

# The Role of Incubation in India's Innovation and Development Ecosystem



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By

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# CHAPTER ONE

## INTRODUCTION

### **Introduction**

The history of innovation is as old as that of humankind itself, with its prime focus to helping human beings to live a comfortable life. The evolution of innovation studies has not only added a new dimension to the domain of scientific knowledge production but has also influenced individuals as well as nations. Innovation is defined as “...the implementation of a new or significant product, process, and organisational method in business practices, workplace organisational or external relations” (OECD 2005). Innovation practices in the contemporary time show the wide dimensions and coverage, either as new knowledge or any other type of arrangement to achieve the goals of development.

With the shift in the structure of the universities from teaching and research to the entrepreneurial mode, universities have become a significant player in spearheading the mechanism of innovation and development (Wissema 2009; Mowery and Sampat 2004). The processes that involve generation transfer and diffusion of knowledge through technology transfer, patenting and commercialisation of innovations is being shaped by the integration and interdependence of various actors, institutions and policymakers.

The term “university entrepreneurship” (techno-entrepreneurship, academic entrepreneurship, incubates, start-ups) is often referred to in the academic literature to describe the way universities have undergone interaction with the industry or market. In this context, a growing body of academic literature related to academic entrepreneurship based on the national, regional and sectoral development has been addressed and many others have come out for further attention.

Technology business incubation is one such arrangement where the start-ups explore their ideas into visionary dreams under guided support by the incubator (Phillips 2004). The process, which was initiated accidentally in

the the Batavia industrial centre in New York around 1959, can now be seen in almost all the corners of the world. The main objective of the study is to assess the role of university start-ups (UST) in promoting the national innovation ecosystem. In continuation, the study explores all the key aspects associated with the incubation, which include technology transfer, commercialisation, and diffusion of knowledge by emphasising inclusive, sustainable growth and how the process helps in regional and national development.

Technology-based incubation centres are becoming an attractive model for not only an entrepreneur but also the policymakers because of their potential to create jobs and wealth. The incubation model not only promotes regional and national development but also stimulates industrial growth. These low-cost technology firms are more innovative, and flexible compared with high-tech entrepreneurial firms and act as a support system for these high-tech firms. Thus, these incubates are more appropriate in leading the economy towards the development goal. (Manimala and Vijay2012)

Furthermore, the Incubation centre brings about the following benefits among different actors (United Nations Publication2004)

- Government- Regional Economic Development, Job Creation, improvement in National Technology Capability.
- Research and Development- Commercialization of Technology, Interaction with Industry
- Business/Corporate Sector- Better Investment Choice, Access to Innovative and New entrepreneurial model, Access to New Technologies.
- Technology Start-ups- Better access to resource and business development training Reduces market risk

Governments around the world have begun to recognise the strength of Incubation model and how it plays a key role in raising income, technological capability of a country by providing jobs and wealth. However, the process has also influenced the private players to incorporate the model, as it led to trace the new entrepreneurial knowledge domain, which in a way influences the new business avenues. (Manimala and Vijay 2012). The Incubation process started way back in 1959 at the Batavia Industrial Centre, New York. However, a full-fledged entrepreneurial model was started in 1970. HP (Hewlett-Packard), one of the most popular computer manufacturing brands, is being innovated through the Incubation



Centre. In the United States, the incubation model has been creating more jobs than any other community programme like infrastructure, bridges, water or other projects. (Aernoudt2004)

In other words, incubation is an institutional mechanism that helps innovation and entrepreneurship grow in smooth atmosphere. The mechanisms associate the academic and industry in a common platform to develop, technology transfer, commercialise new technology in emerging technology. Further, with the shift in the economic model of the world from Industrial to Post-Industrial, manufacturing and now to the knowledge economy have also prioritised the incubation and entrepreneurship. It is being recognised that start-ups make an important contribution to technological innovation, economic growth, employment generation and in all development agenda (United Nations Publication 2004).

According to the National Business Incubation Association (NBIA)<sup>1</sup> a US-based organisation has estimated that incubators create 20 times more jobs than other community projects. According to the report of NBIA in 2005 North America has provided 100,000 jobs from 27000 start-up companies. In Asia, China has been a major player in providing jobs through Incubation. By the end of 2003, China had employed 336,000 people from more than 500 incubating companies. (Manimala and Vijay, 2012). India has also successfully developed the incubation model with Technology Business Incubator (TBI) and Science, Technology Entrepreneurs Park (STEP) working since 1982. As an investment viewpoint, STEP has generated more revenue in terms of direct and indirect tax, though there is been little knowledge among people about the schemes that the government runs. Apart from this, the cultural, social and political situations have also inclined the effective working of incubation centre in the country (United Nations Publication 2004).

However, the innovation- incubation development model is being quite an effective phenomenon, but the effectiveness and success of the same enclose any encumbrance. The problems can be traced at the three-phase

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<sup>1</sup> NBIA- the National Business Incubation Association or now known as the International Business Innovation Association (INBIA) is a leading organisation supporting business incubation and entrepreneurship around the world. INBIA serves more than 2000 members across 60 nations. INBIA promotes business incubation by organising conferences and specialised training and consults governments and corporations on incubator development.

of innovation, the Birth, Survival and Growth Phase. The common problem has been seed capital and marketing or commercialisation of product along with Intellectual Property Right. The effective academia-industry collaboration and policy paralysis have also been major contributors to the effective incubation model. (Manimala and Vijay, 2012)

The literature on innovation suggests that innovation is a systematic phenomenon, where the role of networks and linkages among various actors and agencies plays a significant role in influencing the overall process of innovation. The study while addressing these issues, also attempts exploring the barriers related to start-ups, from the methodological viewpoint the study adopts the systems of innovation approach in mapping all the key actors and their interaction in shaping the innovation process. In addition, the studies try exploring the limitations in the system's framework in addressing issues related to developing countries.

In India the process of technology incubation took shape in 1982 with the setting up of National Science and Technology Entrepreneurship Board (NSTEDB) <sup>2</sup>an apex body under the department of science and technology in 1982, with a broader objective to enhance technological growth by integrating academia-industry for an effective, efficient, and sustainable development. (Tang et al., 2013).

Currently, in India, there are 125 technology business incubators (TBI) situated at different locations, and in the diversified domain in almost all the diversified and emerging areas of science and technology. The central purpose of this paper is to explore the role of different, linkages between actors, institutions, and networks around the incubation process in India and how it influences the process of innovation.

This study explores the extent of linkages of and interactions between different actors in the vicinity of technology business incubation to trace the extent of an innovation process. Two public-funded technical institutes namely: IIT (Indian Institute of Technology) Kanpur and IIT Madras, with diverse and profound technical expertise, have been chosen as the desired case. Moreover, this study in a way attempts to address the issues related to the incubation process in India, and how it influences the innovation

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<sup>2</sup> NSTEDB- National Science and Technology Entrepreneurship Board was set up in 1982 by the government of India, is an institutional mechanism to promote self-employment among the science and technology labor in the country and to set up knowledge-based and innovation-driven enterprises. More detail information can be accessed through the web link <http://www.nstedb.com/about-us.him>

ecosystem, with the larger context of the development agenda in the 21<sup>st</sup> century.

## **Genesis of Incubation**

The incubation process, which is considered one of the important components in the national policy of every nation, started its journey in quite an unplanned or rather an unusual way. A developer rented out an 850,000 sq. ft area vacated by a large corporation by dividing it into different subparts, this is how the first incubation process started in New York near the Batavia Industrial Centre in 1959.

During the '60s the incubation programme was going quite slowly, but the process gets accelerated in the '70s with the formation of the National Science Foundation's Innovation Centre Program. An initial effort was to commercialise selected technological innovation, but the process of commercialising research accelerated by a significant shift in policy instrument like Bayh-Dole Act<sup>3</sup>. The Act changed throwing uncertainty over-commercialization of basic research. Apart from changes made in the technology commercialisation by promoting innovation from the university to the market, the US government emphasises the significance of intellectual property rights and how it changes the dimension of innovation in the country as well throughout the globe.

Over the years, the evolution of the incubation model has gone through constant changes, initially, it was of the mixed type that supported all kinds of services from low to high-tech. However, in Europe, the incubation model started in 1975 as a subsidiary unit called the British Steel Industry (BSI) to create jobs due to the closure of the steel industry. The transformation to a technology-based incubation model was formed to support regional development. In Germany, the first incubation centre was established around 1983 to transfer the research findings from the University of Berlin to the market. Similarly, in France, the incubation started with the establishment of Antipolis Technology Park, with the

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<sup>3</sup> Bayh-Dole Act- The Bayh-Dole Act was one of the important activities concerning technology transfer from the university. The act is also known as patent and the Trademark Act Amendment came in 1980. According to which the university retains ownership of the invention made under federally funded research. In return, the university is expected to file a patent to ensure commercialisation upon licencing. The royalty of such a venture is being shared by both inventor and university/college department.

primary goal to focus on fulfilling the regional development gap (Aernoudt 2004).

In the 1990s, the trend to create sector-specific incubation centre or technology clusters such as biotechnology, information technology was framed. Besides the promotion and establishment of technology business incubation, the efforts have been generated to form other forms of incubation model, namely: the social and the basic research incubator. In which the former provides business development services to people with low-income capacities, low skilled worker, political refugees, whereas the gaps in the latter bridge between the basic science labs, for example, MIT (Massachusetts Institute of Technology) Labs basic research in Electron, Atoms to the market/economy (Aernoudt 2004).

However, besides the different objectives and philosophies, the technology business incubation model has been one of the more popular and widely accepted models of incubation, especially in the developing countries. Table 1–1 given below describes the typology of incubators along with its primary objective and the sector it explores.

**Table 1–1 Typology of Incubators**

	Main Philosophy	Main Objective	Secondary	Sector
<b>Mixed Incubators</b>	Business Gap	Create Start-ups	Employment Creation	All Sector
<b>Economic Development Incubators</b>	Regional or Local Disparities	Regional Development	Business Creation	All Sector
<b>Technology Incubators</b>	Entrepreneurial Gaps	Create Entrepreneurship	Stimulate Innovation, Technology Start-ups	Focus on Technology mainly recent
<b>Social Incubators</b>	Social Gaps	Integration of Social Categories	Employment Creation	Non-Profit Sector
<b>Basic Research Incubators</b>	Discovery Gaps	Blue-sky Research	Spin-off	High-Tech

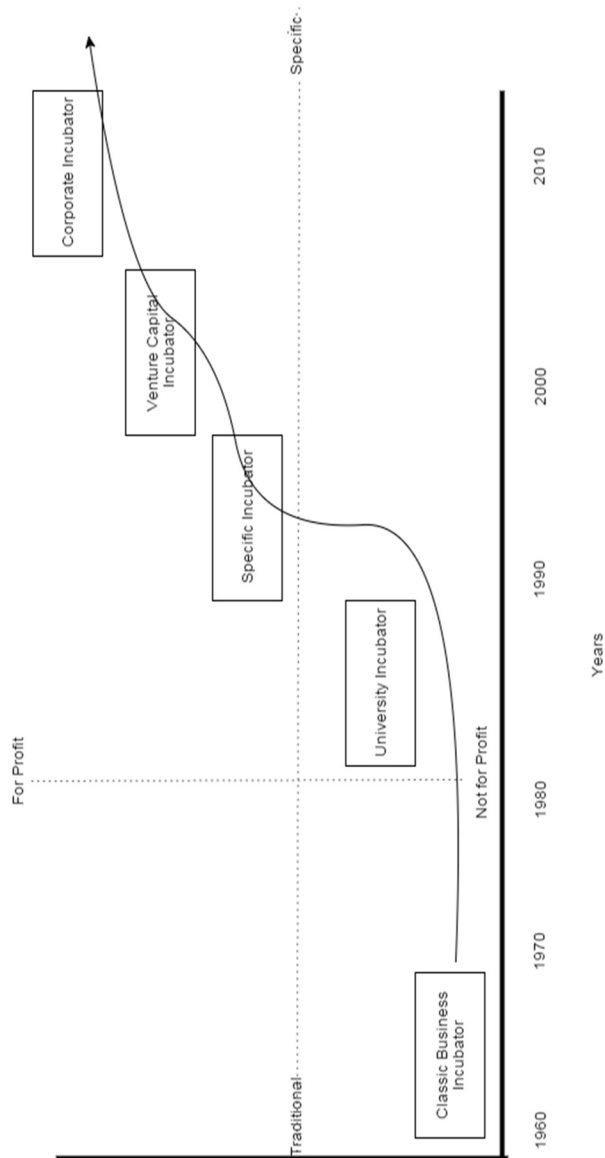
Source: (Aernoudt, 2004)

Besides the diversification in the objectives and the philosophies, the incubators are distinguished in the domain of business models. However, in the discourse of incubation, two important business models exist namely: '*for profit*' or '*not for profit*'. The '*not for profit*' model is most popular and widely used, it seeks commercialised research, enhances economic growth, and thus creates employment with the creation of new start-up ventures. Whereas the '*for profit*' generally operates as a business accelerator, seeking to speed up product development and enterprise growth. About 94% of North America's incubators follow '*not for profit*' model. The scenario is the same in developing countries as Brazil, China, and India. However, the effect of globalisation and shortening the life cycle of the product, along with growing global and regional competitiveness, has shifted a bend towards area/specialization specific '*for profit*' model of incubation centre (Manimala and Vijay 2012).

Figure 1–1, shown below, describes the evolution of the incubation model since the 1960s. The vertical division divides the graph into two categories '*for profit*' and '*not for profit*' business model. Whereas the horizontal division divides into traditional objectives (job creation, economic development) to the specific objective (sector-specific). In the initial phase, the incubation mode concentrated more on traditional objectives, but from the 1990s onwards it shifts towards industry-specific and sector-specific.

Besides the horizontal shifts, the business model shifted from '*not for profit*' to '*for profit*' model. Although this shift can be visualised only in terms of developed countries, as there is a sharp change in the incubator objective while moving across the vertical axis.

Furthermore, besides the existing business model in developing countries like China, India and Brazil, there has been a considerable change in the spectrum of '*not for profit*' model. The model with the evolution of sector-specific clusters in the area of Information Technology and Biotechnology has arranged new dimensions in the periphery of technology business incubation (Akçomak 2009).

**Figure 1–1 Evolution of Incubation Model**

Source: Adapted from (Akçomak 2009)

## **Incubation in India**

The promotion of entrepreneurial initiatives by creating an environment for an interchange of knowledge, in the light of effective academia-industry collaboration, has been on the priority list of the government, well before the formation of an entrepreneurial board. In India, the incubation movement took shape in the 1980s as a policy for promoting entrepreneurship, which was set up under the initiative and support of the United Nations Fund for Science and Technology (UNF&ST).

In this progression the government has set up the National Science and Technology Entrepreneurship Board (NSTEDB) an<sup>4</sup> apex body under the department of science and technology in 1982 with a broad objective of promoting gainful self-employed among the Science and Technology (S&T) labour in the country and to set up knowledge-based and innovation-driven enterprises. The broader objectives of these activities were to integrate the modules of education and research for relevance, competence, excellence, entrepreneurship and development to expand the process from merely generating knowledge to transferring knowledge to industry and society at large. Incubation centres in India act as seedbeds for technological innovation and new industrial ideas. The Ministry of Science and Technology initiated the Science and Technology Entrepreneurship Park (STEP) programme under the NSTEDB in 1984 in collaboration with the financial institute-like IDBI, IFCI, and ICICI. STEP has tried integrating the linkages between academia, industry and R&D institutions to inculcate a culture of Entrepreneurship. (Tang et al.,2011)

Presently, there are 125 TBI centres in the country at different locations. The basic premise of STEP is to translate the knowledge produced from the campus to market/commercialization. The process deals with the young graduates and alumni of the institute to create wealth creation, increase employment opportunities, an increase technological self-reliance perspective.

In India, STEP has promoted nearly 788 units generating an annual turnover of INR 130 Crores and employment of 5000 persons. TBI

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<sup>4</sup> NSTEDB- National Science and Technology Entrepreneurship Board was set up in 1982 by the government of India, is an institutional mechanism to promote self-employment among the science and technology labour in the country and to set up knowledge-based and innovation-driven enterprises. More detail information can be accessed through the web link <http://www.nstedb.com/about-us.him>

(Technological Business Incubation) is another form of incubation setup with good market potential located in the host institute containing expertise, facilities to facilitate the R&D required in selected thrust area. The TBI may have areas ranging from Biotechnology, Information and Communication Technology, Design, Micro-electronics, Agri-Business, Environment, Energy Etc. An incubation centre with business support and minimum infrastructure enables a tenant company to start its venture; generally, the survival rate of the company in TBI is 70–80 per cent (NSTEDB).

## **Research Context**

The emergence of the Technology Incubation model in India started in the early 1980s, but its full-fledged operation started around 2000. Since its inception, the major problem surrounding the incubators was the availability of seed funds for start-ups. Besides financial constraints, the problems related to collaboration and correlation between different actors like Government bodies, University, and Industry were the other major barriers in establishing an efficient incubation platform. In addition to these, in the light of technical and marketing barriers, social and cultural factors, the entrepreneurial culture is quite an obsolete factor in Indian society. Technology incubation is an entirely new process, the process apart from enriching and promoting new technology also adds the malfunction components to these developed technologies, with the liabilities of newness along with global and regional competition has also influenced the profession of entrepreneurship in the country.

The main objective of the study is to assess the role of university start-ups (UST) in promoting the national innovation ecosystem. In continuation, the study explores all the key aspects associated with the incubation, which includes technology transfer, commercialisation, and diffusion of knowledge by emphasising inclusive, sustainable growth and how the process helps in regional and national development. The literature on innovation suggests that innovation is a systematic phenomenon, where the role of networks and linkages among various actors and agencies plays a significant role in influencing the overall process of innovation.

Also, most of the studies on the above-mentioned theme have been undertaken in the context of developed economies, mainly in the US. The innovation studies are primarily in the Indian context and that too in the area of technology business incubation are less in number. Existing studies have focused mainly on examining the attributes and failures of linking the



TBI to its other components. In this context, this book tries addressing these entire fragmented problems in a combined space as these are not mutually exclusive to each other. The study while addressing these issues, also attempts exploring the barriers related to start-ups, from the methodological perspective the study adopts the systems of innovation approach in mapping all the key actors and their interaction in shaping the innovation process. In addition, the studies try exploring the limitations in the system's framework in addressing issues related to developing countries.

### **The objective of the study**

Innovation is quite a complex and interrelated system approach, where actors and agencies, namely government, institutions, universities, financial players, firms, are engaged together in the pursuit of innovation. The debateable question for the scholars and policymakers in the developing countries like India is, that can the incubation process triggers off technological development in the country, besides elevating revenue and jobs in the country? The main objective of the book lies to answer the question about the effectiveness of the incubation programme in India and to track the problems associated with it and how it is helping in accelerating the trajectory of national innovation by supplementing the objective of inclusive and sustainable development in India.

More emphatically, the study to discover the linkages among the actors tracks the involvement of various organisations and their inter-dependency occurring in the innovation process by drawing a schematic network diagram by locating all the actors and institutions involved in the incubation process (see fig 1–4). Moreover, the study has been proposed by comparing innovation at two premier technical institutes namely IITK (Indian Institute of Technology Kanpur) and IITM (Indian Institute of Technology Madras) with the following objectives.

- To explore the role of a different actor, s institution their linkages and network around the Incubation Process in India.
- To identify the role of R&D collaboration, Intellectual Property Rights (IPR), Technology Transfer and Commercialisation around Incubation Process in India.
- To analyse the learning and technology commercialisation process in the incubation innovation process in India

## **Research Questions**

However, with the above mention objectives, the basic entity of the thesis is to empirically understand the role of a technology incubator in analysing innovation within the parameters of some guided questions:

- Who are the actors and networks involved in the Incubation process?
- How do different actors and networks influence the growth of the Incubation process concerning the issues of innovation and development?
- What are the policies and strategies influencing the Incubation process?
- How does the National Innovation System help in understanding the linkages, among different actors concerning the technology business incubation process in India?

## **Analytical Framework**

The concept of systems of innovation rests on the objective that innovation in firms is not an independent phenomenon rather it is the interaction and interdependence between different elements or components in the system. The interaction and interdependence have a huge impact on the innovation process. Thus, the system becomes an ideal framework for analysing, describing, and understanding the process of innovation at a different level and how it influences the policy framework.

An innovation system is defined as

“A group of private firms, public research institute, and other facilitators of innovation promotes the creation of new or number of technological innovation institutions...promotes or facilitates the diffusion or application of these technological innovations” (Beije, 1998; Schrempf et al., 2013).

## **System Approach to Innovation**

The system of innovation frameworks was developed in parallel in Europe and the US around the 1980s, but the initial footmark was created by Christopher Freeman in collaboration with the IKE group. The collaboration helps in developing the early concepts in developing systems of the innovation approach. Freeman conceptualised the system approach to understand the process, historical insight, and collaboration. His first effort was to understand the innovation approach of Japan. However, the work of

Lundvall (1992), Nelson (1993), and Edquist (1997) has contributed quite significantly to developing the system approach.

The system of approach framework has three sub-sections, these sections were developed to analyse and understand the process of innovation from a different level. These subsections are

- National Innovation System- the NIS approach analyses the interaction of actors, involved in the innovation process, which is being shaped by the political, social, and economic factors. The approach is also used to analyse the differences or comparisons between countries and their innovation systems
- Regional Innovation System- the RIS approach analyzes the innovation process based on “Region” or in other words, the research in RIS attempts analyzing technology, innovation concerning the location.
- Sectoral or Technological Innovation System- the Sectoral or technological approach tries analyzing the innovation dimensions for certain technologies or sectors.

The basic concept of innovation systems or systems of innovations is that the growth of an economy does not depend only on the growth of a few firms, or research organisation rather, it is more about the interaction between and with the government institutions for effective production and diffusion of knowledge (Johnson et al., 2003). The systems approach is a contrast to the other approaches like the neo-classical economic model, organisational theory. It not only accommodates the characteristics of the different institution, knowledge creation, role of government etc. but can also handle other aspects associated within the framework of innovation (Nadvi and Schmitz 1998). The concept of systems of innovation is relatively new, but its origin can be traced in the writing of Friedrich List (1841). However, it is quite interesting to note that the development of the national system of innovation concept comes out from the developed countries and an incredibly small amount of literature has been contributed from the developing third world countries.

This system approach though analyses the innovation process at different levels, these sub-sections of systems of innovation approaches can be categorised, and evaluated on the six dimensions mentioned below (Coenen and Diaz Lopez 2010)

- System Boundaries

- Actors and Networks
- Institutions
- Knowledge
- Dynamics
- Policy Implication

However, the similarity in these approaches is that they emphasise learning. The system of innovation framework is more of interactivity, non-linear, and has evolutionary characteristics that make it a more complex framework. However, the performance of the SI approach is evaluated with its historical analysis of economic or innovative activities and diffusion of knowledge (Schrempp et al., 2013).

The systems of innovation approach systems have presented an entirely new concept in theorising, analysing, and describing the efficiency but also the problems from micro to macro perspective. However, the subsection of SI frameworks like NSI, RSI, and SSI has presented a holistic approach for analysing innovation at a different level. The table 1-2 given below summarises the different approaches in the SI framework

**Table 1–2 Summary of different approaches in systems of innovation frameworks**

Authors	The type of System Innovation	Study Context	Unit of Analysis	Analytical Framework
<b>Christopher Freeman</b>	NSI	Japan	Socio-Economic Adaptation	MITI Company R&D for importing technology, education and training institutes
<b>Lundvall</b>	NSI	Scandinavian Countries, Mainly Denmark	User-Producer Interactive Learning	The role of Public Sector, Education, R&D institutions, standard and training institute, production, marketing and financial system.

<b>Nelson</b>	NSI	15 Developing and Developed Countries	Co-evolution between technology and organisational based firms based on competition and routines	Allocation of R&D activities, the source of funding, characteristics of the firms, important industries, the role of the university, government policy.
<b>Breschi and Malerba</b>	SSI	Various Sectors in OECD Countries	Inter-sector knowledge interactions	Technological regimes, dynamics of innovations, knowledge and spatial boundaries
<b>Carlsson</b>	SSI/TSI	Swedish Technological System	Technological Knowledge Networks	Institutional infrastructure, clustering resources, economic competence, development blocks
<b>Saxenian</b>	RSI	IT Sectors in Silicon Valley	Blurred firms in a region	Informal information exchange, human resource, inter-firm network
<b>Cooke</b>	RSI	An innovative region in Europe	Localised social and productive interdependence	Financial capacity, institutional learning, productive culture.

Source: (Chang and Chen 2004)

## National System of Innovation (NSI)

The concept of National Systems of Innovation or commonly termed as NSI, was developed in the 1980s. The framework focuses on country-

specific factors influencing the process and innovation. The concept is mainly linked to three authors: Freeman (1992), Lundvall (1992) and Nelson (1993). The NSI framework provides a holistic approach to the interaction among actors involved in the innovation process. The approach is quite popular among OECD<sup>5</sup> countries and among policymakers around the globe. The concept rests on three important words “*National, System and Innovation*”, which gives the fundamental concept for the NSI framework. However, there is quite a close related definition by different scholars, which help in defining the concepts holistically. The NSI framework is defined as follows

“The network of institutions in the public and private sector, whose activities and interactions initiate, import, modify and diffuse new technologies”. (Freeman 1992)

“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 border of a nation-state”. (Lundvall 1992)

“A set of institutions whose interactions determine the innovative performance of national firms”(Nelson 1993)

“The national system of innovation is constituted by the institutions and economic structures affecting the rate and directions of technological change in the society”(Lundvall 1992)

“All important economic, social, political, organizational, and other factors that influence the development, diffusion, and use of innovations”(Edquist 1997)

“The set of distinct institutions that jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which government forms and implements policies to influence the innovation process”. (Metcalf 1995)

The definitions provide a wide interpretation of NSI though there have been different interpretations among researchers in another way, all of them tried describing the relationship between the actors and how it influences the innovation process.

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<sup>5</sup> Abbreviated as the Organisation for Economic Cooperation and Development is an international economic organisation of 34 countries. It is a forum of countries committed to democracy and market economy by providing a platform for comparing policies and coordinating domestic and international policies of its members. More details can be tracked at [www.oecd.org](http://www.oecd.org)

## **Nation Boundaries**

The term 'Nation' is quite a significant terminology in defining the NSI framework. The nation-state defines not only the national boundaries but also the cultural, political values that shape the institution in the innovation process (Lundvall 1992). Further, these boundaries of cultural and political dimensions also shape the technological changes occurring in the nation. On the other hand, the interactivity among firms, people having different skills, organisational interaction also depends upon the specific boundaries of the nation (Edquist and Johnson 1997). The national boundaries in the NSI framework not only describe the geographical or cultural dimensions but also denotes the role of the state and the power attached to it.

Public policies according to (Edquist 1997) are an important element that influences the innovation process of the nation. The policies parameters not only influence the technological change but also in the kind of institutional setup for developing innovation. The Nation component thus acts as a key factor in the NSI framework, according to Nelson and Rosenberg (1993) the foremost concern in the empirical studies on NSI is to see whether R&D activities are influenced by the geographical context. However, it is being found that the R&D activity in different sectors differs in the institutional setup and they do not overlap.

The concept of Nation and its boundaries are getting blurred, with the federal setup of the nation along with the globalisation effect has sublimated the nation and international boundaries. However, the homogeneity of the cultural and social parameters is also quite difficult to locate in the context of conceptualising the term 'Nation' in the NSI framework (Lundvall 1992). Thus, the systems of innovation approach and its sub-section as national, regional and sectoral provide a different level of analysis for understanding, evaluating technological change (Edquist 1997)

## **System Approach**

The system defines the conglomeration of all the components or elements, and the larger the performance of the system is not concentrated on a single element or component but rather the interaction between the components associated with the system (Nadvi and Schmitz 1998). According to (Lundvall 1988) the performance and importance of the innovation process are significant only when the elements or components associated are interdependent and have a non-linear relationship. According to Lundvall (1988), a system of innovation is constituted by its

elements and how the relationships among them help in production, and diffusion of knowledge. The important constituent of system innovations is the institutional setup and its structure, both these factors impact enormous impact on interactive learning among firms, organisation and even nation. However, the emphasis of Lundvall (1988) was quite informal and mainly based on the social and cultural element of institution whereas that (Nelson and Rosenberg 1993) approach was more of formal emphasising on R&D activities.

## **Innovation**

The term Innovation as defined by Schumpeter as “new combination”, either in the form of product, process, raw material or the new form of organisation. Lundvall (2007) interpreted the innovation, not only in terms of new combinations but also in the process of diffusion and its use. In a broader sense, technological innovation is a cumulative and path-dependent entity, where the newness of innovation becomes significant when it is widely used. Moreover, according to (Lundvall 1988) the innovation process in the NSI framework mainly depends on three types of learning.

- Learning- Mainly associated with the production, distribution and consumption function in the firm as learning –by- doing, learning-by -using and learning-by-interacting
- Searching- the formal activity carried out for market analysis and R&D
- Exploring- the research activities performed in the academic or research institute outside the periphery of the private sector.

There have been quite a number of definitions for theorising the concept of innovation by the different researcher. These definitions hold significance as the way we define innovation will help us in defining innovation systems. In other words, the definition in the broader sense includes the dimension of diffusion and use, and in the narrow view, it is more about technological changes.

The concept of NSI was initiated and developed by authors like (Freeman 1992), (Nelson 1993) and (Lundvall 1992). Freeman describes Japan’s innovation’s performance while explaining the innovation process he explains the embeddedness of technological, social factors in explaining the economic growth. However, the element of his work is been focused on four basic components (Soete et al. 2010)

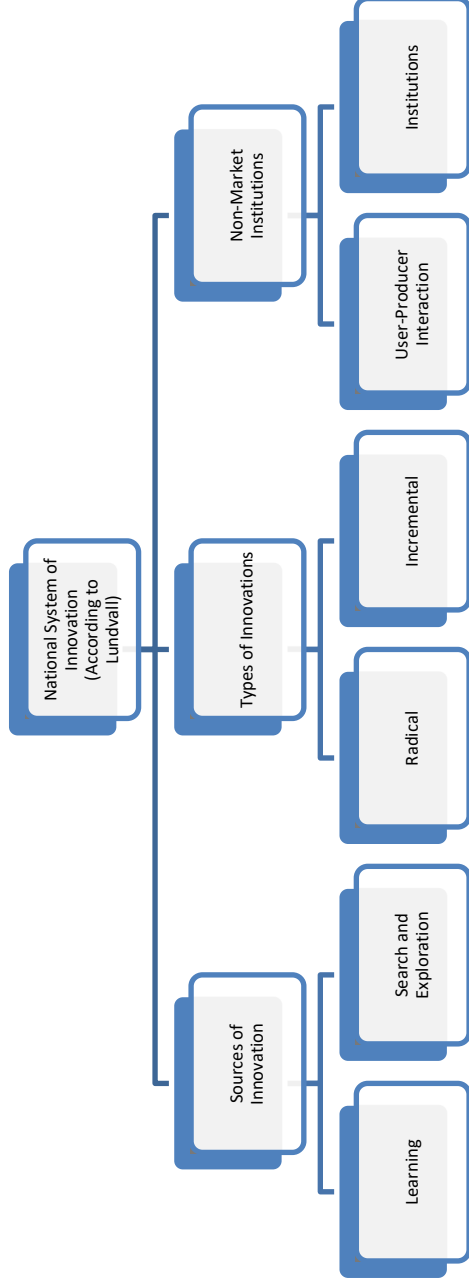


- Role of policy
- Role of corporate R&D
- Role of human capital and capabilities
- The role of the accumulation industry in enhancing economic growth.

However, Lundvall (1992) explains the role of interaction in the production of new knowledge. According to him, the NSI framework consists of three building blocks. The first one deals with the sources of innovation and the action of actors, which will lead to innovation. The second building block differentiates between types of innovation mainly radical and incremental. The third block is non-market institutions like user-producer interaction and institutions, both of which are important aspects of exchanging knowledge. The third author to contribute to the evolution of the NSI framework was Richard Nelson, his idea centred around the set of actors mainly in R&D institutions working on science and technology and how they collaborate in the innovation process. However, over the years, based on the primary contribution by these three researchers, the NSI frameworks have evolved quite significantly. The concept is being widely used by the policymakers as a part of their innovation strategies in both developing and developed countries. The first developing country to adopt the NSI framework in its innovation strategy was South Africa (Schrempf et al., 2013).

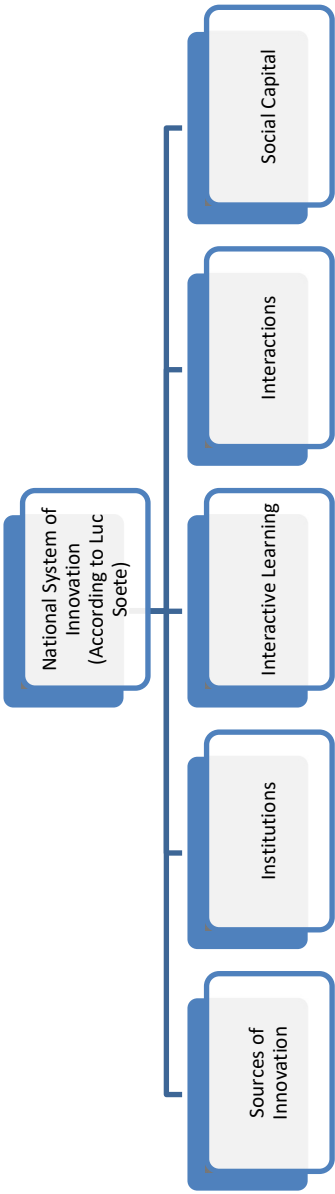
The evolution of the NSI concept from analysing institutions to focussing on learning has shifted more towards the knowledge domain. The progression of knowledge as a key component in the economy has initiated knowledge as an important component in the NSI domain. Luc Soete has proposed five key elements after a comprehensive overview of the concept of NSI.

**Figure 1–2 National system of innovation as explained by Lundvall (1992)**



Source: (Lundvall1992; Schrempf et al. 2013)

Figure 1–3 National System of Innovation as explained by Luc Soete (2010)



Source: (Soete et al. 2010; Schrempf et al. 2013)

- Sources of Innovations- Sources of innovations is one of the important components in the innovation process, the classical economic approach considers R&D as the main source of innovation. However, apart from R&D, producer-consumer interactions, the availability of skilled human resources are also important factors in the innovation process (Godin 2006).
- Institutions- As mentioned by many authors' institutions (both market and non-market) constitute one of the important elements in shaping the innovation process.
- Interactive Learning- Interactive learning is an equally important component in NSI concept. Continuous learning among human resource, institutions, market and firms provides knowledge in analyzing the innovation (Lundvall 2007).
- Interactions- Interactions and interactive learning are closely connected and it provide a great degree of value to the NSI concept. Effective interaction and coordination between organisations and institutions constitute a successful innovation system.
- Social Capital- Social capital is also an important component, it is argued that the greater the degree of effectiveness of an institution, the more social capital they form in the system. Trust is an important component for innovation, as innovation symbolizes newness, thus, trust reduces the risk of newness and influences the rate of success in the innovation process (Soete et al.2010)

The NSI framework is more comprehensive in accessing the policy parameters in the systems, as it is the conglomeration of different components like social, political, and economic, which helps in accessing the innovation dimension more comprehensively. However, the framework is more interactive and interdependence makes it more productive than any other approach (Soete et al. 2010).

### **Component, Activities and its Relations**

According to (Edquist 1997) institution and organisation are the main components of the SI framework. Organisation or individuals used to perform the activities and institutions act as a facilitator. Different authors have described these terms differently for Nelson & Rosenberg institutions are the different type of organisations whereas (Lundvall 1992) describes them as rules and regulation while defining the term institutions and organisations (Edquist 1997).

The set of institutions may vary among systems, as research institutions vary across nations, having different laws, norms, and values across the nation and between systems. The relationship between an organisation and an institution is quite important for carrying out the innovation process. Organisations are said to be deeply influenced by the institutions set up, rules and regulations. In other words, the organisation appears to be embedded in the institutional framework by legal, norms, standard etc. and thus, it influences the process of innovation and systems as well.

However, it is also seen that the organisation also influences the institution, and the process is vice-versa. In other words, both the institutions and organisation are embedded in a mutually dependent setup. The embeddedness between an organisation and institution brings out a complex process of interaction, which is one of the foremost components of the SI framework (Edquist and Johnson 1997).

Apart from identifying the components and their relationships, it is also quite important to identify the activities and what factor(s) influence the diffusion, development and use of innovation. The performance of innovation can be evaluated on the functionality of these factors. However, Edquist (1997) has listed out some of the important activities for the systems of innovations. The detail of which is listed below

1. Provisions of Research and Development (R&D), creating new knowledge, primarily in engineering, medicine, and the natural sciences.
2. Competence building (provisions of educations and training, the creation of human capital, production and reproduction of skills, individual learning) in the labour force to be used in innovation and R&D activities.
3. Formation of new product markets.
4. Articulations of quality requirements emanating from the demand side concerning new products
5. Creating and changing organisations needed for developing new fields of innovation e.g., enhancing entrepreneurship to create new firms and entrepreneurship to diversify existing firms, creating new research organisations, policy agencies.
6. Networking through the market and other mechanisms, including interactive learning between different organisations (potentially) involved in the innovation processes. This implies integrating new knowledge elements developed in different spheres of the SI and

coming from the outside of the elements already available in the innovating firms.

7. Creating and changing institutions- e.g., IPR laws, tax laws, environment and safety regulations, R&D investment routines, etc.- that influences innovating organisations and the innovation process by providing incentives or obstacles to innovation.
8. Incubating activities, e.g., providing access to facilities, administrative support, etc. for new innovative efforts.
9. Financing of the innovation process and other activities that can facilitate the commercialisation of knowledge and its adoption.
10. Provision of consultancy services of relevance to the innovation process, e.g., technology transfer, commercial information, and legal advice.

The list provided is provisional and it changes with the increase in knowledge of the innovation process. Innovation is a multifaceted phenomenon and the SI explains the role of different activities. However, the activities across the NSI framework tend to vary less compared to the organisation performing and the institution influences these activities. To understand and explain the innovation process, it is important to know about the relationships between components and functions. The activities across different systems appears to be the same, but it may vary across organisations performing and the institutions influencing them with various norms, rules specific to the context of different institutions. Hence, the relationship between organisation and functions is not of one type (Edquist1997)

### **Broad and Narrow concepts of an NSI**

The concept of NSI is based on two extreme poles named as broad and narrow concepts. The SI (Systems of Innovation) framework is quite a broader platform than R&D and technology diffusion system. The framework, on one hand, accounts for the impact of institutions and structural factors on new technology on productivity and economic growth, and on another side, it should be smaller than the economic system. These two extreme views generate a narrow and broad concept of the NSI framework.

Nelson (1993) describes the narrow definition as a set of institutions (formal structure), which are directly involved in scientific and technical activities. The innovations in these institutions are an outcome of learning