Innovation *in* India

Combining Economic Growth with Inclusive Development

Edited by
Shyama V. Ramani

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I would like to dedicate this volume to

All the contributors of this book and their families,

And in particular to my own family and parents -
Kalyani and M.S. Venkataramani,

And to my cheer-leading team: Raji, Raja, Divya, and Vivek.

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Prologue

This collective volume is a testimony to how an informal network bound by a common motivation can generate an innovation – namely, this book! It all started with a visit to New York in 2005 at the invitation of Professor Claude Henry of the Ecole Polytechnique in Paris. He told me that Professor Richard Nelson was organising a meeting with Professor Jeffrey Sachs to get economists together to discuss how technology and innovation could contribute to the attainment of the Millennium Development Goals and that I would certainly enjoy the brainstorming. Dick, as Professor Nelson is fondly called, is one of the fathers of evolutionary economics and the national system of innovation approach – subjects I knew only by name at that time. The meeting was fascinating. I had never before gone to a meeting with so many economists to simply brainstorm and debate about what would be good to study. After listening to Dick, I have become his devoted disciple. I totally loved his style of teaching and his generosity in imparting knowledge and holding stimulating discussions. I began to work with him and Franco Malerba, one of his many loyal students, on a book dealing with sectoral systems of innovation in a set of developing countries[1]. Now, Dick did not just solicit authors to submit chapters. He organised meetings and there was a lot of debate on the contents and it was a collective process of knowledge generation, coordinated by him and Franco. I learnt a lot from working with Dick. And it just occurred to me that we should be doing something similar on India.

Why did I want a team? Well, India is a big country. It has a lot of industries and a lot of poor people. The dynamics of innovation generation is different in different sectors, and when targeting different communities. This multidimensional subject cannot be deeply analysed by only one scholar. It requires a team and a collective process of knowledge generation.

[1] Franco Malerba and Richard Nelson (editors), *Economic Development As a Learning Process: Variation Across Sectoral Systems* (Edward Elgar, 2012).

Right from 2006, I started talking to those who I thought might be interested in working on this book. They were academics I met in different conferences, especially GLOBELICS[2], which is the main international meeting place for scholars interested in sharing ideas on how technology and innovation can spur development and growth. But I did not have money to organise meetings. I had no research contracts. I just had strong intentions. So the process of putting the book together has been somewhat slow. There were some wonderful takers and a few leavers. Indeed, every individual who has contributed a chapter to this book is a scholar who was personally motivated to do it too – who believed that it is a good idea to explain the dynamics of innovation generation in India to the world! So this book is the fruit of cooperation between a set of academicians who were spread over three continents but managed to work as a team off and on for four years, exchanging ideas over emails, and intermittent meetings, to bring out the present volume with its detailed examination of the Indian innovation system. I would like to thank all the contributors for their wonderful work, and particularly Gita and Smita for egging me on when I felt like giving up!

I would also like to extend my sincere thanks to Cambridge University Press team and the editors Sana Bhanot and Suvadip Bhattacharjee for their kind support throughout!

Last but not the least – thanks Dick for your enthusiasm!

[2] http://www.globelics.org/

CHAPTER 1

Innovation in India

The Challenge of Combining Economic Growth with Inclusive Development

Shyama V. Ramani and Adam Szirmai

When India attained Independence in 1947, the first concern of its policymakers was to invest and create capacity in heavy industries, such as power, iron, steel, machinery, and chemicals. The post-Independence development strategy focused on the creation of a public sector capital goods industry that would be the motor of its industrialisation. The private sector was left to cater to the demand for consumer durables and non-durables. At the same time, the founding fathers of the nation were convinced that a country could not develop industrial capabilities without first acquiring scientific and technological capabilities. Thus, the government invested in the creation of a network of public universities and institutes for advanced research to provide qualified labour to burgeoning industries. After nearly nine centuries of policies focusing on the extraction of economic surplus for the benefit of domestic and colonial elites (Maddison 1974; Lal 1988), this marked a new beginning for the acquisition of scientific, technological, and innovation capabilities as a national prerogative. Now, it is a little more than 60 years since the foundation of India's national system of innovation was laid, and it is time to look back and examine what form it has taken. What are the achievements of the Indian system of innovation? How has it performed in terms of building industrial capabilities and promoting development? What are its shortcomings? What does the future hold? These are the questions that we seek to answer in this book through a study of several sectors from different perspectives. In this introduction, we outline the elements of a conceptual framework that brings the different chapters together.

The broad conceptual framework of the book: The national system of innovation

In mainstream economics, development is seen as a derivative of economic growth, whereby growth sustains and fuels development. The determinants of economic growth are spelt out in different theories, among which the neoclassical models on the relationships between inputs like land, labour, capital, and technology and outputs such as national income are the most widely accepted and taught in economics departments all over the world. This book adopts an alternative approach to examine the processes of capability accumulation in India, termed as the national system of innovation (NSI) approach, spearheaded by the seminal works of Lundvall (1992), Nelson (1993), and Freeman (1995). This approach has also inspired the notion of a sectoral system of innovation (SSI), incorporating sectoral specificities in an innovation system, including the impact of economic actors within and outside of the NSI (Lee and Lim 2001; Malerba 2002; Malerba and Nelson 2012).

The NSI approach itself emerged from an older stream of literature of the evolutionary school of economics on the industrial 'catching-up' of the presently developed countries in the form of a set of rich and well-documented historical case studies (Rosenberg and Birdzell 1986). This approach was then applied to explain the rise of the 'newly industrialising countries' of Asia in the 1980s, and is now also applied to understand the emerging economies of today (Fagerberg and Godinho 2005; Lundvall et al. 2009).

Interestingly, the 'catch-up' and 'economic growth' models share a common assumption that if knowledge is codified and freely available, late-comer countries can acquire existing technologies at a low cost. However, thereafter, their reasoning and forecasts of the consequences diverge totally. Post-war neo-classical models of growth assume that if knowledge is codified and freely available, latecomer countries can converge to the same steady-state equilibrium growth rate determined by the rate of exogenous technological change. As capital moves to low-income countries, where it is scarcer and returns are higher, the low-income countries start growing more rapidly than the high-income countries. Thereby, the gap between the two is reduced. However, this 'convergence hypothesis' has been invalidated by decades of uneven economic growth and persistent gaps in income per capita between the low-income and high-income countries (Landes 1998).[1] Endogenous growth theory, a later

[1] According to Landes, over the past 250 years, the difference in income per capita between the richest and the poorest country in the world has increased from 5:1 to 400:1. Based on PPP dollars from the World Bank's World Development Indicators, the ratio between

version of the neo-classical growth theory, advocates endogenised technological change as a result of purposeful human investments, and predicts divergence between the rich and poor countries based on increasing returns to scale in human capital and knowledge production (Aghion and Howitt 1993). However, endogenous growth theory, in turn, cannot account for spectacular cases of catch-up.

In contrast to the deductive approach of macro-economic modelling, the catch-up literature tries to generate inductive theory via historical case studies of economic development and the accumulation of capabilities. In catch-up theory, knowledge may be freely available, but its absorption and integration depend on a range of institutional characteristics, and social and technological capabilities. The basic difference between the catch-up theory and the standard neo-classical growth theory is that the former does not assume general convergence. Instead, it supposes that specific countries with special characteristics can profit from the advantages of backwardness and achieve accelerated catch-up. The main message of the catch-up literature is that technological catching-up cannot be taken for granted because a variety of necessary and complementary capabilities may be needed for effective absorption of existing technological knowledge, even if it is freely available. For example, they may include financial-institution capabilities to bear the costs of risky investment (Gerschenkron 1962), an educated workforce with social capabilities (Abramovitz 1986), public labs and firms with technological capabilities (Lall 1992), etc. Furthermore, building a platform of favourable capabilities may require sweeping institutional and organisational changes, in the absence of which 'catching-up' may be stalled. Thus, rather than being a homogeneous or linear process, catching-up in terms of scientific, technological, and industrial capabilities is likely to be costly, difficult, nation-specific, and non-systematic with sectoral and cluster idiosyncrasies. Acquiring, adapting, and implementing technologies are creative acts of innovation, and countries and firms have to invest heavily in building capabilities. But once the conditions for catch-up have been realized, late-comer countries normally grow much more rapidly than the lead economies because they can absorb state-of-the-art technology (when freely or quasi-freely available), without bearing the costs and risks of its development. This is what Gerschenkron referred to as the 'advantages of technological backwardness.'

Like catch-up theory, evolutionary economics also allows for both processes of *catch-up* and *falling behind*. An important notion here is that of the size of

the richest and the poorest country in 2008 was 200 to 1, i.e., between Norway, the richest country and the Democratic Republic of Congo, the poorest country.

the technological gap. If the technological gap is too large, it is very difficult to creatively absorb technology, as the conditions in the countries of origin and the countries of destination are too different. However, if the gap is not too extreme, advantages of backwardness will tend to prevail, and catch-up will be possible (e.g. Verspagen 1993). Finally, in contrast to neo-classical growth theory, evolutionary economics emphasises the heterogeneity of economic actors, who can respond in different ways to the incentives provided by their environments.

The catch-up literature demonstrates beyond doubt that national environments influence the processes of accumulation of knowledge and technological capabilities and that such trajectories are path dependent – even when countries are well-connected to international markets. After all, the institutions and public policies that generate the incentives for knowledge creation and accumulation are highly country-specific. Thus, the NSI assumes that the commercialization of innovations in any country in a new science-based sector is a collective process embedded within a system specific to the country. In other words, the creation, development, adoption, and diffusion of innovations evolve as a function of the existence and functioning of networks between the state and a variety of organisations, such as firms, consumers, public laboratories, universities, financial institutions, and civic associations. The catch-up process is then traced as the outcome of the strategies implemented by the actors in the innovation system, taking into account the interdependence between their actions.

The evolution of the national system of innovation as a game

In the last three decades, the systems approach has emerged as a useful framework to organise historical evidence on the accumulation of scientific, technical, innovation, and industrial capabilities of 'late-comer' countries in 'catching-up'. At the same time, it remains a conceptual framework rather than a theory, open to many forms of interpretation and investigation, as regional, national, and sectoral path-dependent trajectories can be studied in many ways (Edquist 2001; Lundvall 1998).

In the present book, for instance, the evolution of capacity building in any sector is considered as a game played between a set of players, whose strategies may be inter-dependent and whose choices jointly determine final outcomes. In other words, outcomes such as innovation generation are not viewed as being due to the efforts of just one actor, say a firm, but as the result of the profile of actions chosen by the State, other firms, laboratories, intermediaries,

and so forth, in the NSI and SSI. The choices of the actors are influenced by the institutional and regulatory frameworks, which provide incentives for the actors. Typical actors in the NSI and SSI are presented in Fig. 1.1.

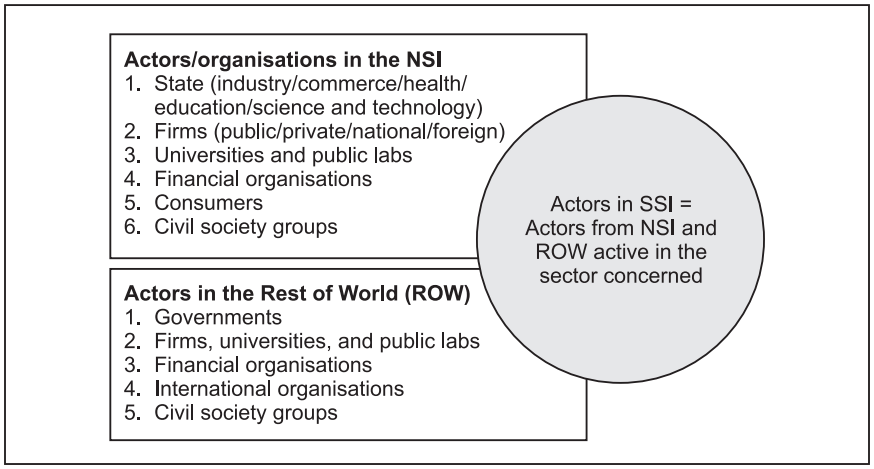

Fig. 1.1: Actors considered in the national system of innovation (NSI) and sectoral system of innovation (SSI)

In such games, the rules are set by the national and international institutions, policies, and regulation. For each sector, only some of the regulations or some of the rules of the game may be pertinent. As regulations change, the rules of the game change, and the outcomes may also change. Each actor has a set of objectives that it tries to attain. It is also endowed with a set of resources, constraints of all kinds, beliefs, cognitive structures, and a knowledge and information base. The constraints might take the form of behavioural norms, limited resources and skill, and incomplete or imperfect information base too. Each actor chooses its strategy so as to move closer to its objectives, given its constraints. The final outcome in terms of capabilities of all actors – and hence economic growth as well as inclusive development – will depend on the joint play or actions mobilised by all actors in the game, as given in Fig. 1.2. Outcomes of the game also include innovation performance, changes in the system of innovation, and ultimately, rates of economic growth of a more or less inclusive nature.

A game corresponds to a set of rules, actors, objectives, and constraints. Whenever any of these changes, a new game is set in motion. Thus, it is to be kept in mind that no notion of 'equilibrium' can be evoked in this framework.

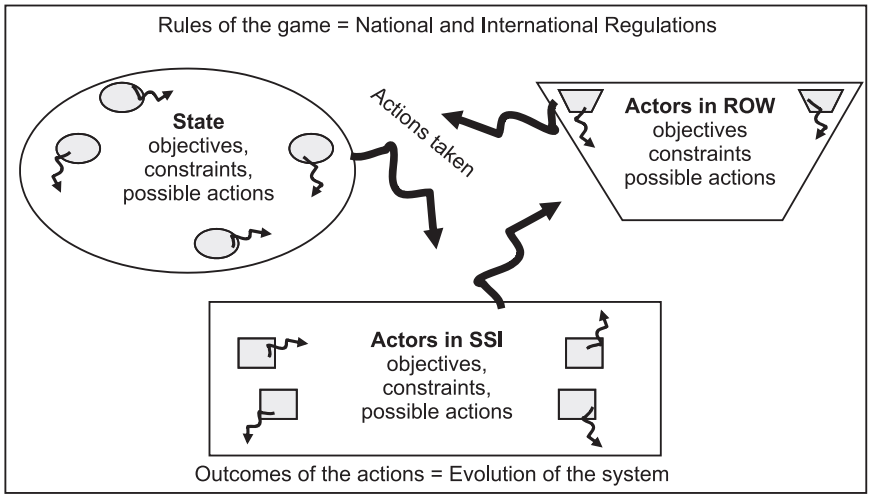

Fig. 1.2: Games within games = Capacity building
Note: ROW – rest of World; SSI – sectoral system of innovation

Rather, instead of optimising, agents continuously adapt to a continuously shifting environment while pursuing their goals. Consequently, with such continuous evolution, the discourse cannot be in terms of static equilibrium but in terms of outcomes over time, which may or may not converge.[2] Finally, these outcomes need not be socially optimal or even economically efficient at either a niche or sector level.

We illustrate this process in Fig. 1.3. Suppose, at a point of time, we start with a particular state of capabilities (in absolute terms and growth rates) in a sector, corresponding to some game (i.e., rules, actors, objectives, and constraints). The State sets the rules of the game so as to encourage 'catch-up' vis-à-vis some region of reference. As the game proceeds, the existing trajectory may continue undisturbed or there may be a new stimulus in the sectoral or national system of innovation that triggers a new game. The response of some actors provokes other changes in the system, all of which finally results in a new state of capabilities. Then the change in the size of the gap between the region of reference and the country in question reflects how successful the country has been at 'catching-up.' Ultimately, catching-up in terms of capabilities is reflected in catching-up in terms of gross domestic product (GDP) per capita.

We illustrate these notions with two examples. Many more will be elaborated in the book.

[2] See Surie (2011) for more detailed illustrative examples.

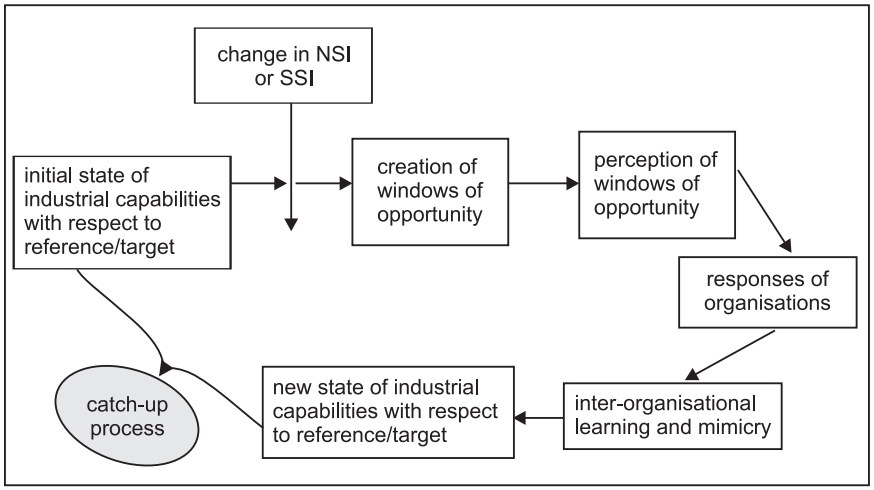

Fig. 1.3: Dynamics of catch-up at sector level
Note: NSI – national system of innovation; SSI – sectoral system of innovation

Till 1972, the main rule for innovation in the Indian pharmaceutical sector was that no Indian firm could re-engineer any branded or patented drug. However, there was a health crisis due to the lack of availability of essential drugs, and in order to come closer to its objective of ensuring access to basic drugs to its citizens, the Indian government changed the rules of the game. It was decreed that the Indian firms could produce patented drugs if they could produce them in ways different from those of the original innovator. Now, the same rule in Latin America had not had any impact. But, somehow in India, the private firms responded by investing in developing innovation capabilities. This triggered domino effects in the entire sector, resulting in a robust indigenous pharmaceutical industry by the mid-1980s. There was definitely catching-up.

From the beginning of the 1960s, when India's population rose to about 480 million, severe food shortage was experienced and India started importing about 10 per cent of its indigenous food grains production from the USA under the PL480 (Public Law 480) programme. The strategy of the State was to invest in the public agriculture research centres and universities, but this had little impact. However, a series of four unforeseen and/or uncontrollable events radically changed this situation. The first stimulus came from outside the country. The creative research of Norman Borlaug, an American professor of agriculture science, led to the creation of a new dwarf variety of wheat with 'short legs' that could support a greater amount of wheat grains on any stalk. This gave rise to a set of new 'high-yielding varieties' or 'modern varieties'

of seeds, ushering in the Green Revolution.[3] The second occurred when the Minister of Agriculture at that time, C. Subramaniam, responded by taking the bold stance that the Indian government must pave the way for the adoption of modern varieties. This was followed by a third critical response on the part of the Indian public laboratories in terms of redesigning the modern variety seeds to Indian conditions with deep commitment. Finally, the food crisis was resolved for the time by the enthusiastic adoption of the Green Revolution by the large farmers. Thus, again catching-up in terms of capability acquisition, production, and growth had occurred through some chance events and the joint responses of various actors in the innovation system.

The above discussion makes it evident that not only new technology generation, but other macroeconomic outcomes also such as the rates of economic growth, development, trade, or foreign direct investment (FDI) can be visualised as being the outcomes of games played between the same actors as those mentioned in the NSI and SSI. However, in these cases, it is far more difficult to pinpoint and trace the role of each actor in the final outcomes. Thus, instead of looking into such games, we take a bird's eye snapshot of the evolution of the rules of the games and the macroeconomic outcomes in the following two sections.

Rules of the game that have impacted all sectors: Going from socialist-licence-Raj to market liberalisation in an era of globalisation

The set of rules and the strategy of the State guiding the building of industrial capabilities can be considered to fall into two distinct phases in India. At the same time, within each phase, there have been a number of changes, of which we can mention only a few in this chapter. We briefly outline the evolution here, noting that the impact of this radical transition between phase 1 and phase 2 persistently rears its head in many of the studies presented in the book.

Game 1: Building indigenous capabilities with an import substitution policy

During the 1950s, the perceived success of the economic growth model of Soviet Russia had a strong ideological impact and set the tone for the rules of the game and the strategy of the Indian State. Inward-looking trade and

[3] Professor Borlaug was awarded the Noble Peace Prize in 1970 for his role in the creation and diffusion of this life-saving innovation throughout the world.

investment policies were adopted (as by many other developing countries) to minimise dependence on imports and develop a publicly owned industrial base to serve the needs of its citizens while curbing monopolistic and oligopolistic tendencies of the private sector. The public sector was viewed as the motor of economic growth from the 1950s to the 1990s, and the private sector was mistrusted as being made up of entities whose profiteering and growth had to be controlled through rules and regulations (Ahluwalia 1991; Bardhan 1984).

In order to monitor and control the process of industrialisation, the Indian government presided over what was in many respects a 'closed command economy' as distinct from an 'open market economy.' The ensuing 'import substitution' policy was marked by five major industrial policies. First, ceilings were set on the overall profits of the companies in many sectors. Second, the Foreign Exchange Regulation Act of 1973 (FERA) restricted the foreign equity holdings. Third, the Monopolistic and Restrictive Trade Practices Act of 1969 (MRTP) was implemented to protect against undue concentration of market power. Fourth, a '*license Raj*' (or rule of the license regime) stipulated that licences had to be obtained from the concerned ministries for any expansion in the manufacturing base, imports, and exports. Fifth, final market prices were controlled in a number of non-luxury goods sectors, such as pharmaceuticals, in order to facilitate accessibility.

In the above context, the response of the industrialists to these rules was to get deeply involved in getting permits, licenses, and quotas and clamouring for fiscal and customs duty concessions for themselves rather than formulating strategies for innovation or growth. The largest monopolistic enterprises with access to the government paradoxically turned out to be best at playing the license game, even though one of the explicit aims of public policy was to control the large private firms. Neither State nor industry was inclined to invest in the development of innovation capabilities in the private sector. Public investment was channelled into building basic infrastructure and manufacturing industries, leaving technological learning to take its own course through 'learning by doing or learning by growing.' The business vision of both Indian firms and multinationals in India was oriented towards maximising very short-run profits with minimal R&D investment.

A policy change during the 1970s, however, changed the game rules in some sectors, giving them a first impetus for the development of innovation capabilities. Thus far, India's intellectual property rights (IPR) system had been defined by the 'Indian Patents and Designs Act of 1911' of colonial times, which was based on the British 'Patent Act of 1852', permitting only product

patents. This was changed by the 'Patent Act of 1970' to an IPR regime, which recognized only process patents for food, medicine, and chemical processes. Such a policy experiment was initiated to promote the accumulation of technological capabilities in the public sector and induce private sector investment in these key industries. That the Government of India made its move a quarter of a century after the country attained its freedom testified to its inadequate awareness and appreciation of the reality that even in 1972, countries like Sweden, Switzerland, Spain, Italy, Japan, China, Brazil, and the erstwhile USSR either did not have an IPR or allowed only process patents in key sectors in order to catch-up.

Transition towards Game 2 of economic liberalisation

Throughout the 1980s, there were changes in regulation and State policy that took the rules of the game more and more away from its original format of import substitution with strict monitoring and control of investment (Bradford DeLong 2003). This culminated in 1990 in a series of policy jolts, with the impetus coming again from outside events. Just as during the 1950s, India had been inspired by the economic growth models of the former USSR and China; during the 1980s, it could not remain inert as these regions embraced 'market systems' and the Chinese high-command introduced pragmatic 'State capitalism', following the classic dictum of Deng Xiaoping, 'it doesn't matter if a cat is black or white as long as it catches mice.' Following these worldwide trends, Prime Minister Rajiv Gandhi pushed for economic reforms during the late 1980s, and this was fully realized with liberalisation and de-licensing in 1991 under the leadership of Prime Minister Narasimha Rao (Kotwal, Ramaswami, and Wadhwa 2011). Liberalisation of national and international financial transactions followed in 1995. Thereafter, government regulation via manufacturing and marketing licenses only served to monitor the quality and safety of the final products arriving in the market. Price control on commodities, including drugs, was eased. Procedures to obtain foreign technology agreement, imports, and exports were greatly streamlined and 100 per cent foreign ownership was permitted in most sectors. Excise duty was slashed on imports, while a value-added tax was added on domestic product. Lastly, in order to maximise the gains from globalisation and promote its exports, India signed the Uruguay round of GATT, which concluded in 1994, to become a member of the World Trade Organization (WTO) in 1995. India was thereby obliged to meet all provisions of the Trade Related Aspects of Intellectual Property Rights (TRIPs) by 2005, including a return to a uniform product patent regime in all manufacturing sectors.

Policy efforts to meld growth with inclusive development

'Inclusive development' refers to a growth process that benefits all sections of society without excluding any specific group and renders 'economic opportunities,' generated by the growth process, accessible to all. One of its main challenges is to ensure that the poor and marginalised populations that are often hidden in the informal economy, i.e., in productive activities not formally registered under local laws or as vulnerable informal workers, are also able to improve their conditions of life in the growth process. In other words, development is inclusive when the different sections of society, including the disadvantaged sections such as rural populations, women, youth, elderly, ethnic/religious groups, or immigrants, benefit from economic growth and have opportunities to participate in the production process.

Promotion of inclusive development has been one of the stated aims of the Indian policy since national independence. In order to contribute to the attainment of this objective, the strategy of the main player, the State, has been to invest in the national programmes under the 'Five-year Plans', starting from 1951. However, India's performance in terms of expanding inclusion is poor as compared to other emerging countries, especially China (for more details see the next section). It is beyond the scope of the book to explore why State policy has performed less well in India than in other emerging countries. But in this introduction, we will highlight the types of strategies and rules implemented in the past and at present for inclusive development, without delving into the details (which can be found in many other text books).

During the pre-liberalisation period, from the 1950s to the 1990s, the main focus of the inclusive policy was on rural India. Four types of strategies were deployed. First, to lower inequity stemming from skewed land ownership, land reforms were carried out to abolish intermediary institutions and feudal systems of land holdings, and the land was transferred from feudal landlords to indigent populations in a series of bold steps. However, while land reform was successful in some places, it was very unsuccessful in others due to landowner interests at local and regional levels (Frankel 1978). Second, to promote balanced development, public sector manufacturing units were set up in peri-urban areas and incentives were provided for private industry to be set up in the less-developed states. Small-scale industry received government support and protection, particularly in spinning and textiles. A variety of credit agencies were created to help small farmers buy seed, fertiliser, and pesticides. Third, access to essential goods like food grains, fuel, and medicines was established through a public distribution system and a public health care system.

The public distribution system functioned via 'ration cards' that provided essential goods according to whether the household was below or above the poverty line. Fourth, there was a policy of positive discrimination in education and public sector employment for marginalised social groups.

Following liberalisation, many of these measures to promote balanced regional development and access to essentials were continued. In addition, some of the diffused programmes were transformed into mission mode projects with specific targets in terms of not only provision of commodities but also their usage and maintenance. Unlike the strategies in the pre-liberalisation phase, these programmes aimed to facilitate the 'participation' of the disadvantaged in the growth process, and thereby, increase their 'income generation capacity' through ensuring the satisfaction of their basic needs. Initially, the focus remained on rural India. For instance, the 'Indira Awas Yojana – Rural Housing Mission' was launched in 1996, followed by the 'National Drinking Water Mission' and the 'Total Sanitation Campaign' in 1999 to ensure that the rural population had housing, access to drinking water, and a functioning toilet. Another major programme, the 'National Rural Health Mission', was initiated in 2005 to ensure healthcare for all. Similarly, in 2007, the 'National Food Security Mission' was initiated to lower hunger.

New and committed government programmes are being initiated to increase the scope of inclusive development. These represent real radical breaks from the past and are emblematic of efforts being taken to redistribute the gains of economic growth more equitably. For instance, the 'Mahatma Gandhi National Rural Employment Guarantee Act' of 2005 ensures adult members of every rural household 100 days of employment in every financial year as unskilled manual labour in public works at minimum wages fixed by the government. Though there is a debate on the efficiency of its implementation and the labour shortages it is leading to in rural areas, it has definitely had a positive impact on women's empowerment (Vij 2011) In many families, women are being allowed to break socio-cultural barriers and work outside of the confines of their homes for the first time in order to augment the earnings of the family. Also, for the first time, urban slums and urban development are being explicitly taken into account in State plans in the 'Jawaharlal Nehru National Urban Renewal Mission', also initiated in 2005. The objective of this programme is to develop the infrastructure of cities in a planned and integrated fashion, build capabilities in municipalities, renew inner city areas, and ensure universal access to basic services to city dwellers, including those in slums.

These measures constituted the action-investments of the State in the game. However, what contributed the most to the melding of 'catch-up' with 'inclusive development' was a new game-rule in the form of a system of positive discrimination. In educational institutions and public sector firms and agencies, seats were reserved by quota for those belonging to a 'Scheduled Tribe,' a 'Scheduled Caste,' a 'backward class' or a 'religious or linguistic minority.' For example, according to the website of the Ministry of Social Justice and Empowerment:

> Backward Classes means such backward classes of citizens other than the Scheduled Castes and Scheduled Tribes as may be specified by the Central Government in the lists prepared by the Government of India from time to time for purposes of making provision for the reservation of appointments or posts in favour of backward classes of citizens which, in the opinion of that Government, are not adequately represented in the services under the Government of India and any local or other authority within the territory of India or under the control of the Government of India.[4]

By inducing a large-scale participation of previously marginalised groups, the quota system enormously strengthened the social capabilities[5] that form the base for the accumulation of scientific and technical capabilities. Though little known outside of India, this system of positive discrimination, introduced in the 1950s and gradually expanded, is surely among the most complex, extensive, and inclusive in the world. The system varies between states, sectors, and academic disciplines. It has yielded from good to excellent returns in terms of increasing the caste and religious diversity of staff and students in academic institutions, public administration, and public agencies, as well as empowered the socially disadvantaged sections of society.

Such bold moves to develop social capabilities also have their down side. First, given the reservation quotas in the public sector, many of the Scheduled Caste graduates prefer to get job in the public sector, while the other graduates aim for jobs in the private sector, where social identity is surely important too, but does not determine recruitment. Thereafter, since the private sector pays higher wages than the public sector, economic inequalities are not reduced. Second, the system is used by economically well-off members of the lower castes

[4] http://socialjustice.nic.in/aboutdivision4.php

[5] Abramovitz (1986) describes 'social capabilities' as the quantity and quality of the educated labour force.

and religious minorities, who are more aware of the advantages provided by the system, but who have no real need of economic support for either access to education or employment, thereby blocking seats for the poor from the same communities. Third, given that access to higher degrees and professional careers in universities and public laboratories is also subject to the official reservation policy, many talented students and researchers seek to leave India for other countries where their social identity is less of a burden for their professional evolution. Fourth, it doubly marginalises the poor of the upper castes or other communities not designated as being 'backward,' who have neither the funds to go to private academic institutions, nor the requisite social identities to gain access to publicly funded institutions.

Most of the chapters in this book do not focus on the impact of innovation on inclusive development per se, but all evoke the consequences of innovation generation for the poor, either directly or indirectly. They show how in agriculture, pharmaceuticals, and energy, the low-income communities have benefited from new products, improvement in existing products, and better access to products through lowered prices. These chapters are complemented by a few that directly address pro-poor innovation-related issues such as sanitation, traditional medicine, demand drivers, and inclusive development.

Game outcomes: Economic growth, inclusive development, and innovation[6]

Growth trends: Satisfactory but not extraordinary

Innovation systems, capability building, and innovative performance are not the goals in themselves. Ultimately they should contribute to better economic performance or the realization of inclusive societal goals. The proof of the pudding is in the eating. In this section, we therefore provide a brief overview of the long-run performance trends in the Indian economy, which serve as a backdrop to the sectoral chapters in the book.[7] We put the Indian performance in perspective, comparing it with the performance of developing countries in general and with the performance of China, the other Asian giant, in particular.

[6] Most of the data in this section is derived from a database for the BRICS economies constructed by Alejandro Lavopa (see Naude, Lavopa, and Szirmai 2012). We thank Alejandro Lavopa for making the data available for this paper.

[7] The sectoral systems of innovation literature tends to neglect quantitative macro-economic trends, focusing on the evolution of the sectoral innovation systems themselves.

In Fig. 1.4, we highlight the long-run trends in GDP per capita since 1950. In this figure, one can see the dramatic acceleration of growth in GDP per capita, since the reforms of 1991. Between 1950 and 1991, the per capita growth of GDP was 1.8 per cent. This increased to an average growth rate of 5.2 per cent between 1991 and 2011. There is an interesting debate on the role of the 1991 reforms in triggering the acceleration of growth. Bradford DeLong (2003) and Rodrik and Subramanian (2005) argue that growth already started to accelerate well before 1991, after the smaller wave of reforms in the early 1980s. Indeed, we see in Fig. 1.4 that the growth in the 1980s increased from

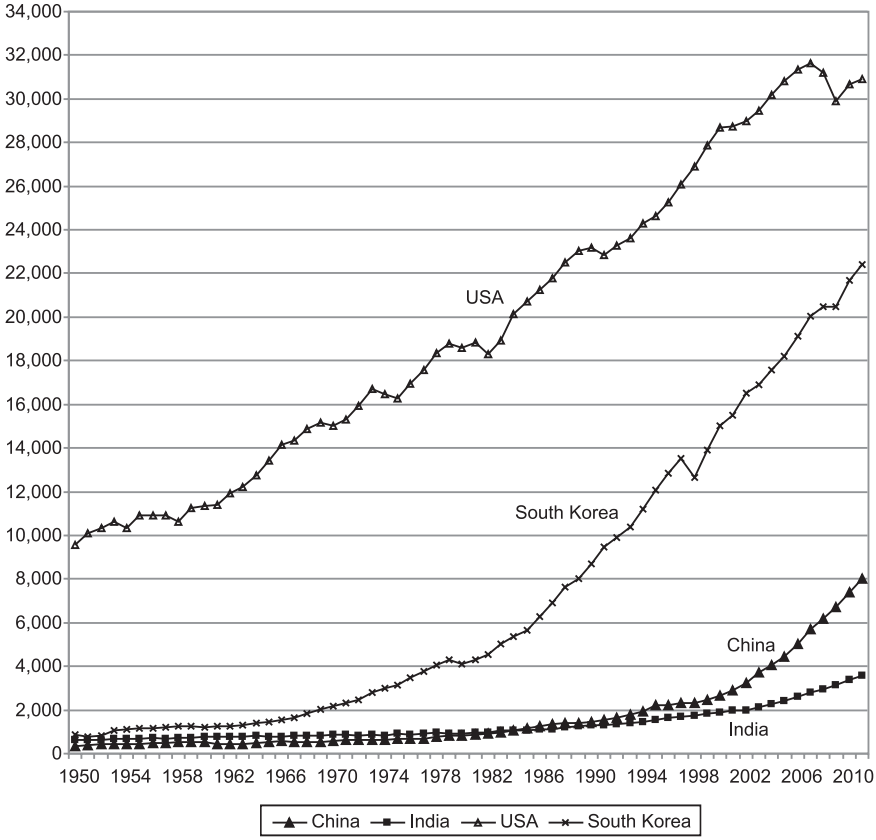

Fig. 1.4: India GDP per capita in comparative perspective, 1950–2010 (Constant 1990 Geary Khamis PPP dollars)

Source: The Conference Board. 2012. *Total Economy Database, Output, Labor and Labor Productivity Country Details, 1950–2011*. Accessed: June 2012; http://www.conference-board.org/ data/economydatabase/

a mere 1.4 per cent per annum between 1950 and 1980 to around 3 per cent per annum between 1980 and 1981.

But it is also clear that growth further accelerated after 1991, pinpointing the importance of the 1991 reforms (see also Mani 2011). Especially, after 2000, growth was very rapid, a clear case of catch-up. However, since 1978, China has been forging ahead of India from very similar levels of per capita income. In 2011, China's per capita GDP was 2.3 times as high as that of India (at 1990 constant Gheary Khamis Purchasing Power Parities). The figure also includes South Korea as an example of really spectacular catch-up.

Development indicators: Definitely lagging behind

In Table 1.1, we present a bird's-eye view of the evolution of both economic and social indicators in India since 1950. In terms of its social indicators, India shows spectacular progress. Thus, infant mortality dropped from 165 per thousand births in the period 1950–55 to 52.9 per thousand births in 2006. Under-five mortality dropped from 332 to 72 in the same period. Life expectancy at birth increased from 38 to 64 years, a gain of 26 years between 1950–55 and 2005–10. Educational enrolment figures point to a similar success story.

In comparative perspective, however, Indian performance pales. In terms of life expectancy and child mortality, India is comparable to the average for developing countries in 2005–10, but is performing far less than the other Asian giant, China. Indian poverty rates in this period are much higher than the average for developing countries. For instance, the percentage of population living on less than a dollar a day is 41.6 per cent, versus an average for developing countries of 25.2 per cent.[8] China has realized a poverty headcount of 15.9 per cent, well below the developing country average. Perhaps the most shocking figure in Table 1.1 is the Indian illiteracy rate of 37 per cent in 2005. In spite of its grand achievements in science, technology, innovation, and education –

[8] Poverty estimates for India vary greatly, depending on the source used. All estimates agree that there are substantial declines in the number of people below a given poverty line over time. But the poverty headcounts in the first decade of the twenty-first century vary. Kotwal, Ramaswami, and Wadhwa (2011) and Aggarwal and Kumar (2012) provide an estimate of 27.5 per cent of the total population in 2004/05, derived from the Planning Commission of the Government of India. The much higher estimates used in Table 1.1 are derived from Chen and Ravallion (2008), based on a poverty line of 1.25 dollars a day at 2005 PPP dollars. The advantage of this dataset is that it uses standard international poverty lines. Its estimate for China is also much higher than the estimates using national Chinese sources.

Table 1.1: Economic and social indicators of India in comparative perspective, 1950–2010

	1950–60			*1980/81*			*2005–10*		
	India	*China*	*Developing countries*	*India*	*China*	*Developing countries*	*India*	*China*	*Developing countries*
GDP per capita (1990 PPP$)	619.0	346.8	766.6	976.7	859.3	1748.4	3366.0	7395.8	4883.2
Manufactures as % of commodity production	15.0	19.7	22.9	28.0	49.3	33.5	34.8	55.7	35.4
Manufactured exports as % of commodity exports	46.0		5.0	51.0	50.0	25.0	54.4	92.8	37.0
Life expectancy at birth	37.9	44.6	42.3	56.2	67.7	59.5	64.2	72.7	66.0
Child mortality by age 1	165.0	122.0	180.0	100.1	39.8	84.0	52.9	22.0	50.2
Child mortality by age 5	332.0	266.0	281.0	135.0	57.0	117.0	72.4	26.4	72.4
Gross enrolment rate, primary education	41.0		75.8	81.7	111.6		116.0	111.0	107.8
Gross enrolment rate, secondary education	23.0		15.7	29.0	46.0		63.0	81.0	64.0
Gross enrolment rate, tertiary education	2.0		2.1	5.0	1.0		18.0	26.0	21.4
Net enrolment rate, primary education							92.1	96.4	86.9
Illiteracy rate (15+)	81.7		55.5	59.0	32.9	35.3	37.2	5.7	19.8
Percentage of population, with less than 1 dollar a day				59.8	84.0	51.8	41.6	15.9	25.2
Number of persons with less than 1 dollar a day (million)				420.5	835.1	1896.2	455.8	207.7	1376.7
Percentage of population, with less than 2 dollars a day				86.6	97.8	69.2	75.6	36.3	47.0
Number of persons with less than 2 dollars a day (million)				608.9	972.1	2535.1	827.7	473.7	2561.5

Sources: Szirmai (2012): www.dynamicsofdevelopment.com; GDP see source note Fig. 1.1; poverty rates from Chen and Ravallion (2008); Life expectancy and child mortality from UN (2010); Enrolment statistics and illiteracy from UNESCO (2012); Illiteracy India 1951 from India Stat; Manufacturing export data from UNCTAD (2012) and World Bank (2012a); Manufactures as % of commodity production from De Vries et al. (2012)

many of them documented in the chapters of this book – close to 40 per cent of the Indian population cannot read or write. Of course, all such figures can be contested, and the rankings may change according to different methods and data sources. But what is overwhelmingly clear is that Indian development has not been very inclusive, in spite of the stated aims of public policy.

Structural change: Whatever happened to manufacturing?

Returning to economic indicators, Tables 1.2a and 1.2b summarize the process of structural change in the Indian economy since 1950 (at current and constant prices, respectively). Many of these changes are rather familiar (see Kotwal, Ramaswami, and Wadhwa 2011; Aggarwal and Kumar 2012). We see a dramatic decline of the share of agriculture in GDP and corresponding increases in the shares of industry and services. What is less familiar is the rather modest increase in the share of manufacturing. In current prices, this increased from 10 per cent in 1950 to 16 per cent in 2009. Its share peaked in 1995, after which India even experienced relative de-industrialisation.

The sector that has expanded the most is the services sector. By 2009, this accounted for 55 per cent of GDP. Thus, India has become a service economy, seemingly skipping the traditional development stage whereby manufacturing dominates the economy before services take over. Optimistically, one could interpret this as a process of leapfrogging to a new development path. But a more pessimistic interpretation is that India represents a case of premature de-industrialisation (Tregenna 2013), where the share of manufacturing starts declining at low or intermediate levels of per capita income. If one accepts the notion that manufacturing is one of the key sectors driving technological change, growth, and catch up in emerging economies (Cornwall 1977; Naudé and Szirmai 2012; Szirmai 2013), then premature de-industrialisation is a serious challenge. In Fig. 1.4, we have documented how India has been falling behind China. Panagariya (2004) has explicitly argued that the reason why Indian growth has been so much slower than that of China is the weak performance of the Indian manufacturing sector. A similar argument has recently been put forward by Naude, Lavopa, and Szirmai (2012). In order to realize India's full growth potential, manufacturing needs to play a more important role than it is playing at present.

Structural change also takes place within the manufacturing sector (see Tables 1.3a and 1.3b). At constant prices, there are declines in the shares of primary-based sectors such food, textiles, and wood products. There are very

Table 1.2a: Structural change in India, 1950–2009

Sector	*Sectoral shares in gross value added (in current prices) (%)*												
	1950	*1955*	*1960*	*1965*	*1970*	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2009*
Agriculture	55.3	46.5	42.8	41.3	43.5	39.0	36.8	31.9	30.0	26.8	23.2	18.7	17.1
Industry	13.9	16.7	19.6	20.8	20.3	22.0	24.2	26.5	27.6	28.0	26.4	28.3	28.2
• mining													
• manufacturing	10.4	12.0	14.1	14.7	13.8	15.3	16.3	16.5	17.2	18.0	15.8	15.5	15.9
• utilities													
• construction					4.3	4.1	4.4	4.9	5.3	4.8	5.7	8.0	8.3
Services	30.8	36.9	37.6	37.9	36.3	39.0	39.0	41.6	42.4	45.2	50.4	53.0	54.6
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Sources:
1950 and 1955: UN national accounts, 1957, 1967
1960–1970: World development indicators online
1970–2010: BRICS database constructed by Alejandro Lavopa

Table 1.2b: Structural change in India, 1980–2008

Sector	*Sectoral shares in Indian gross value added (at constant 1995 prices) (%)*						
	1980	*1985*	*1990*	*1995*	*2000*	*2005*	*2008*
Agriculture	37.4	34.3	30.6	26.5	23.0	18.6	16.3
Industry	24.4	25.0	26.7	27.8	26.7	26.9	26.6
• mining	1.9	2.1	2.5	2.3	2.1	1.9	1.8
• manufacturing	14.9	15.7	16.5	17.9	16.9	16.6	16.4
• utilities	1.8	2.1	2.4	2.7	2.6	2.4	2.2
• construction	5.8	5.2	5.4	4.9	5.0	6.0	6.3
Services	38.2	40.7	42.7	45.7	50.3	54.5	57.1
• wholesale, retail trade, restaurants, and hotels	11.9	12.4	12.4	13.8	14.6	15.8	16.1
• transport, storage, and communications	5.9	6.1	6.1	6.9	8.1	11.6	13.7
• financing, insurance, real estate, and business services	7.7	9.3	10.9	12.3	13.4	14.1	15.5
Other services	12.7	12.8	13.2	12.7	14.2	13.0	11.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: De Vries et al. (2012)

Table 1.3a: Structural change within Indian manufacturing, 1980–2008

	Value added at constant 1995 prices (%)						
	1980	*1985*	*1990*	*1995*	*2000*	*2005*	*2008*
Food, beverages, and tobacco	12.33	12.98	12.34	11.85	12.16	11.25	10.46
Textiles and textile products	21.96	19.16	17.31	16.00	17.16	15.33	15.15
Leather and footwear	–	–	–	–	–	–	–
Wood and products of wood and cork	8.53	5.81	3.55	2.87	2.04	0.93	1.38
Pulp, paper, paper products, and publishing	3.94	3.96	4.48	3.82	2.89	2.93	2.75
Coke, refined petroleum products, nuclear fuel	1.23	2.00	3.08	3.22	2.78	3.76	3.27
Chemicals and chemical products	8.33	9.97	11.61	13.93	15.11	16.18	15.92
Rubber and plastic products	2.27	2.56	3.42	2.96	3.13	1.88	1.76
Other non-metallic mineral products	4.56	5.38	5.77	5.36	6.18	5.60	5.55
Basic metals and metal products	15.82	14.42	14.78	14.96	14.24	15.17	16.34
Machinery nec	7.15	7.70	6.43	6.40	5.79	4.97	4.86
Electrical and optical equipment	6.37	7.27	9.85	8.70	9.35	11.57	11.57
Transport equipment	4.83	4.86	4.93	6.48	5.10	6.27	6.45
Furniture, manufacturing nec and recycling	2.67	3.94	2.43	3.46	4.06	4.16	4.54
Total manufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Groningen Growth and Development Centre, Ten Sector Database. (http://www.rug.nl/research/ggdc/data/10-sector-database)

Table 1.3b: Structural change within Indian manufacturing, 1970–2007

	Value added at current prices 1970–2007 (%)								
	1970	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2007*
Food, beverages, and tobacco	12.8	10.8	9.1	11.6	11.7	10.1	13.2	9.3	8.8
Textiles and textile products	21.0	19.5	21.3	15.0	15.2	11.2	11.8	8.3	7.1
Leather and footwear	–	–	–	–	–	–	0.8	0.6	0.6
Wood and products of wood and cork	0.6	0.6	0.6	0.5	0.4	0.3	0.2	0.2	0.2
Pulp, paper, paper products, and publishing	5.2	4.9	4.2	3.3	3.6	4.0	4.3	3.0	2.7
Coke, refined petroleum products, nuclear fuel	2.0	2.6	2.7	3.2	4.9	5.1	5.0	13.4	13.3
Chemicals and chemical products	13.6	15.1	14.1	15.1	13.9	20.2	21.1	16.2	13.6
Rubber and plastic products	3.2	2.5	2.5	3.4	3.4	2.7	3.4	2.5	2.6
Other non-metallic mineral products	4.1	3.9	3.9	5.8	5.1	4.9	5.6	4.5	6.8
Basic metals and metal products	15.7	16.3	15.2	15.0	15.2	14.6	13.4	17.2	22.2
Machinery nec	6.8	8.1	8.6	9.7	8.0	7.9	6.3	5.6	5.9
Electrical and optical equipment	6.9	8.2	8.8	8.5	8.7	8.0	7.1	7.2	7.1
Transport equipment	7.1	6.9	8.3	7.9	9.5	10.2	6.6	10.6	7.7
Furniture, manufacturing nec and recycling	0.8	0.5	0.6	1.0	0.4	0.9	1.3	1.3	1.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: UNIDO, Indstat Database, Geneva, Various Issues

substantial increases in the shares of chemical products and electrical and optical equipment.[9] The latter is typically a high-tech sector.

In current prices, there are similar declines in food, beverages, tobacco, textiles, and wood and pulp products and similar increases in refined petroleum products. The main difference with the constant price series is that there is no increase in the share of electrical and optical equipment. This is not surprising. Over time, the prices of computers, office equipment, and other electronic equipment are increasing less relative to the prices of other sectors (or even decreasing in absolute terms), so that the current price shares in later years tend to be lower.

Trade: More exports but even more imports

Between 1970 and 2009, there has been a spectacular increase in the openness of the Indian economy, as documented in Table 1.4. The share of exports in GDP increased from 3.8 per cent in 1970 to 20 per cent in 2009. The share of manufactured exports increased from 2.2 per cent in 1980 to 11.7 per cent in 2009. Trade openness (the sum of exports and imports as percentage of GDP) increased from 7.8 per cent in 1970 to 45.8 per cent in 2009. It should be noted that in spite of increasing export success, imports continued to exceed exports, indicating a persistent negative balance on the current account of the balance of payments.

Tables 1.5a and 1.5b provide information on the changes in the structure of exports. The manufacturing sector turns out to be much more important in terms of export share than in terms of GDP. For instance, in spite of all the discussion about the Indian IT sector and service-led growth, manufactured exports in 2009 account for no less than 58 per cent of the total gross value of exports, up from 36 per cent in 1980. This is somewhat at odds with the pessimistic conclusions about premature de-industrialisation derived from Table 1.4.

Within the manufacturing sector, the long-run trends in export shares are rather similar to those for GDP. We see a decline in the importance of traditional low-tech sectors such as food, textiles, and leather and an increase in the shares of refined petroleum products and electrical and optical instruments.

[9] In the international standard industrial classification (ISIC), revision 3, the economy is broken down into 17 one digit groups, of which manufacturing is one. At two-digit level, 99 divisions are distinguished of which 22 are within manufacturing (starting with division 15 manufacture of food products and beverages and ending with division 37). In Tables 1.3a and 1.3b, 22 divisions have been collapsed into 14 categories.

Table 1.4: Indian export performance, 1970–2009

	1970	*1980*	*1990*	*2000*	*2009*
Exports of goods and services (million current dollars)	2,362	11,557	22,594	59,064	257,957
GDP (value added) (million current dollars)	6,1470	184,761	326,796	467,788	1,287,292
Exports as percentage of GDP in current prices	3.8	6.3	6.9	12.6	20.0
As percentage of world exports	NA	0.5	0.5	0.7	1.6
Exports of manufactured goods (million current dollars)	NA	4,154	14,447	37,687	150,517
Manufactured exports as percentage of GDP	NA	2.2	4.4	8.1	11.7
Manufactured exports as percentage of world exports	NA	0.3	0.5	0.7	1.4
Total exports (million current dollars)	2,362	11,488	23,225	61,886	265,022
Total imports (million current dollars)	2,430	17,352	27,919	66,202	325,072
Sum of exports and imports in million current dollars	4,792	28,839	51,144	128,088	590,094
Sum of exports and imports as percentage of GDP	7.8	15.6	15.7	27.4	45.8

Source: UNCTAD (2012)

Table 1.5a: Structure of exports in India, 1980–2009 (%)

Sector	*1980*	*1990*	*2000*	*2009*
Agriculture	27.0	11.6	6.5	2.9
Industry	47.3	67.9	66.1	61.4
• mining	11.3	3.9	1.5	2.7
• manufacturing	36.0	64.0	63.8	58.3
• utilities	0.0	0.0	0.0	0.0
• construction	0.0	0.0	0.8	0.3
Services	25.7	20.5	27.4	35.7
• wholesale, retail trade, restaurants, and hotels	0.0	0.0	0.0	0.0
• transport, storage, and communications	17.3	11.1	10.2	9.1
• financing, insurance, real estate, and business services	7.5	9.3	16.1	26.3
Other services				
Total	100.0	100.0	100.0	100.0

Source: UNCTAD (2012)

Table 1.5b: Structure of manufactured exports in India, 1980–2009 (%)

Manufacturing sector	*1980*	*1990*	*2000*	*2009*
Food, beverages, and tobacco	9.6	6.9	6.4	5.2
Textiles and textile products	26.6	15.0	14.4	5.5
Leather and footwear	12.1	22.8	17.2	8.0
Wood and products of wood and cork	0.8	0.1	0.1	0.1
Pulp, paper, paper products, and publishing	0.2	0.3	0.6	0.5
Coke, refined petroleum products, nuclear fuel	2.1	3.9	4.3	16.2
Chemicals and chemical products	10.6	10.9	12.3	12.6
Rubber and plastic products	2.2	1.3	1.5	1.2
Other non-metallic mineral products	1.2	0.7	1.7	1.2
Basic metals and metal products	7.6	5.7	8.5	9.9
Machinery nec	6.1	4.7	3.5	4.8
Electrical and optical equipment	3.5	2.6	2.9	6.6
Transport equipment	14.4	3.0	2.7	6.5
Furniture, manufacturing nec and recycling	3.1	22.3	24.0	21.6
	100.0	100.0	100.0	100.0

Sources: UNCTAD (2012); World Bank (2012b)

Foreign direct investment

One of the important aspects of economic reform in India is the opening up of the economy to FDI. Before the economic reforms of 1991, India was rather hostile to foreign investment, but its policy stance has since changed and has

become more FDI friendly. Table 1.6 provides evidence of the success of India in attracting increasing flows of FDI. By 2010, foreign investment accounted for 4.5 per cent of total gross fixed capital formation (GFCF). India now attracts 4.3 per cent of all foreign investment flowing into developing countries and emerging economies. A very similar transformation occurred in China, but starting from a completely closed economy, China has now realized a far larger share in total FDI flows than India. In 2010, it attracted more than 15 per cent of total FDI. As percentage of GFCF, FDI in China is lower than that in India. But this is misleading, as China has far higher rates of savings and investment than India (over 40 per cent of GDP). It is interesting to note the high rates of Greenfield investment[10] in both countries, which indicates that foreign investment contributes to the direct creation of new capital and facilities, rather than taking the form of acquisition of existing firms and assets.

Of course, the role of FDI in the economic development of India is debated. Many studies argue that the contribution of FDI to technological change and upgrading is limited because there are few technology and knowledge spillovers from foreign to domestic firms (also shown in some chapters). But on the other hand, other works suggest that there are other kinds of spillovers, which may be just as important in the form of organisational capabilities, marketing capabilities, advertising capabilities, and logistics.

Table 1.6: FDI trends in India and China, 1970–2010

	1970	*1980*	*1990*	*2000*	*2010*
India					
• FDI (current US$, million)	45	79	237	3,588	24,640
• Greenfield investment as % of FDI			97.9	70.3	77.5
• FDI as % of GFCF	0.5	0.2	0.3	3.3	4.5
• FDI as % of GDP	0.1	0.0	0.1	0.8	1.4
• FDI as % of developing countries	1.2	1.1	0.7	1.4	4.3
China					
• FDI (current US$ million)	–	57	3,487	40,715	05,735
• Greenfield investment as % of FDI			100.0	83.5	94.4
• FDI as % of GFCF	–	0.1	3.5	10.0	3.9
• FDI as % of GDP		0.0	0.9	3.4	1.8

Contd.

[10] A form of foreign direct investment where a parent company starts a new venture in a foreign country by constructing new operational facilities from the ground up. In addition to building new facilities, most parent companies also create new long-term jobs in the foreign country by hiring new employees. http://www.investopedia.com/terms/g/greenfield.asp

Contd.

	1970	*1980*	*1990*	*2000*	*2010*
• FDI as % of developing countries	-	0.8	10.0	15.8	18.4
Developing Countries					
• FDI (current US$, million)	3,854	7,479	34,853	257,625	73,568
• FDI as % of world FDI	28.9	13.8	16.8	18.4	46.1
Advanced economies					
• FDI (current US$, million)	9,491	6,599	72,602	1,145,055	70,103
• FDI as % of world FDI	71.1	86.2	83.2	81.6	53.9

Note: FDI – foreign direct investment; GFCF – gross fixed capital formation; GDP – gross domestic product

Source: UNCTADstat

Investment in R&D: Getting better but still insuffi cient

The above facts and figures reflect the progress made in terms of industrial capabilities catch-up. But what has been the investment in R&D and the impact of new technology generation?

Both India and China are conscious of the importance of technological upgrading. Though formal investment in R&D is only one of the ways by which innovation capabilities can be developed (others being through 'learning by doing,' 'licensing' or 'firm or asset acquisitions'), it remains a good indicator of the potential for new technology generation. Table 1.7 shows how successful India and China have been in this respect. In India, R&D investment as percentage of GDP increased from 0.3 per cent in 1980 to close to 1 per cent in 2008. In the same period, however, China started from a lower level of 0.1 per cent and succeeded in raising its R&D expenditure to 1.4 per cent of GDP. Both countries still have some way to go before they achieve advanced country levels of R&D expenditure, which typically vary between 2 and 3 per cent of GDP.

Table 1.7: Total R&D investment as percentage of GDP

	1980	*1985*	*1990*	*1995*	*2000*	*2005*	*2008*
India	0.3	0.4	0.6	0.7	0.8	0.8	0.9
China	0.1	0.2	0.5	0.6	0.9	1.3	1.4
South Korea		1.5	2.0	2.6	2.7	3.1	3.8
Taiwan		1.0	1.7	1.8	2.0	2.5	2.7
Average 16 advanced economies	1.7	2.0	2.1	2.1	2.5	2.6	2.7

Sources: Castellaci and Natera (2011); South Korea, Taiwan, and advanced economies from Szirmai, www.dynamicsofdevelopment.com

Innovation: Lots of patents but no acceleration in productivity increases

Table 1.8 illustrates that India and China are achieving spectacular success in increasing the number of patents granted in the USA. From almost nothing in 1980, the number of patents increased to 403 in 2005 in India and to 565 in China. After 2005, the increase accelerated in both countries, but far more rapidly in China than in India. In 2010, the number of patents in China was 3303, and that in India, 1137. The issue of innovation performance in India will be elaborated in more detail in the subsequent chapters.

Table 1.8: Patent performance, 1980–2010

	(Number of patents granted in the USA)							
	1980	*1985*	*1990*	*1995*	*2000*	*2005*	*2008*	*2010*
India	8	16	23	38	131	403	672	1137
China	4	76	48	63	162	565	1874	3303
South Korea			290	1,240	3,472	4,591	8,730	12,508
Taiwan			861	2,087	5,806	5,993	7,779	9,635
USA			52,977	64,510	97,011	82,586	92,001	121,179

Source: Castellaci and Natera (2011); South Korea, Taiwan, and the USA from Szirmai, www.dynamicsofdevelopment.com; Original source: USPTO, TAF database

Ultimately, what we are interested in are the effects of innovation performance on economic productivity. Fig. 1.5 presents data on the long-run evolution of labour productivity in the manufacturing sector, measured as GDP per worker. Labour productivity can be taken as a very rough proxy of the level of technological capabilities of a country. It indicates the extent to which machinery, education, efficiency, organisation, and technology augment the productivity of raw unskilled labour.[11] Fig. 1.4 represents the labour productivity of four selected countries as a percentage of labour productivity in the USA, the world productivity leader. This means that a graph, which is running horizontally, does not indicate a lack of productivity growth in an absolute sense. Rather, it implies a rate of productivity growth, which is equal to that of the USA, in other words, it demonstrates the absence of catch up.

[11] Here we can only present comparative figures for labour productivity in manufacturing, rather than for labour productivity in the total economy. As manufacturing is one of the R&D intensive sectors of the economy, it nevertheless provides relevant information about the economic outcomes of innovative performance.