CHAPTER 1

Innovation in India

The Challenge of Combining Economic Growth with Inclusive Development

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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.

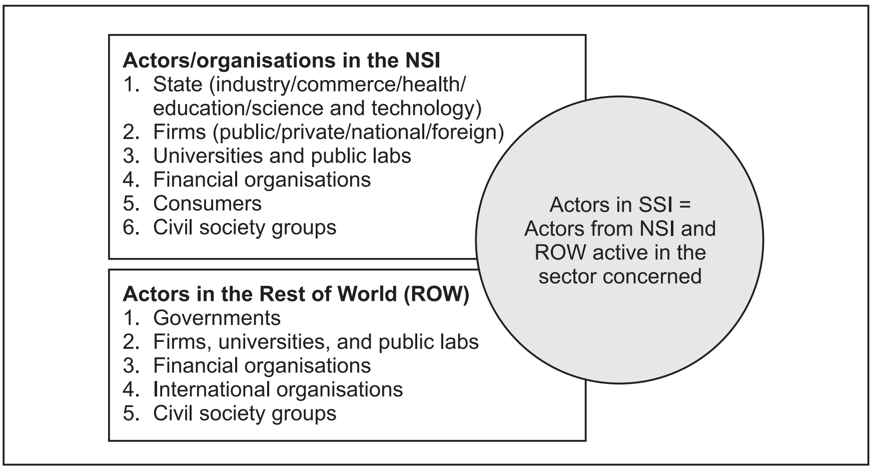

Fig. 1.1: Actors considered in the national system of innovation (NSI) and sectoral system of innovation (SSI)

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.

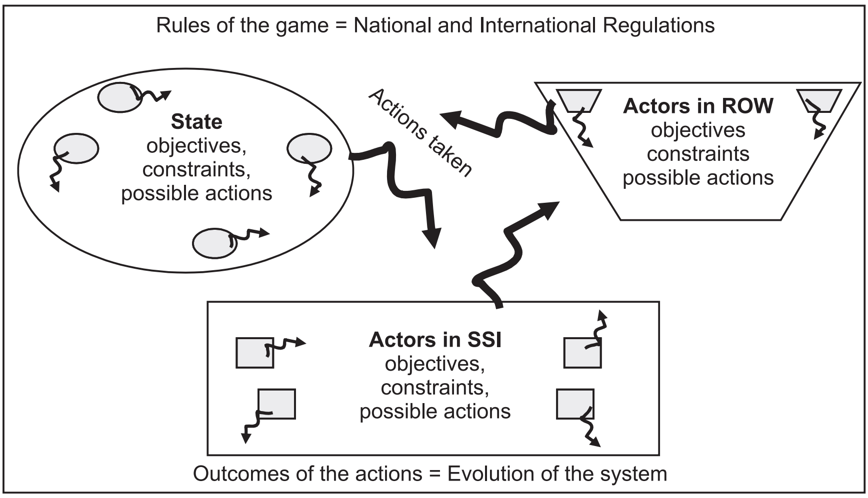

Fig. 1.2: Games within games = Capacity building
Note: ROW – rest of World; SSI – sectoral system of innovation

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.

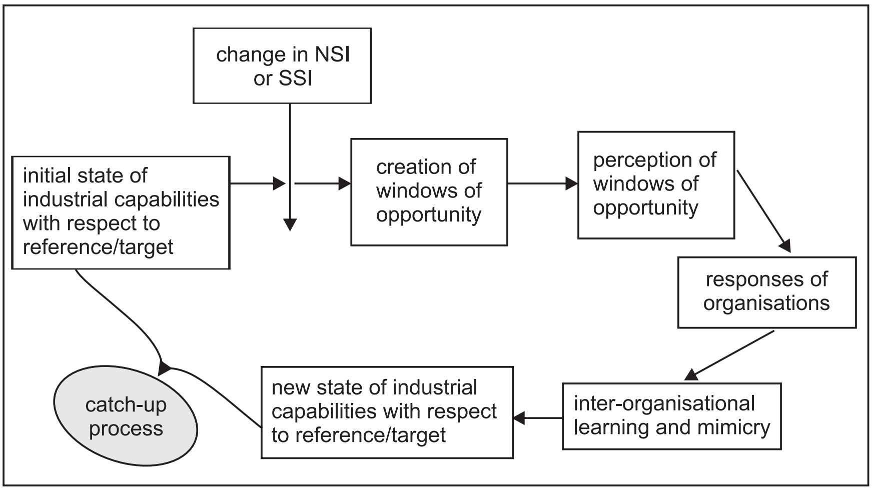

Fig. 1.3: Dynamics of catch-up at sector level
Note: NSI – national system of innovation; SSI – sectoral system of innovation

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.