

CHAPTER 4 THE NATIONAL INNOVATION SYSTEM

4.1 NIS: An overview

Increasing importance has been given to the study of National Innovation System in recent years by the policy makers of the countries worldwide. The systems approach to innovation helps the policy makers have an insight into the nature and sources of innovative and economic performance. The process of innovation is a non linear multidisciplinary approach that involves multi actors' participation. Research & Development happens to be important for economic growth but the interactions between the institutions & organisations-both private and public are equally important. The underlying principle of the National Innovation System establishes the importance of such interactions as to how the universities, enterprises & the government organisations interact and the knowledge whether tacit or codified in an economic system. The policy relevance of understanding the innovation system and how the subsystems within the economic system interact can be of great help to augment the innovative performance and capacity of the knowledge based economies. For example the study of financial system as related to NIS could be of immense value for the policy makers to look into financial imperatives to promote the innovative activities in an economy.

An understanding of the NIS can help address the need gap in the current Innovation system, identify the system imperfections and direct the policy interventions to promote innovative performance of an economy. The relationship between different subsystems of the economy, e.g. R&D policies, Financial systems ,Taxation policies, Educational system and how they interact with each other can help the policy makers identify the gaps and recommend the institutional set up and relevant policies to enhance the innovative performance and competitiveness of the economy.

Technology-related analysis has traditionally focused on inputs (such as research expenditures) and outputs (such as patents). But the interactions among the actors involved in technology development are as important as investments in research and development.

The Definition

Traditionally the understandings of technology policy & performance have focused on the measurement of the *inputs* (such as expenditures on research and development and the number of research personnel) and *outputs* (such as patents). Recent theories of NIS have established the importance & significance of the interactions or linkages among the people and institutions. It is of utmost importance to understand how the different actors of the economic system namely the firms, universities and the government organisations relate to each other in knowledge production, flows and diffusion. The analysis of these linkages and the strengths of these linkages need to be identified to leverage on the conceptual and empirical understanding of the NIS. This is evident from the various definitions as follows:

“ .. the network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify and diffuse new technologies.” (*Freeman, 1987*)

“ .. the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state.” (*Lundvall, 1992*)

“... a set of institutions whose interactions determine the innovative performance ... of national firms.” (*Nelson,*)

“.. that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies.” (*Metcalfe, 1995*)

“ .. the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country.” (*Patel and Pavitt, 1994*)

Common to all these definitions are the interactive behavior of the institutions and the knowledge flows (Table 4.1) between the various institutions-private and public.

Table 4.1: Core knowledge flows in National Innovation Systems

Type of knowledge flow	Main Indicator
<i>Industry Alliances</i>	
Inter-firm research co-operation	Firm Surveys Literature-based counting
<i>Industry/university interactions</i>	
Co-operative industry/University R&D Industry/University co-patents Industry/University co-publications Industry use of university patents Industry/University information-sharing	University annual reports Patent record analysis Publications analysis Citation analysis Firm surveys
<i>Industry/research institute interactions</i>	
Co-operative industry/Institute R&D Industry/Institute co-patents Industry/Institute co-publications Industry use of research institute patents Industry/Institute information-sharing	Government reports Patent record analysis Publications analysis Citation analysis Firm surveys
<i>Technology diffusion</i>	
Technology use by industry Embodied technology diffusion	Firm surveys Input-output analysis
<i>Personnel mobility</i>	
Movement of technical personnel among industry, universities and research institutes	Labor market statistics University/Institute reports

Source: OECD, 1997

4.3: The approaches to NIS

Recent trends in the research on national innovation systems focus on policy based approach and the Performance-oriented studies .Since the late 1990s, efforts have been made to evaluate and to compare innovation systems in terms of their performance. The growing number of policy-oriented studies of innovation systems signals that the creation of innovation-enhancing framework conditions has become a central target of policymakers around the globe, and particularly in highly industrialized countries.

Table 4.2: Descriptive model of National innovation Systems

Framework	Elements /activities (innovation processes)	Remarks
Liu & White (2001)	research, production, "end-use (customers of the product or process outputs)", "linkage" and "education"	
Chang and Shih (2003)	R&D expenditure, R&D performance, technology policy, human capital development, technology transfer and the climate for entrepreneurial behaviour	allow for an analysis of the structural specifics of a national system of innovation.
NIC model by Furman et al. (2002)	endogenous growth theory (Romer (1990)), the theory of international competitiveness as developed by Porter (1990), and the national systems of innovation approach	<p>it only takes account of one output measure of innovation, given that in an NIS various actors contribute in many different ways to the system's performance.</p> <p>Porter and Stern (2002) have recently applied the national innovative capacity model to a larger number of countries (75 countries in total) than Furman et al. (2002) have. Apart from the different sample size and differences in the employed data set, Porter and Stern (2002) make use of the empirical results in order to generate a ranking of the nations analyzed.</p>
Nasierowski and Arcelus (2003)	"R&D efficiency"-, and the second part examines "R&D productivity “which is defined as a country's efficiency in the translation of technological success into national productivity growth.	

4.4 NIS & Indian Economy

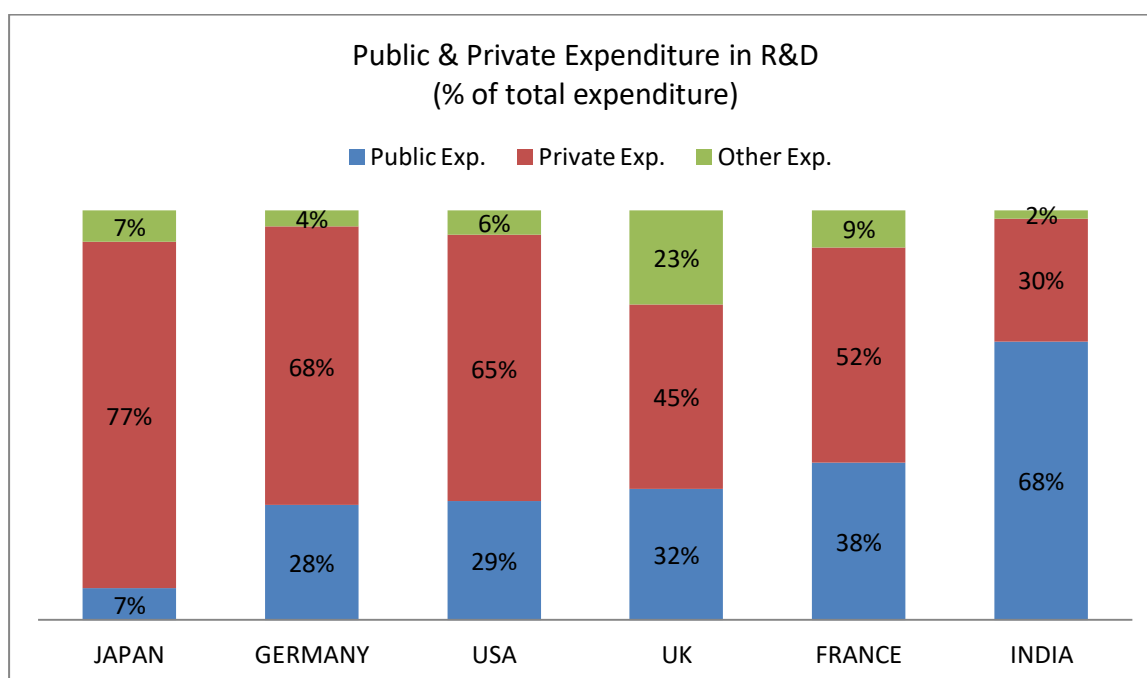
The word 'innovation' appears in a policy document for the first time in 2008, in the draft National Innovation Act. This development reflects a broad sentiment in both policy and business circles that the country is becoming more innovative – or at least certain industries.

In January 2003, the Prime Minister formally announced a new Science and Technology Policy, the main objective of which was to raise India's overall research intensity from 0.80% of GDP in 2003 to 2.0% of GDP by the end of the Tenth Five-Year Plan in 2007. Although this target has not been reached – the GDP/GERD ratio stood at 0.88% in 2007.

According to the Global Competitiveness Report 2014-15, India's capacity for innovation has been lower than that of many countries like the USA, UK, South Korea, and even other BRICS countries (Brazil, Russia, India, China, and South Africa) except Russia. Even in quality of scientific research institutions, India scores lower than China, Brazil, and South Africa. This is also exhibited through its poor score on university–industry collaboration on R&D as compared to some other BRICS nations like China and South Africa. In terms of patents granted per million population, India fares badly compared to other BRICS countries. In terms of company spending on R & D also India is far below China. Only in terms of availability of scientists and engineers, India scores better or is equal to other BRICS countries.

The R&D expenditure by the private enterprises has been also very low as is evident from the table in the following page:

Figure 4.1: Public & Private Expenditure in R&D



India faces an innovation challenge. Clusters can be powerful catalysts in this process and hence the research studies related to the innovative clusters merit due attention and appreciation. The Global Innovation Index reports conclude that India needs to improve the innovation performance to enhance its global economic competitiveness and bridge the innovation gap when compared to the innovating developed economies. The research efforts related to the *innovation ecology, the structure of innovative interactions, industrial interdependencies and the Government policies can help us plan and develop the cluster based policies to supplement the National Innovation Policy.*

Table: 4.3: Global Competitiveness Report

Country	Capacity for innovation		Quality of scientific research institutions		Company spending on R&D		University – Industry collaboration on R&D		Availability of scientists and engineers		PCT patents granted/ million population	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
USA	5.9	2	6.1	4	5.5	4	5.8	2	5.3	5	149.8	11
UK	5.3	10	6.3	2	4.8	14	5.7	4	4.8	22	89.1	18
South Korea	4.7	24	5.0	27	4.5	20	4.6	26	4.4	42	201.5	8
South Africa	4.3	35	4.7	34	3.4	48	4.5	31	3.5	102	6.5	45
China	4.2	40	4.3	39	4.3	23	4.4	32	4.4	43	11.7	34
Brazil	4.1	44	4.0	50	3.5	43	3.8	54	3.3	114	3.2	50
India	4.0	48	4.0	52	3.8	30	3.9	50	4.4	45	1.5	61
Russia	3.8	66	4.0	56	3.2	62	3.6	67	4.1	70	7.1	41

Source : Global Competitiveness Report 2014-15, World Economic Forum.

Note : PCT- Patent Cooperation Treaty.

The Science, Technology & Innovation policy in India has undergone significant changes keeping in mind the national interests and objectives.

Table 4.4: Innovation Policy in India

Innovation policy /Instruments			
Period	Horizontal Policies/Instruments	Vertical Policies/Instruments	Regulatory Framework
1947- 1980 (Science Oriented Approach)	SPR(1958), TPS(1993), Drug and Cosmetics Act (1940), Industrial policy(1948 and 1956)		IPA (1970)
1980-1995 (Technology Centric Approach)	HGT, Industrial Policy(1991) Education Policy (1986)	NBDB(1983), DBT(1986)	
1995-2000 (Technology Centric Approach)	DPRP (1994), NIMTLI (2000)	NBRI	WTO(1995), Patents Amendment(1999)
2000 beyond (Systemic Approach to S&T Innovation)	STP(2003), Tepp, NIF GLP NMCC(2005)	Biotechnology Vision(2001), DNBS(2005), SIBRI(2006)	Patents Amendment (2002 and 2005) , Ethical Guidelines

Source: Dr. Parveen Arora, Director (SC-F), NSTMIS, Department of Science & Technology,(DST) Government of INDIA

The Scientific Policy Resolution of 1958 envisioned the promotion of science and technology in India with the following objectives:

- To foster, promote, and sustain, by all appropriate means, the cultivation of science, and scientific research in all its aspects - pure, applied, and educational;
- To ensure an adequate supply, within the country, of research scientists of the highest quality, and to recognise their work as an important component of the strength of the nation;
- To encourage, and initiate, with all possible speed, programmes for the training of scientific and technical personnel, on a scale adequate to fulfil the country's needs in science and education, agriculture and industry, and defence;
- To ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity;
- To encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom;

- To secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.

The first five year plan (1951-56) and the second one (1956-61) aimed at building the National Laboratories and research institutions primarily under the Council for Scientific and Industrial research. IITs were set up and infrastructural facilities were extended to institutions like IISc. The third plan (1961-66) focused on basic and applied research particularly in agriculture, atomic energy and engineering research. The fifth five year plan came out with the sectoral plan and efforts were made to enhance the interaction between research agencies and promote the technology transfer.

The Indian patent act of 1970 brought some significant changes related to the Intellectual property protection and regulation which helped the pharmaceutical industry grow and develop. A detailed technology policy statement was introduced in 1983 to align the science technological initiatives with national priorities. The sixth plan (1980-85) and the seventh plan (1985-90) encouraged capacity building through reverse engineering and import substitution. A proposal was made to provide for the fiscal incentives through public funding of Research and development. However tax breaks & exemptions till early 1990s were restricted primarily for public sector institutions and laboratories.

Post 1991 through the ninth, tenth and eleventh five year plan (1997-2012) greater emphasis has been laid out in the area of science and technology. DST and CSIR initiated the collaborations with the industry on public-private partnership. Various initiatives like the Drugs and Pharmaceuticals Research Programme (DPRP) was launched by DST in 1994 and The New Millennium Indian Technology Leadership Initiative (NMITLI) was promoted by the CSIR (under DSIR) in the year 2000

The Technology Development Board (TDB) established in 1996 after the adoption of Technology Development Board Act, 1995 assists firms that develop and commercialise indigenous technology or adapt imported technology for wider domestic applications. Assistance is implemented by way of soft loan or contribution towards equity capital. TDB has recently joined hands with two major private equity investors to invest in equities of start-up companies. There are some instances where the government and the private players have engaged in more target oriented projects by collaborating through consortiums. The Collaborative Automotive Research (CAR) by Technology Information, Forecasting, and

Assessment Council (TIFAC-DST) is an example. The very recent Science, Technology and Innovation (STI) Policy 2013 mulls over significant paradigmatic shifts to achieve innovations at all levels. The Eleventh Plan had also highlighted the urgency to put in place institutional mechanisms that may support an innovation ecosystem linking the public and the private and leverage innovation prospects in the SMEs.

4.4.1 Innovation support mechanism

A number of programmes were initiated by the different scientific departments of the Government of India to support the small enterprises:

1. The Small Business Innovation Research Initiative (SBIRI)- supports early stage, pre-proof-of-concept research in biotechnology by the industry, and late stage development and commercialisation of new indigenous technologies particularly those linked to societal needs in healthcare, food and nutrition, agriculture and other sectors

2. Technopreneur Promotion Programme – TePP (promoted by DSIR) supports individual innovators.

3. The TIFAC-SIDBI- Revolving Fund for Technology Innovation Programme (SRIJAN) was launched by TIFAC in 2010, as a joint TIFAC-SIDBI Technology Innovation initiative. Under the scheme, TIFAC set up a revolving corpus with Small Industries Development Bank of India (SIDBI) to fund industries particularly the Micro Small and Medium Enterprises (MSME) for scaling up and commercialisation of novel products and processes.

4. Under Technology Development and Demonstration Programme (TDDP) the DSIR provides partial financial support towards prototype development, cost of pilot plant, cost of equipment, test and evaluation of products, user trials, etc.

4.2.2 Cluster Based Approach for SMEs

The National Innovation Council (NInC) has aimed at facilitating and nurturing innovation ecosystems in industry clusters including those in the traditional sectors. The primary objective is to establish such mechanisms like Cluster Innovation Centres (CICs) which

would provide a platform for exchange of knowledge and learning among workers, entrepreneurs, exporters, public funded S&T institutions government agencies, etc. An established mechanism of this nature is expected to significantly augment prospects of technology adoption and ensure speedy diffusion.

The Ministry of Micro, Small and Medium Enterprises has also adopted cluster development approach as its key strategy for enhancing the productivity, competitiveness and capacity of Micro and Small Enterprises (MSEs). Clustering of units enables agencies including banks to provide services at lower physical and transaction costs. This in turn ensures improved availability of these services for enterprises in this sector. The flagship scheme of the Micro & Small Enterprises – Cluster Development Programme (MSE-CDP) was launched in October 2007 to support growth and sustainability of MSEs by addressing common issues technology improvement & skills and quality enhancement ,market access, access to capital, and to set up common facility centres.