists in India. The first priority for this group is to conceptualize, in a series of focused discussions on the 'next steps', the nature of the reform they are collectively promoting. The second priority is to include key decisionmakers from the national planning commission, the ministry of finance, and the Indian diaspora in these deliberations.

Reform being designed and implemented incrementally cannot have a clear blueprint. Whereas complex problems are solved in traditional hierarchical organizations by reducing them to simple tasks, and then aggregating the results of the simplified operations, reform of the Indian innovation system relies on solving complex problems by seeking out individuals who are already resolving (a part of) them. These systems of linking global expertise to local circumstances are called *search networks.*

What is required is a credible search network to link the champions from innovative communities, key economic decisionmakers and selected members of the diaspora, who could serve as antenna for new trends to be reflected in strategic decisions. To illustrate our point, we review the example of Taiwan.

When the Taiwanese government decided to promote venture capital industry in the beginning of the 1980s, it had neither the capability, nor the blueprint for doing so. There was opposition to the idea because the venture-capital concept was foreign to traditional practices, in which family members closely controlled all of the financial affairs of a business. Entrenched interests wishing to maintain the status quo were strong. Through intense interaction with Taiwanese expatriates in Silicon Valley, new institutions provided matching capital contributions to private venture capital funds. One example is the Seed Fund, with initial allocation of NT$800 million which later was complemented with an additional 1.6 billion.

Two American-style venture funds—H&Q Asia Pacific and Walden International Investment Group—were created in the mid-1980s. They were managed by US-educated overseas Chinese who were invited to reallocate to Taiwan. Once the first venture funds proved successful, domestic IT firms created their own venture capital funds. After those became profitable, even conservative family groups started to invest in venture capital funds and IT businesses.

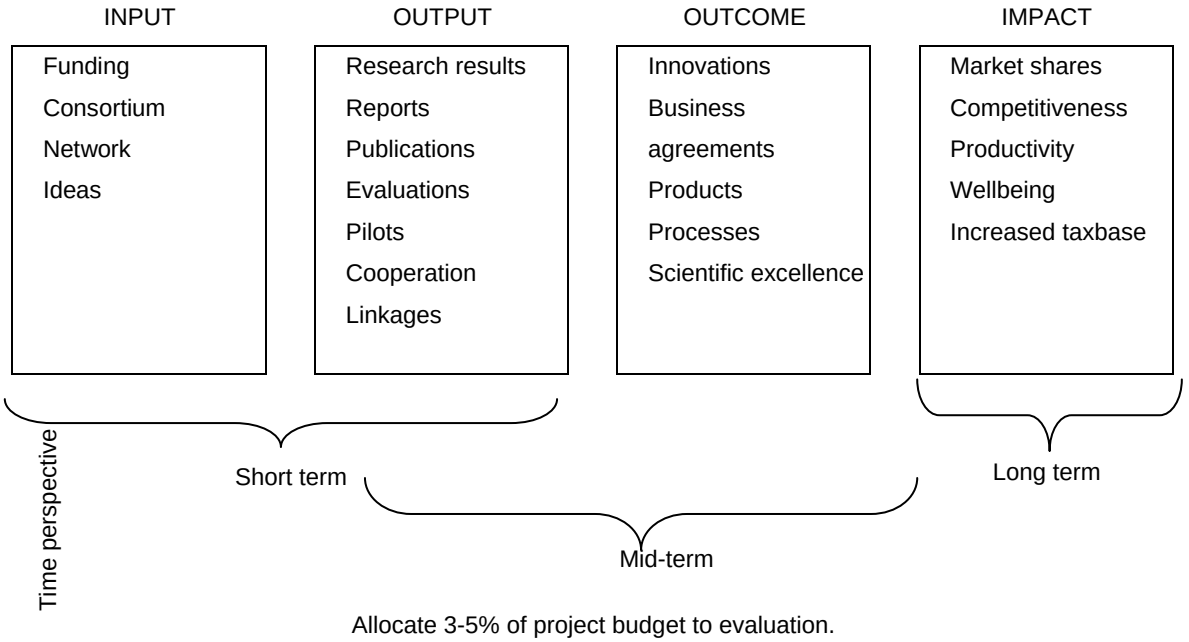
The search network initially consisting of key dynamic and forward-looking members of the Taiwanese government and leading overseas Chinese engineers in Silicon Valley was central to the modern venture capital industry emerging in a very unlikely place that had been dominated by conservative and risk-averse business groups. Although this network lacked a blueprint, it did have Silicon Valley as a role model, and a clear idea of 'what to do next'. By defining each subsequent step of the process, the network expanded, eventually encompassing also the sceptics and opponents as well.

5.2 Systematic evaluation of programmes

Evaluation is a management tool, linking the impact of programmes with budget allocation decisions. Figure 3 illustrates key concepts of the evaluation of innovation programmes: inputs, outputs, outcomes and impact and their respective timeframes.

Key issues in the design of a national programme evaluation process include concerns with respect to cost-effectiveness criteria. It is important that outlined evaluation criteria are transparent, objectives clear, and application of the criteria measurable. The cost effectiveness of the process must also be factored in when designing an evaluation process. Incorporating widespread use of ICT could be a step towards greater cost effectiveness.

Figure 3
From inputs to impact: long-term time horizon in innovation



Allocate 3-5% of project budget to evaluation.

Source: OECD (2003)

To avoid potential conflict of interest in implementing a national procedure for programme evaluation, the monitoring and evaluation processes should be separate. While monitoring and ex post reviews should be carried out by a neutral third party, ex ante evaluation can be carried out within the programme itself, to facilitate linking the programme's key financial decisions to evaluation. International projects should be evaluated and monitored in the same manner as national projects, bearing in mind national benefits, objectives, and demands.

Optimal would be a 3-5 per cent of the programme budget allocated to evaluation. While evaluation ideally should be a management tool, i.e., evaluation results should affect decisions relating to budgetary allocations, this can initially be an over-ambitious goal. Programmes that, based on evaluation, are likely to be found to be inefficient will resist regular review procedures. Again, this is the problem of political economy in managing the entrenched interests. To ameliorate the problem, such feedback should be made public. The mere fact of public access to impartial evaluation results will provide a strong disciplinary element and pressure relevant agents to change established procedures and improve performance.

5.3 Portfolio of strategic pilots and its deliberative evaluation

Strategic pilots should examine new organizational models, test their feasibility, and in this way harness the unique features of India's innovation system. These pilots are strategic because they introduce all the features of the reformed innovation system: accountability for results, built-in incentives for collaboration and structures of governance for the continuous redesign of the pilots. In that sense, they are elements of the desired innovation system.

The four features of India's uniqueness (unparalleled heterogeneity of the economy; pressure on the elite organizations to open up; unique complexity of the concerted action problem, and the need for new solutions to address India's major challenges) were discussed in section 2. Here we examine four pilots to address each of these challenges in order to get an idea of how pilots can signal and design new strategic solutions.

Strategic pilot 1: A new agenda for India's talented diaspora: piloting new organizational solutions

Diaspora is a part of India. Both share the same culture, history and understanding of the unique problems of the country. But it also constitutes a part of the global knowledge and hence understands the possibilities knowledge can bring. India's diaspora has been crucial in spurring private sector growth, namely outsourced IT, and later outsourced knowledge process. The new challenge now is to make a similar contribution in the delivery of public services, particularly in education and health, and especially in the less developed states.

A pilot on new delivery modes of non-communicative (non-infectious) diseases that relies on the ideas, projects and contributions of India's expatriates and which is currently being developed by the ministry of non-resident Indians is one example. Why would successful Indian doctors, epidemiologists and engineers residing abroad return to Bihar, a state considered to be underdeveloped or backward? The answer is that they

do not need to make a permanent comeback, merely periodic visits. More to the point, the commitment of talent to organizations abroad usually is not a constraint to diaspora contributions. Rather, it is first and foremost the lack of commitment by the local public sector and its inability to find space in projects that can be monitored for utilizing the energy, knowledge and resources of the expatriates. Once such projects are defined and diaspora involved in their implementation, their contribution can be crucial. The second constraint is one of logistics and bureaucracy. Many medical professionals, particularly retirees, would be willing to engage in projects for a limited time, but are faced with problems of finding temporary residence or other logistics. A pilot could alleviate both constraints by finding an organizational model to transform the interest of the diaspora into specific projects. One such model is the GlobalScot (Box 5).

GlobalScot operates mainly with private sector talent so the model cannot be duplicated in the private sector domain, yet the procedure that enables transforming general interest so as to involve diaspora in specific commitments deserves closer examination.

The Bihar pilot would focus on the lower end of India's heterogeneity. At a higher end, a private early-stage fund could be established in Karnataka with diaspora participation. The Taiwan venture capital example mentioned earlier illustrates one general approach to an early-stage pilot involving expatriates.

Box 5
From a general interest to specific projects: the GlobalScot network

GlobalScot is a highly innovative and successful network of about 850 high-powered Scots from all over the world who use their expertise and influence as antennae, bridges, and springboards to generate projects in Scotland. GlobalScot forms a part of the Scottish Enterprise—Scottish Economic Development Agency. The search role of diaspora members can be illustrated by the following:

- An inward investment project identified by one of the first members to join GlobalScot brought an internet licensing company to Glasgow. The company, which, initially employed eight people, will 'quickly become a multimillion pound business', according to the company's founder.
- At a crucial stage of its negotiations with a US blue-chip company, a Scottish electronic engineering company received, within a day of its request, a full day's advice on how to negotiate a licensing deal.
- A specialist training provider to the international oil and gas industry looking for an entry point into the Gulf of Mexico was connected to a GlobalScot member who was the former president of Enterprise Oil, Gulf of Mexico. The member introduced the firm to oil and gas companies in the region, which led to cooperation with several of the companies and a firm foothold in the market.
- A company specializing in creating virtual characters for gaming software made valuable connections with a number of GlobalScots during a trip to California for an exhibition. A director at the company described the contacts as 'an absolute bull's-eye target for the type of business advice needed... people you would never dream of trying to reach, as there would usually be about a dozen gatekeepers between you'.
- A GlobalScot member who is vice-president for production procurement at IBM donated one day a month to work with Scottish Enterprise's electronics team, providing insight into the global electronics sector by advising on new product developments, growing and shrinking markets, and new opportunities.

Source: Compiled by the author.

A critical question is how to gauge whether the pilots are succeeding and, if so, how to scale and diffuse them. This is a function of the so-called deliberative evaluation: information pooling from the pilot's implementation, and discussions among all concerned parties as to what should be the 'next step' for the pilots. The Ministry of Overseas Indian Affairs can adopt a new role for itself by focusing mainly on the design and continuous deliberative evaluation of the pilots. We would, in fact, argue that it should be its main role. By mastering and focusing on such a new function, it would be providing an important signal for other government agencies.

Strategic pilot 2: High-quality, mass-market higher education as a spinoff of IITs

India is not the only country facing a conundrum of elite institutions that need to adapt to the changing societal environment.

The Monterrey Institute of Technology in Mexico is a premier private education organization comprising a network of 33 campuses all over the country. It is a franchise system of local campuses, each financed and governed by local private sector leaders. Its Virtual University is a worldwide leader in remote learning, championing an ongoing, continual education agenda all over the Spanish-speaking world and making inroads into such giant markets as China. To reach students with limited financial resources, the Institute launched a spinoff—TecMilenio (Millennium University)—designed to combine the high level of teaching associated with the Tec de Monterrey brand with education at dramatically lower costs. By May 2004, approximately 10,000 students were enrolled, with the per student costs approximately three times lower than in the parent organization. What are the main factors that allowed this dramatic reduction in costs without a compromise in quality?

The curriculum is designed and often delivered through the management of private sector firms. TecMillenium shares offices in some instances with these firms so that students and teachers often work, learn and teach in the same location. To tap the best professors and courses, distance education is commonly utilized. Pedagogy is based on problem-solving and conceptual tests. Yet, testing is standardized and centralized. Teaching remuneration is based on student test results. The small management structure draws on carefully selected professors from Tec de Monterrey staff and translates the needs of industry into pragmatic curricula. Thus the vested interests of professors sometime perpetuating decades-old material are curbed: content is determined by the needs of the industry. TecMilenio hopes to achieve a student enrolment of 100,000 by the year 2010.

TecMilenio is a spinoff from Tec de Monterrey. Drawing on the strengths of the parent university while evading the unavoidable rigidities of established organizations, TecMilenio is evolving into a 'lean and mean just-in-time' system of low-cost learning, quite different from the educational model of its parent institute.

Based on this example, to introduce low-cost high-quality education, we propose a spinoff similar to the IITs.

Strategic pilot 3: Establishing Foundation India as an incubator of search networks in order to open new avenues for the economy

As is well-known, India is a leader in knowledge process outsourcing, which became the major development in the decades around the millennium. Public debate is centred on what could be 'the next big thing' for India: the new avenue of learning to give India global recognition. This perspective is compelling, valid, and inspiring, yet is usually focused on a single possibility, a major high-tech company such as a future 'Google of India'. Understandable, but such a perspective ignores key possibilities for the future.

Even within the confines of a high-tech innovation agenda, the 'next big' thing could also be a cluster of middle-sized companies (some of them expanding into major companies), as exemplified by the Israeli biotechnology cluster. Second, and more importantly, a mid-tech agenda—distinct from both the export-driven high-tech agenda (which seems to dominate the limelight) and the indigenous informal technology agenda that focuses on the very poor and their related technology—could over the coming decade become the next 'big thing' in India. Israel (prior before its innovation takeoff in the beginning and mid 1990s), and Taiwan (prior to its venture capital boom in the end of the 1990s) are two highly relevant benchmarks for India. In both cases, the innovation takeoff relied upon (and would have been unthinkable without) high-tech talent abroad. Highly innovative government programmes were established in both countries to tap into relevant global management and marketing networks in Silicon Valley and other similar places. Such programmes adapted and adopted to the Indian reality seem indispensable in the search for the 'next big thing' in high-tech innovation agenda.

Although many elements of the relevant new innovation clusters already exist and are available off–the-shelf, many more need to be developed, and aligned into a coherent whole. Experience shows that the complex task of design and implementation *cannot* be accomplished in a top-down fashion or with top-down coordination. This is an important message for India, as proposals to establish a science and technology super-ministry embodied with extraordinary powers are still popular. Insistence on top-down blueprints is one reason why the appropriate traditional technology agenda largely failed.

We propose Foundation India to be established as a hub and springboard of private-public search networks. Foundation India could be conceived of as a private-public entity with an endowment of US$100-300 million, with the autonomy to develop and provide (in collaboration with the private sector) seed financing for the purpose of generating demonstration effects of how new technology can address mundane but pressing issues of everyday life in India (examples include, but are not limited to, clean energy technologies, value-added agriculture, appropriate transportation solutions, etc.).

In order to succeed, Foundation India would need to perform two tasks simultaneously:

- Project development: scan the world in search of appropriate technologies, adopt these to India's needs and ultimately develop them into commercially viable projects;
- Seed capital financing: provision of seed capital to some of the projects as demonstration and to trigger to venture capital industry and other sources of finance.

Box 6

Project selection in Foundation Chile as an example of deliberative evaluation

Only in the aftermath of the 1982 economic shock did the Foundation develop the activities that define it now. Sharp devaluation, low domestic interest rates and high uncertainty produced a situation favourable to domestic investment but with nationals unwilling to invest. Seeing an opportunity in salmon farming, the Foundation decided to launch the firms itself, hoping that success would lead to imitation and complementary activities. Thus it acquired the necessary technology, free, from specialist public agencies in the Pacific northwest of the United States, and founded one firm to produce smelts, another to develop the hatching and ranching technology for Chilean waters and a third for smoke-curing fish. From these firms evolved the Chilean salmon industry, which now produces exports valued at US$600 million annually.

In the next two decades the Foundation's model of supporting development was refined in three crucial ways. First the Foundation shifted from creating start-ups itself to co-venturing with outside partners. Whereas during 1985-93, 87 per cent of the start-ups were totally owned by the Foundation itself (and only one of the joint ventures involved a foreign partner), during the period 1994 to 2004, 75 per cent of the start-ups were joint ventures, and six of these were with foreign firms. Thus the Foundation went from spinning out projects developed internally to networking with outsiders to create projects. Second, technological complexity of the projects increased, with biotechnology in particular becoming more important. Since projects, such as new vaccines, development of pest-resistant fruit varieties, often required the integration of scattered intellectual property and diverse technical tools for genetic manipulation, many of the external partners had to construct networks of their own to serve the specific needs of the emergent companies. Thus the Foundation, in effect, builds search networks linking global knowledge with local capabilities.

Third, the Foundation's own project selection and review mechanism became more explicitly comparative and competitive. Staff members, hired on the basis of demonstrated technical knowledge and familiarity with the markets and business practices in a particular sector, apply for internal grants to develop a plan for launching a new venture in some general area. The best of these preliminary plans can be used to apply for a second, longer-term grant to develop a new business venture, typically in partnership with outsiders; and so on until the proto-venture becomes a candidate for seed capital and enters the familiar sequence of venture capital financing. So far, at least, the transparency inherent in the broad and continual benchmarking of projects at every stage has also functioned as an effective governance mechanism, assuring that public funds are indeed directed towards public purposes, as best these can be defined at any moment.

Source: Based on Fundación Chile (2005).

One benchmark for the proposed Foundation India is a similar arrangement in Chile. The Foundation Chile was created as a nonprofit corporation by the Chilean government in 1976 with a US$50 million in payment by conglomerate ITT as part of an indemnity agreement for the expropriation of its national telephone subsidiary. Under the terms, ITT was to manage the new facility for ten years, but its initial efforts were not successful: its first director-general, who was a semi-retired food ITT research scientist, steered the new institution towards the provision of social services such as school lunches and nutrition for infants. A year later he was replaced by the head of ITT's Spanish telecommunications laboratories, who improved the Foundation's project-management skills, but who favoured dedicating the Foundation to telecommunications

projects, for which there was no market, and foodstuffs for which the markets were incipient. The related dialogue on the shortcomings of the suggestions, however, drew attention to opportunities in renewable resources—principally forestry, aquiculture, horticulture—which became the lasting focus of the Foundation (Box 6).

Strategic Pilot 4: Leveraging venture philanthropy to address India's challenges

The so-called venture philanthropy relies on the following principles:

- tapping into new sources of finance, such as the wealth of super-achievers;
- recognizing that managerial expertise and knowledge, and new organizational solutions, rather than money, are the most important contribution to development;
- support to managerial teams that pilot new solutions: Following the lead of venture capitalists, venture philanthropists remain personally involved in these managerial teams;
- focus on deliberative evaluation: systematic discussion of the elements in new approaches that work and those that do not;
- focus on leveraging other resources, including those of the government through strategic alliances.

Following the venture philanthropy approach, what we propose is the creation of a civilian version of the famous US DARPA as an extension and scale up to the NMTLI programme. Indian version of DARPA could be started as an alliance between the Bill Gates Foundation, the super-achievers among India's diaspora, the private sector, and NMTLI programme.

5.4 Innovation foresight process as a deliberative evaluation of the future

Foresight offers challenging visions of the future and transforms them into effective present-day strategies through the provision of core skills in future science-based projects and unequalled access to leaders in government, business, and science. The process of foresight attempts to identify potential opportunities for the economy or society from innovative science and technology, and considers how future technology can address society's key challenges.

The Technology Information Forecasting and Assessment Council has conducted a number of long-term forecasts for India (in auto parts industry, for instance). However, the foresight process we propose for India differs from forecasting methods in a number of ways. It is participative, with the processes receiving as much emphasis as the outcomes because of their need to develop a shared vision across independent agencies. It is long term, with perspectives taken as long as 25 years in terms of direction and tendencies, although resource plans and implementation elements are usually much shorter, typically with three to eight year horizons. It is focused on needs rather than technologies, emphasizing the key trends in society's changing needs for products and services and the contributions that knowledge and research in science and technology in particular are likely to make in achieving increased wellbeing.

Early efforts using this type of foresight approach were carried out in the UK in the 1990s but have now been widely adopted throughout the EU and elsewhere. They have proven particularly useful in defining longer-term needs and helping to develop the creative linkages from which innovations emerge. The methodology, in summary, entails:

- a steering group, comprising leaders from the three main constituent communities: government, academia and business;

- a secretariat to identify the main participants (usually through some variant of a co-nomination exercise), to initiate and shape discussions (initial position papers, arranging and orchestrating working groups), and to draw together, in conjunction with the working groups, individual contributions into an integrated summary;

- an organized programme of semi-autonomous working groups, by topic lines (which reflect a mix of key needs and strategic technologies) to undertake analysis, evaluate evidence and reach conclusions regarding the designed timeframe and to produce a summary report on their evidence, findings and prognosis;

- an integrative effort, usually conducted by chairpersons of the working groups and the secretariat to integrate the efforts of the groups into a single entity, and develop a strategic level conclusion from the entire effort, usually suggesting lines of action and priorities for resource use over a shorter timeframe.

In parallel with the written papers, one important output is the cohesion that emerges from the collaborative process and a broad ownership, although not necessarily universal, of the strategic lines and priorities for future action. It provides government, academia and business with a template as reference for their efforts in the future. In several cases, the exercise has been taken to a lower level of aggregation: converting national foresight exercises to the regional level, for example. Exercises are repeated, and analyses and conclusions updated using the same procedures, although reduced at times in scale and scope, for example, to three to five year cycles to ensure that they remain relevant and take into account both intervening scientific progress and changes in the needs of society.

Promotion and dissemination efforts are then initiated to ensure widespread awareness of the findings and conclusions of the reports, adding to the shared vision of goals and reducing information asymmetries across target audiences. This also enables the findings to be incorporated into public policy and budgetary cycles and into strategic decisionmaking in the enterprise sector. Academic bodies have also used the reports in determining the allocations and priorities for selective efforts in research and teaching.

With the foresight reports as a guide, the steering group could use their prestige and influence with the concerned independent executive agencies to direct resources to fund programmes that are recognized in the findings of the reports. Next, monitoring and evaluation would follow, along the cyclical lines described earlier.

One of the consequences of the foresight process is the articulation of poorly structured issues that are of concern to everyone. For instance, widespread ramifications of an

Box 7

Foresight processes in Canada and the Netherlands

Technology road maps (TRM) for industry R&D: Technology road mapping is a planning process driven by the projected needs of tomorrow's markets. It helps companies to identify, select, and develop technology alternatives to satisfy future service, product or operational needs. Via the TRM process, companies in a given sector can pool their resources and work together with academia and governments to look five to ten years into the future and determine what their specific market will require. The TRM process is led by industry and facilitated by Industry Canada.

Strategic Project Grants Programme of the Natural Sciences and Engineering Research Council of Canada (NSERC): The Strategic Project Grants Programme funds project research in target areas of national importance and emerging areas that are of potential significance to Canada. The research is at an early stage with the potential to lead to breakthrough discoveries. Targeted areas are identified in consultation with experts from all sectors.

Identifying opportunity for leapfrogging: This is a new body created by NSERC to provide advice on the key areas where Canada may have an opportunity to leapfrog into the front ranks of research in the natural sciences and engineering. The NSERC Circle comprises all the recent winners of NSERC E.W.R. Steacie Memorial Fellowships and the Gerhard Herzberg Canada Gold Medal for Science and Engineering.

In the Netherlands foresight processes are conducted by a number of advisory bodies. The Royal Netherlands Academy of Arts and Science engages in foresight processes from the perspective of promising scientific developments. Several other bodies conduct or are involved in the foresight processes from the perspective of knowledge demand. For instance, the Sector Councils, which cover a broad array of societal sectors, draw up research agendas formulated on the basis of inputs from government, science and the sector involved. A recent example of a priority-setting mechanism with a direct follow-up in investment funding is the ICES-KIS programme which involves extensive consultation with various stakeholders.

Source: OCED (2003).

aging population emerged as the unexpected outcome of the first foresight process in UK. A nationwide foresight process in India can start with a focus on the country's thematic challenges, such as access to clean water or road congestion.

Let us now come back to the agents of change—search networks of champions. These networks are consolidated through the deliberative evaluation of projects and programmes, the 'next step' discussion that takes into account the lessons emerging from the implementation of projects and relevant international best-practices. To illustrate this principle, we use the example of a leading multinational: Nokia. Many of its labs (called lablets, a name borrowed from Intel which pioneered them) are intentionally co-located at major research universities. Their success is judged by the impact they produce in attracting young talent, graduate students. But that cannot be the only criterion for evaluation: it is possible that talent is being attracted because instead of the opportunity of conducting potentially interesting research for private sector in general and for Nokia in particular, the attraction may be the selection of topics. Indeed, if such applied research is conducted, there needs to be a discussion on how it could be

relevant for Nokia, and how to attract relevant graduates to Nokia. What is usually expected from a formal evaluation is dialogue, not a set of figures: a mini-innovation foresight on its own.

For each strategic pilot (including innovation foresight itself), a similar deliberative evaluation needs to be set up. Many uncoordinated and isolated programmes could be aligned through such a deliberative evaluation, as it allows transforming piecemeal actions into coordinated strategy. Ideally, there should be a body to pool information and lessons from specific pilots and projects from different domains of innovation. Such a new function could become the single most important responsibility of the re-designed National Knowledge Commission (NKC) but of course the NKC is not the only candidate for this function; another candidate could be an agency to coordinate national innovation foresight (see Box 7).

6 'Double transformation': summary of the main principles

The analysis of policymaking and policy implementation is an emerging branch of literature on innovation. Usually policy prescriptions follow as an afterthought of positive analysis, with the assumption that there is little that can be said about implementation of policies. This paper attempted to consider the 'how to' issues of reform of the India innovation system. Because of the focus on political economy, it is written in a different style compared to the rest of the report. Analysis in this paper is more controversial and, by necessity, is based less on statistical data than on observations of institutional evolution. Benchmarks from countries as diverse as Scotland, Finland, Mexico, and Chile were discussed and the emphasis was on the best practices of emerging economies as being more relevant for India's institutional environment.

Here is a summary of the main principles underpinning our analysis and recommendations.

6.1 Reliance on diversity within existing institutions as the 'Archimedean point' with which to leverage reform and change

India's public sector record in coordinating innovation efforts can be notoriously fragmented and inefficient, but some sections perform better than others, and there are recognized pockets of excellence virtually within every ministry or public sector organization. The same internal diversity is even more visible in the private sector. Importantly from a policy perspective, better performing segments of the public sector and of the productive sector are beginning to join forces in a variety of private-public partnerships and programmes in a coordinated effort to overcome the binding constraints and to develop new projects.

6.2 Reliance on search networks linking better performing segments of the economy

Search networks are networks of individuals and institutions solving complex problems by finding individuals who already are working on the solution to (part of) the problems. The proposed strategic pilots show how to institutionalize emerging search

networks to bring together champions from private and public sectors and India's talent abroad. Search networks sustain change and reform by linking better performing segments of Indian economy.

6.3 Aim for 'double transformation'

This principle is about the creation of appropriate context for reform. Reform which starts from the better performing and more entrepreneurial segments of the economy are more likely to succeed. The demonstration effect of growth makes the diffusion of reform to other segments of the economy easier. It also neutralizes the resistance of vested interests. Growth is more likely to provide space for self-reinvention at least among some segments of the entrenched interests and to define their position in a new reform scenario. China is the paragon of double transformation, but in India, too, a strategy of ad hoc incrementalism relied on this policy principle in substantial ways.

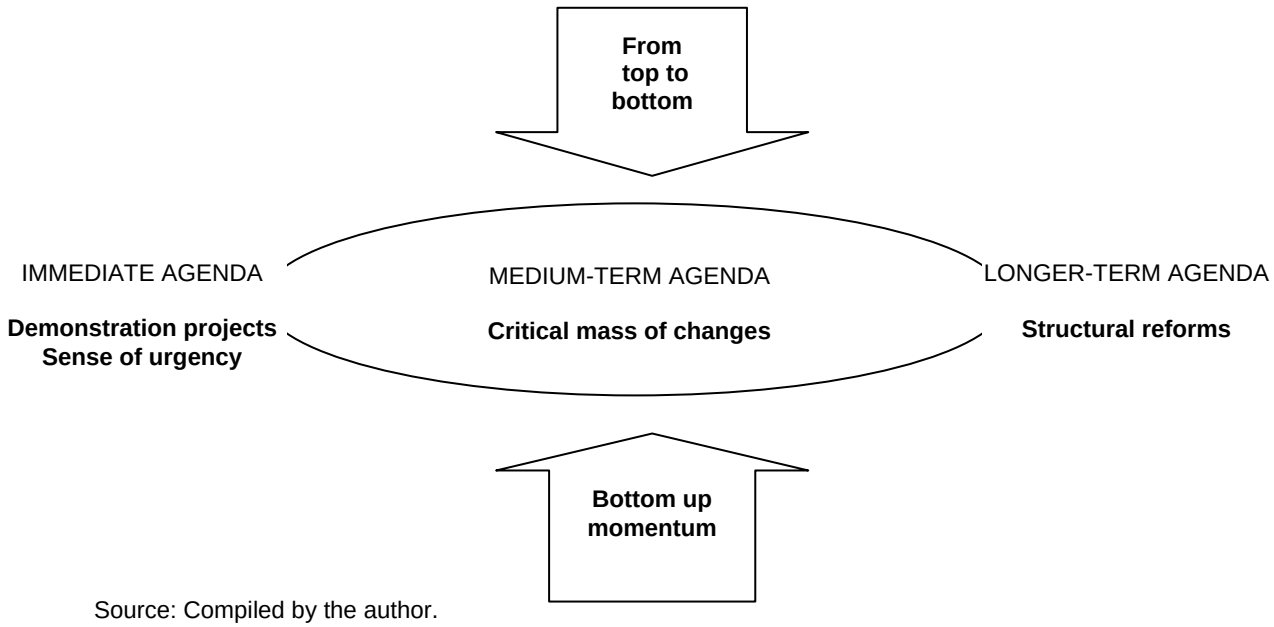
A new impetus for change in the Indian context could be achieved by focusing reform efforts on the major challenges the country faces, such unique transportation, clean water, energy solutions, etc.

6.4 Reliance on top-down measures to free up policy space

Programmes, policies and projects cannot be multiplied ad infinitum. The introduction of new pilots means cutting down on existing programmes. This not only provides budget space to trigger piloting and experimentation but, more importantly, provides the correct incentives for players to perform. Underperforming projects are scaled down, and released resources reallocated to test new approaches.

A pragmatic agenda for change often implies focusing on bottom-up entry points (the immediate policy agenda), scaling them up to ensure coordination and concerted action

Figure 4
Virtuous circle of growth and reforms



Source: Compiled by the author.

(the medium-term policy agenda), and then moving on to major reforms (the longer-run policy agenda). The art and craft of policymaking is about sequencing the various horizons of a policy agenda in a virtuous circle of growth and reforms. A pragmatic agenda to get around the many institutional rigidities faced by India is needed in order to: (i) create momentum for change by fostering stakeholder awareness in order to (ii) get a consensus on tackling some of the key obstacles at the national level (to enhance demand for an institutional change); and then (iii) moving ahead with concrete, manageable bottom-up approaches that can serve as demonstration projects to advance the larger agenda (Figure 4).

6.5 Be humble and ambitious at the same time: bootstrapping approach

Being humble and ambitious at the same time is about bold vision and strategic change in the long-run, albeit gradual implementation. It is about bootstrapping—of incremental bottom-up changes in which a favourable balance of risks and returns encourages the first steps from many diverse entry points. In this process, each move increases the chances of initiating the virtuous cycle of institutional reforms and private sector development (Dorf and Sabel 1998). Policymakers considering bootstrapping need to be prepared for unexpected coalitions for reform.

The prevailing view of reform starts from the design of a blueprint for change, a blueprint with a known outcome. In the proposed ‘strategic incrementalism’ approach, the institutional outcomes are open-ended, and an attempt to draw a blueprint is considered a remnant of central planning. To detect problems and errors, policymakers should constantly monitor and benchmark the process of reform and restructuring.

Acronyms

CSIR	Council of Scientific Industrial Research (of India)
IISc	Indian Institute of Science
IITs	Indian Institutes of Technology
ITC	information and communications industry
NMITLI	New Millennium Indian Technology Leadership Initiative
MNC	multinational national corporations
NTEs	new technology enterprises
TVEs	town and village enterprises

References

Bhojwani, R. H. (2006). 'Innovation Organizations in India'. Background paper. Washington, DC: World Bank. Available upon request.

Clark, G., and S. Wolcott (2003). 'One Polity, Many Countries: Economic Growth in India, 1873-2000'. Available at www.economics.pomona.edu/Andrabi/Economic %20Development/India%20Country%20Study%20(Clark).pdf

Dorf, M., and C. Sabel (1998). 'A Constitution of Democratic Experimentalism'. *Columbia Law Review*, 98 (2): 323-27.

Ellerman, D, (2005). *Helping People Help Themselves: From the World Bank to an Alternative Philosophy of Development Assistance (Evolving Values for a Capitalist World)*. Chicago: Michigan University Press

Fundación Chile (2005). 'Una oportunidad para Promover la Creación de Negocios Innovadores en Clusters Claves'. Santiago: Fundación Chile.

Gu, S. (1996). 'The Emergence of New Technology Enterprises in China: A Study of Endogenous Capability Building via Restructuring'. *Journal of Development Studies*, 32 (4).

Gu, S. (2006). 'Policy Process and Recombination Learning: China in the 1980s and 1990s'. Paper prepared for the Asia Innovation Forum, Innovation Policies and Institutions for the Knowledge Economy, 30 November. Seoul.

Gu, S., and W. E. Steinmueller (1996/2000). 'National Innovation Systems and the Innovative Recombination of Technological Capability in Economic Transition in China: Getting Access to the Information Revolution'. UNU-INTECH Discussion Paper 2002-3. Maastricht: UNU-INTECH.

Huang, C., C. Amorim, M. Spinoglio, B. Gouveia, and A. Medina (2004). 'Organization, Programme, and Structure: An Analysis of the Chinese Innovation Policy Framework'. Aveiro: Department of Economics, Universidade de Aveiro, Aveiro. Available at: www.idrc.ca/en/ev-55213-201-1-DO_TOPIC.html.

OECD (2003). 'Governance of Public Research. Toward Better Practices'. Paris: OECD. Available at: www.oecd.org/document/51/0,3343,en_2649_34269_15429043 _1_1_1_1,00.html.

Polanyi, K. (1944). *The Great Transformation*. Boston. Beacon Press.

Sabel, C. (2006). 'Bootstrapping Development: Rethinking the Role of Public Intervention in Promoting Growth'. Unpublished Manuscript.

Tewari, M. (2006). 'Adjustment in India' Textile and Apparel Industry, in Environment and Planning, 2006'. Available at www.envplan.com/epa/fulltext/a38/a38279.pdf

World Bank (1998). 'China: Rural Industrial Technology (SPARK) Project, Implementation Completion Report 18126. Washington, DC: World Bank.

World Bank (2006). *India Country Economic Memorandum*. Washington, DC: World Bank.