

CHAPTER 1: INTRODUCTION

1.1 Economics of Innovation

“One of the most important achievements of contemporary economies and societies is the constant creation of new knowledge. Yet economic theory is still focusing on the problems central to a past epoch: universal scarcity. Economic analysis is still largely focused on the management of scarce resources, what the economists have termed the optimal allocation of factors. Yet the process which characterises today’s economy is the creation of new factors.” (DeBresson, 1996)

It is this shift in the focus of analysis from the allocation and management of resources to the creation of new factors that has made the study of innovative activities central and so much important to modern economics. Various studies (Mansfield et al., 1977; Bresnahan, 1986; Trajtenberg, 1990; Coe and Helpman (1993); Eaton and Kortum (1993) and Lichtenberg (1992); Caballero and Jaffe (1993) related to the growth and developments both at the firm and the national level have recognised the augmenting importance of innovation. The celebrated world leading Economists from Adam Smith to Robert Solow, Ricardo, Marx, Marashall, Schumpeter and Keynes all have recognised the importance of innovation and the role it plays in long term growth and productivity. Even the celebrated critic of the capitalist society, Karl Marx appreciated the importance of innovation and did mention in *the communist Manifesto* that “*The Bourgeoisie (i.e., capitalism) cannot exist without constantly revolutionizing the instruments of production. Conservation of the old modes of production in unaltered form was, on the contrary, the first condition of existence for all earlier industrial classes. The bourgeoisie, during its rule of scarce one hundred years has created more massive and more colossal productive forces than have all preceding generations together. It has accomplished wonders far surpassing Egyptian pyramids, Roman aqueducts and Gothic cathedrals...*” [Marx and Engels, 1847].

The term Innovation was coined by the German Economist Riedel (1839) and sociologist De Tarde (1890). However economics of innovation gained its importance only after the release of the *Locus Classic* "The Theory of Economic Development" by Schumpeter. Innovation thereafter became the central focus and the strings of debates & discussions started. In 1985 The concept of a '*system of innovation*' was introduced by B.A.Lundvall though the idea produced some familiarity to the Friedrich List’s conception of “The National System of

Political Economy” (1841), which according to Freeman (1995) might just as well have been called “The National System of Innovation” .Christopher Freeman coined the expression "National Innovation System". Today Research interests worldwide have gained momentum due to the emergence of the Knowledge based economies. (Freeman, 1987, Lundvall, 1988, Nelson, 1993) and the analysis of innovation practices and policies have become really important since OECD initiated this exercise in 1960s. The incredible growth records of the free-market economies do establish the importance of innovation more than ever. The importance of allocative and adaptive efficiency has always been discussed but the changes in the market, technological conditions, augmenting competition; shortening product life cycles have forced the firms to develop the learning economies and creation of new factors.

The “creation of new factors” or “new combinations” happens due to the interactions between the different economic agents, e.g. the firms, universities, Research and development labs and private and public institutions. Though Schumpeter did mention that the “changes in economic life are not forced upon it from without but arise by its own initiative from within.” (Ibid, P.63), Research efforts focused on National Innovation Systems, cluster analysis, clusters dynamics and cluster-based policy have gained global attention only since 1980s primarily due to the emergence of endogenous theories (Romer 1983, 1986).Economists’ curiosity worldwide grew up to study and analyze the knowledge flows in national innovation systems and how the different economic agents interact to create “new knowledge”.

The clustering of innovative activities has been a topic of interest to many of the celebrated economists. Marshall (1890) in his Principles of Economics talked about the “industrial districts “and how the interactions between people, suppliers and the skilled labor pool could benefit the localized industries.” Schumpeter (1912, 1928, 1935, 1939) talked about the bandwagon effect leading to the spatial clustering because of the imitators following the already proven innovations and the temporary monopolistic rents, i.e. entrepreneurial profit. The sectoral mega-clusters have been discussed by Porter "Nations, whatever their overall level of innovative performance, do not usually succeed across the whole range of industries, but “in clusters of industries connected through vertical and horizontal relationships” (Porter, 1990).

The Chains and Network based Cluster approach (The *Filiere* approach by Montfort,1983;Montfort & Dutaille 1983, Roelandt 1986; Witteveen,1997) demonstrate the

relationship within and between the networks & how the clusters emerge out of the various agents interactions & the cooperative networks .

Many of the observations worldwide suggest the increasing importance of innovative activities & the emergence of new technologies that seem to have supported the view point of the modern endogenous growth theories. The structural change due to the digital revolution in the US is one such example. The economy has witnessed the significant growth of some of the new innovating firms. Almost 40% of the top 200 R&D-performing firms in 2005/2006 were founded after 1980, while 32% of the top 200 R&D-performing firms in 1980 had exited by 2005 (Hall and Mairesse, 2009). The growing contribution by the ICT to the GDP in Indian economy is another example. This may exceed the contribution made by the agriculture industry by 2020 bringing about a significant industrial change. The microeconomics of creation and destruction today is quite visible.

Well did Schumpeter observe:

“The first thing to go is the traditional conception of the modus operandi of competition. Economists are at long last emerging from the state in which price competition was all they saw. As soon as quality competition and sales effort are admitted into the sacred precincts of theory, the price variable is ousted from its dominant position. However, it is still competition within a rigid pattern of invariant conditions, methods of production and forms of industrial organization in particular ... that practically monopolizes attention. But in capitalist reality as distinguished from its textbook picture, it is not that kind of competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives” Schumpeter, 1939

It is in these contexts that the study of economic linkages and how they influence innovative linkages become relevant and really important. Where and why in Indian economy the innovative activities are likely to occur? Do they occur in the industries having the greatest variety of economic, technological and scientific linkages? What is the strength of these linkages? Do economic linkages matter? What are the limiting factors? Can we estimate the direct and indirect impact of innovative activities? These are the questions that we need to

answer with reference to Indian Economy as they have direct really important and relevant policy implications.

1.2 The Research aims and objectives

The research aims to map the innovative activities in economic space and identify the innovative clusters and the structure of the innovative interactions in Indian Economy. The project will be useful in enhancing the understanding vis-à-vis the innovative clusters' dynamics and how to sustain the growth or influence of these clusters in certain directions.

My focus of analysis through this work is to develop a theoretical construct to facilitate an empirical analysis vis-a-vis clustering of innovative activities in Indian Economy by using Innovation interaction matrices and the Qualitative Input Output Analysis (QIOA). It draws mainly from the work by Christian DeBresson who in his various surveys along with a team of innovation researchers tried to answer as to “how Innovation emerges from normal economic activity?” I aim to confront the following hypothesis by reconciling inter industrial analysis with the study of innovative activities:

- A. *Innovations cluster in part of the economic space (Schumpeter,1937)*
- B. *Varied linkages in everyday economic life tend to favour innovative linkages and clusters(Aitken 1985)*
- C. *Innovative clusters and linkages may contribute to increase the division of labour(smithian hypothesis)*

The objective is to demonstrate & identify the key locations of innovations and how they diffuse in the economy. 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 outcome of the research can further be used to understand whether innovative activity 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.

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.*

1.3 The Research Questions

The research questions addressed in the thesis are as follows:

- How does Innovation emerge from normal economic activity in Indian Economy?
- What is the structure of innovative interactions? Who are the main suppliers and users of innovative activities?
- Where do innovative acts exist in economic space and how their relative distribution in this space can be measured?
- What is the impact of economy on innovative activity?
- What are the constraints and incentives in the way agents interact and as such why innovative activities cluster?
- What are the policy implications?

1.4 The Methodology

The methodology for the research includes the Innovation Surveys, the compilation of innovative interaction matrices from surveys and Performing Boolean Transactions (Qualitative Input Output Analysis) to analyse the innovative linkages and the clustering of Innovative activities.

1.4.1 The Indian Survey

I have used the methodology of Christopher Freeman & Joe Townsend for the survey in observing the innovative activities (Freeman, 1969, 1974, 1982; Townsend et al., 1981). The unit of analysis in the methodology used for this survey includes the innovative Units and the innovative outputs. The Primary survey included meeting the R&D personnels, top management Executives and other concerned authorities to find about the innovative outputs. Also the Industrial experts in different industries were asked to identify significant innovations in the industries of their expertise and the subsequent validation was made. The secondary research included Printed Journals, Online Gateways and Databases, e-publications, Online Journals, Government and other regulatory body publications, Books in the context of Innovation, NIS, Clustering and Competence, Reference texts Industry Reports among others. The industry representative of the survey is shown in Table 1.1.

1.4.2 The Indian Innovative-Interaction Matrix

The Innovative-activity matrix is a standard square Matrix in which the rows produce the supplier industries of the innovating business unit and the columns show the user industries. The frequency in each cell tells us the number of times a business unit from a supplier industry has created that business unit's economically most important innovation for and with a business unit in a user industry. A variety of types of innovative businesses coexist within an industrial sector. It should be noted that the meaning of supplier and user happens to be different in case of innovative-activity matrix, as information flows both ways between supplier and the first user. Suppliers are known to innovate "with" as much "for" the initial user.

In the survey, efforts have been made to cover as much of the web of innovative interactions as possible. The information about the first three users and for the three main key component suppliers has been asked.

Innovation interaction Matrices reveal the dynamism of the economy. It tells us about the locations where the innovations happen and how they diffuse in the economy. One of the major advantages of the matrices is that they provide us with information we do not get from Input Output Matrices or the data related to the Research and Development and Patents. R&D does not account for non-formal forms of learning, and therefore accounts for only a fraction (around 10%) of innovative knowledge. Patented inventions represent technological *opportunities*, only a fraction of which (between 10 and 40%) are ever used commercially. Furthermore, R&D and patents only provide the source of origin, *i.e.* the supplier. Potential users of research results and inventions have to be conjectured. (Debresson, 1990)

The survey questionnaire (**Appendix 1**) has included the questions regarding the first three key component suppliers and the first three users, as understanding innovation will not be possible without looking into the producers- users interactions. Compiling the matrices thus obtained can be used for comparison to a detailed mapping of the economy and patented invention (Evenson, 1997) by adopting Leontief I/O tables as a reference template.

The lower left-hand corner (or the rows in a matrix) represents the supplier industries of the innovating business unit, while the lower right-hand corner (or columns in a matrix) represents typical user industries. The value of each cell represents the share of supplier

industry “i”’s innovative sales (for that business unit’s economically most important innovation) to industry “j”.

Figure 1.1 The Methodology

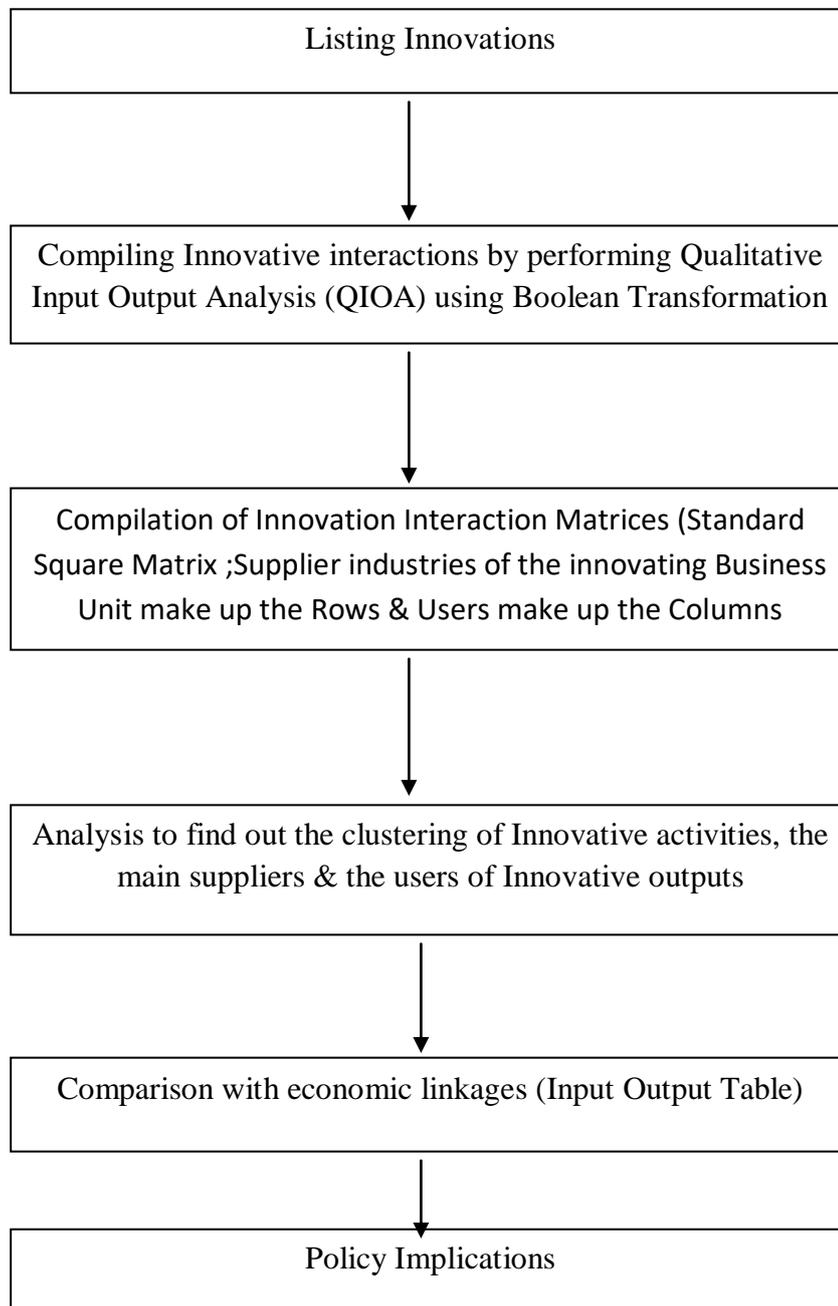


Table 1.1 Industry representative of the Survey

Serial No.	Industries
1	Aerospace/Defense (AE/D)
2	Agriculture (AG)
3	Automotive (AU)
4	Beverage (BE)
5	Biotechnology (BIO)
6	Cement (CEM)
7	Chemicals (CHE)
8	Coal (COA)
9	Construction (CON)
10	Dairy (DAI)
11	Electrical/Electronics (ELE)
12	Entertainment (ENT)
13	Financial Services (FS)
14	Glass & Ceramics (GLA)
15	Healthcare (HC)
16	Information Technology (IT)
17	Leather (LEA)
18	Metal (MET)
19	Oil & Gas (O&G)
20	Packaging (PKG)
21	Paper (PAP)
22	Pharmaceuticals (PHA)
23	Plastics (PLA)
24	Power (POW)
25	Processed food (PF)
26	Renewable Energy (RE)
27	Rubber (RUB)
28	Steel (ST)
29	Telecom (TEL)
30	Textile (TEX)
31	Transport (TRA)

1.4.3. Qualitative Input Output Analysis (QIOA)

We performed the Boolean transformation to find the linkages .The idea that potentially interesting properties of input-output matrices can be derived without knowing individual cell values in great detail seems to go back at least as far as Solow (1952,p.41):

“the particular nature of these properties [e.g.,indecomposability (a property of connectedness)] is illustrated by the fact that they can be investigated with no knowledge of the value of a_{ij} other than which.....are zero and which are not. To test whether an [A] matrix is decomposable, one needs only the matrix with a_{ij} replaced by ,say + and 0.”

Binary (Boolean)transformation as we know can be performed on either transactions (z) or coefficients (A) to generate matrices with a “1” in cells for which $Z_{ij} = 0$ (or $a_{ij}= 0$) ,and a “0” elsewhere.

For Example, let A=

$$\begin{pmatrix} 0 & .2 & 0 \\ .2 & .3 & .1 \\ .3 & 0 & 0 \end{pmatrix}$$

With a filter of 0, we have $W^{(1)} =$

$$\begin{pmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 1 & 0 & 0 \end{pmatrix}$$

Where $W^{(1)}$ denotes the Boolean Matrix associated with A ($= A^1$).Higher power of W reflect an indirect connections that exist among sectors.