

## **CHAPTER 5 IDENTIFYING INNOVATIVE CLUSTERS IN INDIAN ECONOMY & ITS IMPLICATIONS FOR NATIONAL INNOVATION POLICY THE CLUSTERING OF INNOVATIVE ACTIVITIES**

*“Innovation is not usually a single-firm activity; it increasingly requires an active search process in order to tap new sources of knowledge and technology and apply these in products and production processes. Systems of innovation approaches give shape to the idea that companies in their quest for competitiveness are becoming more dependent upon complementary knowledge in firms and institutions other than their own. The cluster approach focuses on the linkages and interdependencies among networked actors in the production of goods and services and in innovation. In so doing, the cluster approach offers an alternative to the traditional sectoral approach.”(OECD, 1999)*

### **5.1 Introduction**

Polarisation of Innovation in some part of the economic space has been well attended earlier. Marshall’s industrial districts, Schumpeter’s innovation clusters, Eric Dahman’s development blocs, François Perrroux’s development & growth poles, the concept of high technology agglomerations all have accepted the polarisation of innovation in economic space.

This is the basic premise of my research effort. I aim to identify the innovative linkages by using innovation interaction matrices and the QIOA by performing Boolean transformation.

It draws mainly from the work by Christain De Bresson who in his various surveys along with a team of innovation researchers tried to answer as to “how Innovation emerges from normal economic activity?” His research endeavours tried to confront the following hypothesis by reconciling inter industrial analysis with the study of innovative activities:

*D. Innovations cluster in part of the economic space (Schumpeter,1937)*

*E. Varied linkages in everyday economic life tend to favour innovative linkages and clusters(Aitken 1985)*

*F. Innovative clusters and linkages may contribute to increase the division of labour(smithian hypothesis)*

Innovation here refers to the innovative activities and not the proven innovations per se as it would be known only after the adoption and diffusion whether the innovation is incremental

or radical. *Clustering of Innovative activities refers to the clusters that emerge out of various important interactions between the users and producers.*

The framework can be used to demonstrate & identify whether & how industrial linkages impact clustering of innovative activities. This will also help us locate the innovative clusters, map the structure of innovative interactions in Indian Economy and establish patterns in clustering and innovative activity. The findings can be very useful for policy decisions and prescriptions to have the structural insight and develop the required Institutional support to promote learning and innovation.

The thesis provides a pathway for the further research possibilities of examining whether innovative activity in India happens to be a function of or depends on the prior economic interdependence as manifested by input output analysis and to understand the impact of Indian economic environment on the innovative activities and vice versa.

## 5.2. The Cluster Analyses

The cluster concept as shown in the table below differs from the traditional sectoral approach. The sectoral approach emphasises the importance of horizontal relations and competitive interdependence (competitive partners operating in same industry), whereas the cluster approach also focuses on the importance of vertical relationships between dissimilar firms and symbiotic synergetic interdependence.

**Table 5.1: Traditional sectoral approach vs. cluster –based approach**

<ul style="list-style-type: none"> <li>▪ Groups with similar network positions</li> </ul>	<ul style="list-style-type: none"> <li>▪ Strategic groups with mostly complementary and dissimilar network positions</li> </ul>
<ul style="list-style-type: none"> <li>▪ Focus on end-product industries</li> </ul>	<ul style="list-style-type: none"> <li>▪ Include customers, suppliers, service providers and specialised institutions</li> </ul>
<ul style="list-style-type: none"> <li>▪ Focus on direct and indirect competitors</li> </ul>	<ul style="list-style-type: none"> <li>▪ Incorporates the array of interrelated industries sharing common technology, skills, information, inputs, customers and channels</li> </ul>
<ul style="list-style-type: none"> <li>▪ Hesitancy to co-operate with rivals</li> </ul>	<ul style="list-style-type: none"> <li>▪ Most participants are not direct</li> </ul>

	competitors but share common needs and constraints
<ul style="list-style-type: none"> <li>▪ Dialogue with government often gravitates towards subsidies, protection and limiting rivalry</li> </ul>	<ul style="list-style-type: none"> <li>▪ Wide scope for improvements in areas of common concern that will improve productivity</li> <li>▪ and increase competition</li> <li>▪ A forum for more constructive and efficient business-government dialogue</li> </ul>
<ul style="list-style-type: none"> <li>▪ Search for diversity in existing trajectories</li> </ul>	<ul style="list-style-type: none"> <li>▪ Search for synergies &amp; new combinations</li> </ul>
<b>Source : Adapted from Porter,1997</b>	

The clusters have been analyzed at micro level, meso level and macro level. Micro level refers to clusters of firms whereas meso and macro level refer to clusters of sectors /industries. The “relation between the entities in a cluster may refer to innovative efforts or to production linkages.”(Alex Hoen)

**Table 5.2: Production linkages (Source :Alex Hoen)**

	<b>Innovative efforts</b>	<b>Production linkages</b>
<b>Micro</b>	Diffusion of technologies and knowledge between firms, research institutions ,etc.	Suppliers and buyers in a value added or production chain of firms
<b>Meso</b>	Diffusion of technology and Knowledge between sectors	Backward and forward linkages between sectors; partial analyses
<b>Macro</b>	A split up of the economic system in sectors that diffuse knowledge or technologies	A split up of the economic system in sectors that form value added or production chains.

**Table 5.3: Cluster Analysis**

<b>Level of analysis</b>	<b>Cluster concept</b>	<b>Focus of analysis</b>
<b>National level (macro)</b>	Industry group linkages in the economy as a whole	Specialisation patterns of a national/regional economy Need for innovation and upgrading of products and processes in mega-clusters
<b>Branch or industry level (meso)</b>	Inter- and intra-industry linkages in the different stages of the production chain of similar end product(s)	SWOT and benchmark analysis of industries Exploring innovation needs
<b>Firm level (micro)</b>	Specialised suppliers around one or more core enterprises (inter-firm linkages)	Strategic business development Chain analysis and chain management Development of collaborative innovation projects

**Source: Boosting innovation: the cluster approach, OECD proceedings, 1999**

There have been various techniques used for clusters analyses.

- *Input-output analysis*. Used for inter-industrial linkages (Hauknes, 1999; Roelandt et al, 1999; Bergman et al., 1999) and the interdependences among the innovative activities (DeBresson et al)
- *Graph analysis*. Useful to identify the shapes and patterns of the linkages between firms or industry groups (DeBresson and Hu, 1999)

- *Correspondence analysis* (such as factor analysis, principal component analysis, multidimensional Scaling and canonical correlation): Used for similarity-based cluster analysis (Vock, 1997; Arvantis and Hollenstein, 1997; Spielkamp and Vopel, 1999).
- The *qualitative case study* approach as exemplified by the Porter country studies (Rouvinen et al, 1999; Drejer et al, 1999; Stenberg et al, 1997, Roelandt et al, 1999)

### 5.3 Why would Innovations cluster in economic space?

Various theories exist exploring as to how the economic environment affects the direction of innovation & why do innovative activities cluster? One of the observations is that the sectors with relatively higher rate of growth of demand will witness more of innovative activities as the investors are likely to invest more into the sectors that appear more promising. (Schmookler, 1966)

Another reason for clustering is the relative differences in factor endowments and allocation that can also induce a bias towards techniques that avoid the use of scarce and expensive ones but use intensely the abundant & inexpensive ones.

DeBresson tried to answer this by building a stochastic model for locating Innovative activities. He began with his hypothesis that innovative activity is a function of prior economic linkages, or

$$I=f(L) +r$$

r being the residual.

To enable estimation, he writes

$$I=a+bL+r$$

Where a is the intercept and b the coefficient relating the linkage index L (the simple index of the combined first order forward and backward linkages) to the level of innovative activity I.

Model estimations at different spatial levels had the following conclusions:

- In most of the cases except Greece, the relationship of innovative activity and domestic linkages seem to hold. Domestic economic linkages and innovative activity were found to be related in case of Italy, France and China.
- Import linkages (including only imports of goods & equipment and NOT import of new technology) do not matter as much as foreign technological linkages do. It was observed that import linkages affect innovation propensity less than domestic linkages.
- Varied economic linkages are a necessary but not sufficient condition for innovative linkages. The variety of economic contacts and information may be a limiting factor, but not the only one. Beyond a certain threshold of linkages, other limiting factors may come into play.(DeBresson, 1996)

Various other studies suggest that the networks and industrial interdependences emerge due to the *trade linkages* (Hauknes, 1999; Roelandt *et al.*, 1999; Bergman and Feser, 1999), *innovation linkages* (DeBresson and Hu, 1999), *knowledge flow linkages* (Viori, 1995; Poti, 1997; Roelandt *et al.*, 1999; van den Hove and Roelandt, 1997) and *commonality of knowledge base or factor conditions* (Drejer *et al.*, 1999). Networks of innovation are the rule rather than the exception, and most innovative activity involves multiple actors (OECD, 1999).

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This interdependence has its manifestation in clustering of innovative activities in part of the economic space. Schumpeter also observed that the proven innovation will encourage more imitations leading to a bandwagon effect due to the reduction of uncertainty & the expectation of the entrepreneurial profits.

Some of the other reasons include the following:

- The conditional probability of adoption of complementary innovations is greater than that of adopting of substitutes. (Debresson)
- There exists lesser possibility that one will switch to a new technique (even if the technique is superior) (Cowan 1990)
- The transferability of the learning competencies (the firm can leverage on the existing knowledge base given the possibility of the transferability)

Understanding the dynamics of “knowledge-based economies” and “learning economies” merits understanding of innovation and technical change. The policy makers, economists and researchers have shown keen interest in understanding the first user’s role in innovation (Meyers & Marquis, 1969; Utterback, 1975; Rothwell et al., 1974; Teubal, 1987; Lundvall, 1988; Von Hippel, 1976, 1989). This importance of suppliers and customers’ interactions is all evident in many innovation surveys based on the OECD’s *Oslo Manual* of innovation indicators (OECD/EUROSTAT, 1997)

The point in focus is to examine the process of knowledge acquisition, usage and diffusion and the dynamics of social interaction and the cooperative networks. Lundvall states NIS as the “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) Nelson also mentioned NIS to be “... a set of institutions whose interactions determine the innovative performance ... of national firms.” Freeman defined NIS as “... the network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify and diffuse new technologies.” (Freeman, 1987). Metcalfe also defined the NIS as “... 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)

Despite the conceptual variations approach of networking and interdependence, the literature on innovation systems underpins two essential dimensions of innovation:

- The interaction between different actors in the innovation process, particularly between Users and producers of intermediate goods and between business and the wider research Community is crucial to successful innovation (interdependency).
- Institutions matter, because innovation processes are institutionally embedded in the setting of systems of production (systemic character).

This chapter presents interdependence among innovative activities between different industries in Indian Economy. Table 5.4 presents the levels of analysis with variations on the cluster concept and the focus of analysis. My analysis uses the concept of Innovation interaction Matrices for identifying the linkages and aims to identify the clustering of innovative activities in Indian Economy.

**Table 5.4: Level of Analysis and cluster concept**

Country	Level of analysis			Cluster Technique					Cluster Concept
	micro	meso	macro	I/O	Graph	Correlation	Case	Other	
Australia		X	X	X		x	x		Networks of production, network of innovation
Austria		X	X					Patent data & trade performance	Marshallian industrial districts
Belgium	x				x			Sciento-metrics	Networks or chains of production, innovation & cooperation
Canada		X	X	X			x		Systems of innovation
Denmark	x	X		X	x		x		Resource areas
Finland	x	x					X		Clusters as unique combinations of firms tied together by knowledge
Germany	x	X		X		x			Similar firms & innovation styles



Italy		X		X					Inter-industry knowledge flow
Mexico		X	X				x		Systems of innovation
Nether-Lands		X	X	X			x		Value chains & networks of production
Spain		X		X			x		Systems of innovation
Sweden		X					x		Systems of interdependent firms in different industries
Switzer-land	x	X				x	x	Patent data	Networks of innovation
United Kingdom	x	X					X		Regional systems of innovation
USA		X		X			X		Chains & networks of production

**Source: DeBresson, 1995**

#### **5.4: Identifying Innovative clusters in Indian Economy**

Over the last decades, science policy produced a shift towards the policies designed to stimulate innovation (OECD, 1978). In its general review, *Technology and the Economy: the Key Relationships*, the OECD paid renewed attention to structural and systemic elements (OECD, 1992). There have been studies with focus on the NIS but (Lundvall, 1992; Nelson, 1993) but approaches focusing on reduced-scale systems, *i.e.* inter-industrial innovative clusters and networks have increased.

##### **5.4.1 The Survey: Unit of analysis**

Most of the surveys (France, Italy, China, and Greece) have considered the business units for analysis. The Canadian Survey included business units as well as the innovative outputs. I have used the hybrid approach as used for Canadian survey. For each innovative output, upstream and downstream interacting partners are identified.

Our assumption here is that both the manufacturing and service industries are the suppliers of innovative outputs. *The earlier surveys are representative of the manufacturing industries*

*and represent only the manufacturing industries to be the suppliers of innovative outputs. However given the increasing economic importance of the service industries, I included them in my research.*

The survey methods include interviews with the senior executives and R&D personnel of the business units. A questionnaire (**Appendix 1**) has been used for the survey. I interviewed 269 executives from different industries and visited 5 Innovation Labs. The secondary sources included the trade journals, reports of the trade and/or industry associations, Research and development laboratories and patents data among others. The industrial experts from different industries were also asked to identify the innovations in their sectors of competence. Based on their response, the further validations have been done with the supplying industries and the user industries of the innovative activities. For each innovative output, the upstream and downstream interactions are identified so that mapping of innovative interactions as much as possible becomes feasible.

#### **5.4.2 QIOA (Qualitative Input Output Analysis)**

Research studies in 1960s (Myers & Marquis,1969;Utterback,1975;Rothwell et al.,1974;teubel,1987;Von Hippel ,1976,1989;Lundvall,1988) evidenced the first users role in creation of innovative activities. Innovation happens to non-linear multidisciplinary process that involves at least two partners. Innovations do not happen in isolation. If this is true, then it is very easy to justify using input output analysis for studying innovative activities. After all Input output tables provide for the economic interdependencies .Innovative activities involve heuristic interdependence (DE Bresson, 1990). I have performed Boolean transformation to compile the Innovation interaction Matrices. (**Refer Appendix 2**)

Some important interactions between suppliers and users in the process of innovation have been shown in the following Figure.

**Table 5.5: Supplier –user interactions**

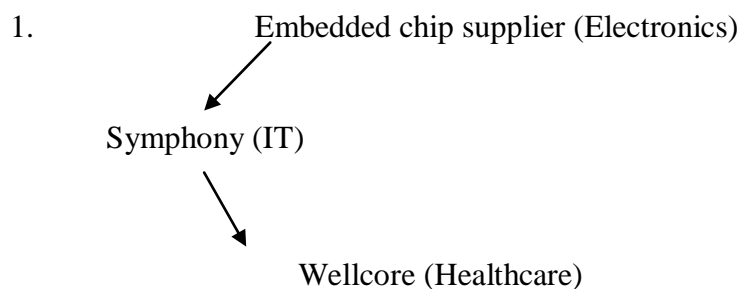
<b>Supplier:</b> <b>the product or service</b>	<b>Client:</b> <b>Its use in a process</b>
Search for a commercial application for supplier’s technical competence	Search for a technical solution for an identified problem and need specification of performance requirements
Conceptual design of solution	Assessment of design and further specifications of performance requirements
Value engineering Prototype model to demonstrate technical feasibility	Assessment of technical choices Testing and assessment of technical performance Specification of operating and fixed cost requirements
Value Analysis, new prototype	Testing, adjustment requirements and firm orders
Pre production engineering De-bugging, quality & production-cost control	Quality control, and operation cost control
Production & launch	Economic use

**Source : Debresson**

### **5.4.3: Mapping innovative activity in the Indian economy with innovative interaction matrices**

The innovation interaction matrix has been compiled after identifying the innovations in Indian economy .The frequency in the cell manifests the various interactions between suppliers and the users for the innovative outputs. Some of the examples are shown below:

**Figure 5.1: Innovative Linkages**



2. TATA STEEL (Blast Furnace slag (a waste by product from steel))



ACC Chaibasa (Portland Slag Cement)

Innovation Interaction Matrices compiled from the survey responses tell us about the key locations in which innovation originates in Indian economy and then diffuses to the rest of the economy. As the creation, adoption and diffusion of innovation also reveal the knowledge creation, acquisition and diffusion of new technologies, the mapping innovative interactions also produces an understanding vis-a-vis learning dynamics in the economy, i.e. how the clustering of innovative activities emerge out of the increased social interactions and division of labour through cooperative networks. In other words it also explains the segments of the learning economy in which firms are more dynamic.

The matrices also allow for the comparison with the economic matrices and the patented inventions (Evenson 1997) by adopting Leontief I/O table as reference template. As stated in the section dealing with the methodology earlier, an innovative matrix is a square matrix, with the suppliers of the innovative output classified by industry in the rows, with the most frequent user industry of innovative outputs identified in the columns.

In an attempt to identify the economic locus of innovative activity in Indian economy, I began to survey the industries (sample size of 32 industries) with an objective to understand their innovation outputs & the first order forward and backward linkages. Such survey can be very crucial and useful in today's context due to the reasons as follows:

- 1) The augmenting importance of the innovation in economic growth and the importance of understanding the structure and pattern of the co-operative networks underlying them.
- 2) Comparing the degree of innovative activity concentration in different countries

The innovation interaction matrix has been compiled after identifying the innovations in Indian economy. The frequency in the cell manifests the various interactions between suppliers and the users for the innovative outputs.

#### 5.4.4 The businesses size

The survey consists of business units of different sizes. The survey definition for the innovative activity is the introduction of a new product or a new process.

#### 5.4.5 The structure of Innovative interactions in Indian Economy

In the survey, we found the main suppliers and users of the innovative activities as shown in the following Tables (5.6 & 5.7). In the table 5.6 , supplying industries of innovative outputs have been ranked; first by the importance of the first order forward linkages (i.e. number of user industries they supplied-column3) and second, by the total number of business units involved in innovating activities-column 1).

**Table 5.6: The main suppliers of innovative output in India**

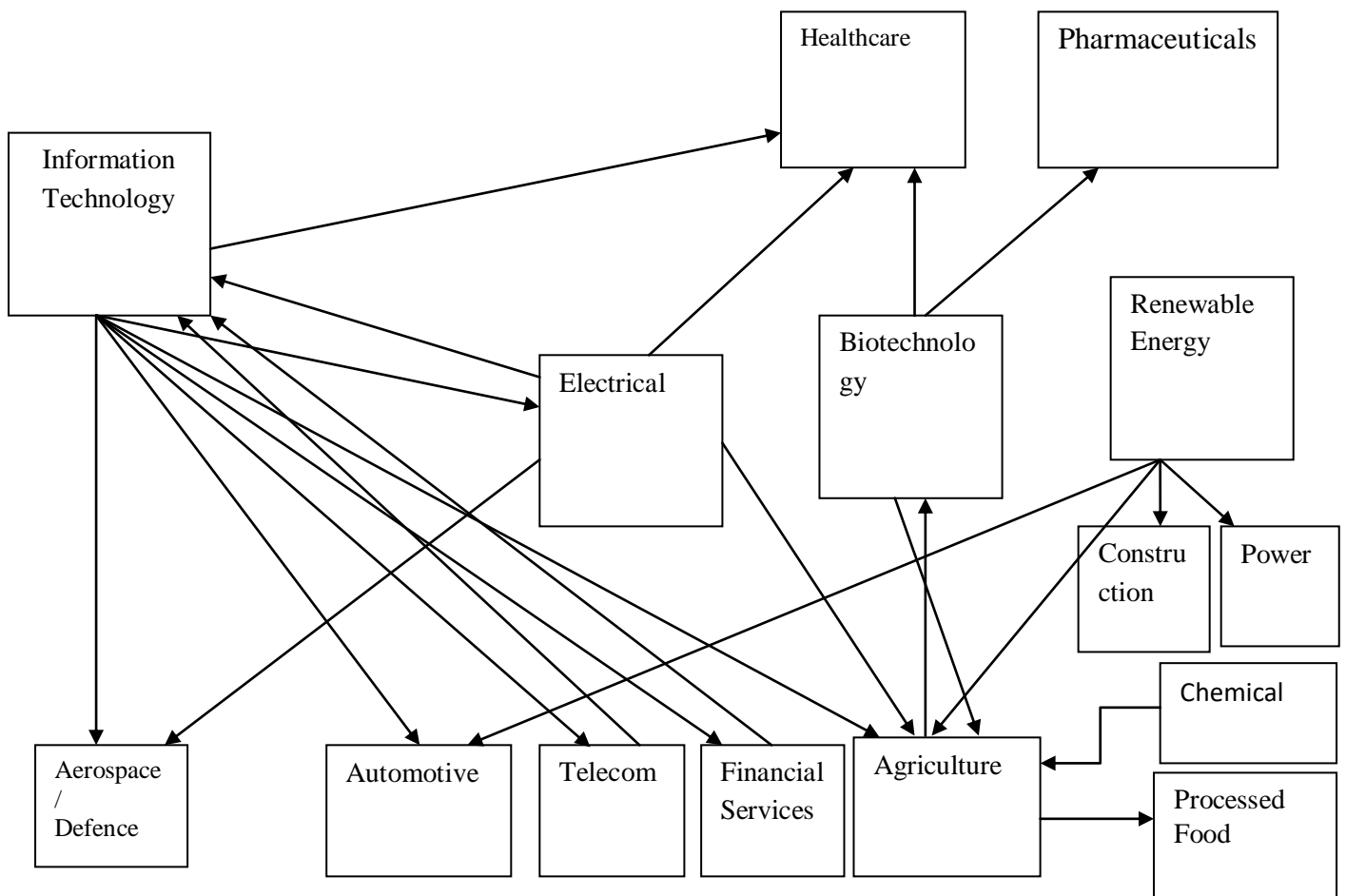
Industries	Frequency	Percentage	Number of users
IT	116	17.28	80
RE	76	11.32	56
ELEC	89	13.26	54
BIO	62	9.23	41
CHEM	56	8.34	33
AG	48	7.15	15
STEEL	20	2.98	11
OIL & GAS	17	2.53	11
Sub-total	484	72.09	
Total	671	100.00	

In the table 5.7. User industries of innovative outputs have been ranked first by the importance of the first order backward linkages (i.e. number of supplier industries they had the supplies from-column3) and second, by the total number of business units involved in innovating activities-column 1).

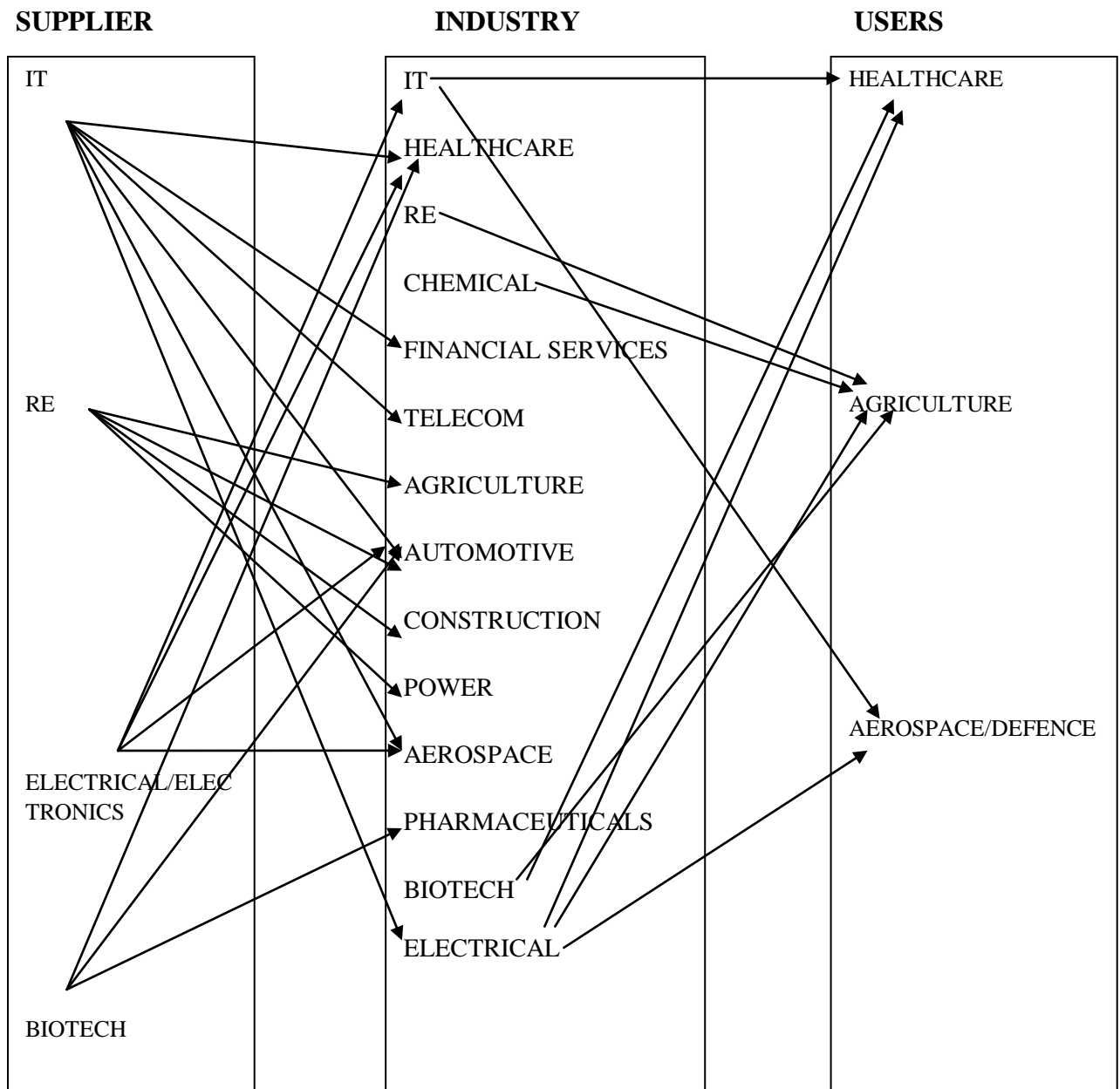
**Table 5.7: The main users of innovative output in India**

Industries	Frequency	percentage	Number of suppliers
Healthcare	108	16.09	57
Agriculture	74	11.02	41
Power	24	3.57	23
Construction	25	3.72	22
Aerospace/Defence	31	4.61	18
Financial Services	25	3.72	17
Processed Food	20	2.98	17
Metal	29	4.32	13
Sub-total	336	50.03	
Total	671	100.00	

**Figure 5.2: Inter industrial Innovative interactions**



**Figure 5.3: Supply-use innovation interactions in Indian Economy**



#### 5.4.6: The findings & recommendations:

The research findings are as follows:

- The innovative activities seem to have clustered around IT, Electrical & Electronics, Cleantech (Renewable Energy), Biotech, Chemical, Healthcare and Agriculture industry.
- The main suppliers for the Innovation outputs happen to be from IT, Electricals, Biotech & Chemical Industry (contributing to 51% of total supplies) whereas the key users happen to be the Healthcare & Agriculture industry (27% of the total use).
- Health care and Agriculture happen to be the main users of the Innovation outputs; however they do not supply the innovation outputs as much. Similarly IT, Electronics, Renewable Energy, Biotech & chemical industries –the key suppliers of the innovation output are not in the list of main users of innovation output.
- Unlike the developed countries, inter industry innovative linkages do not seem strong in cases of Aerospace & Defence, Steel, Metal Products & cement. The policy interventions and decisions have to support the innovation building strategies by promoting cluster dynamics and directing inter-industrial knowledge flows for the enhancement of establishing cooperative networks & production linkages in these industries and also the producer goods industries, particularly the fixed capital goods, as we see in industrially developed economies.
- The findings evidence the lack of interactions between different agents of innovative activities. The Science Technology and Innovation policy of India should map the non informal sources of learning (not captured in R&D, Patents or I/O data). The policy must include the cluster based policies to strengthen the inter industrial learning process and enhance the cluster dynamics and competitiveness.
- Increasing importance has been observed worldwide vis-a-vis the innovation surveys such as the **Community Innovation Survey, the PACE Survey and the surveys related to cluster interactions and the international knowledge flows**. India lacks such efforts. Efforts at the Government, Institutions and the Firms level should be made to undertake such surveys to make them internationally comparable to the benefit of the Growth and development Economists and the Policy makers. Reference Base can be **Frascati manual & Oslo Manual**.
- Listing grass root innovations as promoted by the National Innovation foundation is a very welcome move, however industry focused strategies need to be incorporated by



the growth strategists and policy makers such as ICAP (Industrial Capability Enhancement Programmes) in Singapore.

- More than 85 % of the respondents in the primary survey showed lack of confidence in government policies related to R&D, IP protection and the Government incentives. Care must be taken to address these issues.
- NIC has recommended setting up Innovation Universities, Meta Universities & Introduction of Innovations at Schools Programme, formation of State and Sectoral Innovation Council. The policy should also include industry-academia interaction with specialized profiles and focused strategy such as Brain 21 Programme in Korea. Lack of policy focus relating to enhancing the firms /universities specialized capabilities need attention.
- Maharashtra ,Karnataka,Tamilnadu,Andhra Pradesh ,Delhi including NCR seem to be contributing significantly in terms of innovating activities. Kerala & West Bengal are also catching up but other states really lag behind.