UNIVERSITY INDUSTRY LINKAGES: MOTIVATIONS, PATHWAYS AND IMPLICATIONS

Dissertation

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DECLARATION

I, Acharya Loknath Indramani, declare that the dissertation entitled "**University Industry Linkages: Motivations, Pathways and Implications**" is submitted in partial fulfillment for the award of the degree of Master of Philosophy of Jawaharlal Nehru University. This dissertation has not been previously submitted for any degree of this or any other University and is my original work.

Acharya Loknath Indramani

CERTIFICATE

We recommend that this dissertation be placed before the examiners for the award of the degree of Masters of Philosophy in this University.

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DEDICATED

TO

MY PARENTS

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Acharya Loknath Indramani

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1 Introduction

There is an increasing recognition of the need to strengthen University-Industry Linkages[1] (UIL) in recent decades. The topic has drawn considerable interest from researchers, policy makers and industry. The interest and the importance of the subject can be gauged from the extensive research literature that has emerged, mainly with an inter-disciplinary perspective (Rothaermel, Agung, & Jiang, 2007). Researchers from the diverse field of economics, education, management, and science policy perspective have contributed to the growing literature.

The strength of UIL is seen as an important determining factor for economic competitiveness in the rapidly changing technological landscape. Universities are increasingly expected to play a major role in the economic development of the country(Smith, 2006). In the knowledge intensive economy, growth will be driven by relatively new sectors, which rely heavily on a skilled human resource. Universities are contributing directly to the emergence of new areas like robotics, internet of things, nanotechnology and biotechnology to name a few. Industries, which are looking to gain a competitive advantage, are continuously looking towards Universities to provide solutions. From universities perspective, industries can contribute resources necessary to carry out innovative research. Government policies in not only developed countries but also in developing countries, are recognising the need for enhanced UIL.

The research in this area has focussed on multiple aspects, with a varying role for the academia. First, within a national system of innovation, Universities are expected to play a critical role. However, University's focus continues to remain within the domain of teaching and research. There is an enhanced collaboration between the two, with the firm driving the innovation. A number of initiatives to strengthen the linkages in the form of joint research collaborations, consultancy services, exchange of human resources, technology transfer are undertaken.

[1] We use University in a broader sense, it includes all Higher Education Institutions. Thus, Higher Education Institutes, Academia and University are used interchangeably.

Second, the triple-helix framework calls for universities to take the lead in innovating, in collaboration with government and industry. An important aspect of this is the university not only produces innovative research but also commercialises them. It actively enters into the domain of industry by creating new spin-offs, setting up incubators and research parks. The model derives inspiration from the success of knowledge clusters like California's Silicon Valley or High technology cluster in Cambridge, United Kingdom are a few example. An important and defining characteristic of these regions was a strong UIL.

The third set of studies has focussed on the implications of enhanced UIL on the primary role of University as a teaching and research institution. Some academic researchers also opposed increasing interaction with the industry and commercial activities, believing that it diverts limited resources towards non-academic activities. The main concern relates to increasing pressure on academia may change the orientation of University research from producing basic research to applied research (Nelson 2004). Dasgupta and David (1994) identify the differences in motivation in which academia and firms function. Further, they express their apprehensions that promoting commercialisation in academic institutions would change the institutional rules of carrying out research.

The empirical research based on the three broad categories has focussed on the motivations pathways and implications for UIL. These studies are mostly based on surveys of academics, technology transfer offices, industry R&D managers and policy makers. A large number of studies have also focussed on the importance of the pathways taken for enhancing the linkages. We discuss the empirical literature in detail in the next chapter.

The majority of the literature is focussed on the developed countries. In recent years, studies on emerging Asian economies have also relatively increased. However, there is surprisingly dearth of research on UIL in India. Ansari & Sharma (1991) is one of the earliest studies, which identifies the key pathways[2] of interactions and barriers, which hamper greater collaboration between University and Industry. Basant & Chandra (2006) focus on "the role of University in enterprise creation." Bhattacharya & Arora (2007)

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[2] We use pathways and channels interchangeably

analyse the types of linkages between select University departments and Industry. Joseph & Abraham (2009) is the only comprehensive study with a large-scale sample that covers both Industry and academicians viewpoints. They find weak linkages between University and Industry in India. Krishna & Chandra (2009) look at the knowledge production and transfer activities from two Indian Institute of Technologies (IITs). Krishnan (2011) looks at the role of academia and public research institutions in the automotive sectors, using a case study method. Krishna (2012) looks at the "Role of Universities in the National Innovation System of India".

1.1 Rationale of the study

Similar to global changes, there is an increasing focus on enhancing UIL. Science, Technology & Innovation Policy, 2013 calls for a systematic approach for enhancing UIL. Other government initiatives are focussing on the creation of incubation centres attached to Universities, to help in the formation of successful start-ups.

Already in India, a set of top HEI[3]s seems to be taking global cues and increasingly contributing to the global scientific knowledge, as well as aggressively becoming more entrepreneurial. Also, these institutions are collaborating in generating and transferring of knowledge to industries. Some of them are actively adopting strategies for commercialising the knowledge they have generated, by patenting and licensing them or creating spin-offs based on their research. Technology transfer offices in these institutions, staffed with professionals are becoming part of the university set up to match students and faculties on the one hand and industries on the other(Krishna, 2012; Krishna & Chandra, 2009). However, very little is known outside of these top institutions.

The current study tries to fill the gap by incorporating some of the elements of UIL for a much larger set of HEIs across different disciplinary categories in India. We make use of data furnished by institutions for the National Institutional Ranking Framework, to create a dataset of around 300 HEIs in four different institutional categories: University, Engineering, Management and Pharmacy[4].

[3] IIT, IISc and few private institutes like Amity.

[4] See the section on data for a detailed discussion

Also, there are limited studies on the successful models of University-Industry-Government partnerships in India to establish collaborative research. We provide a brief case study of one such programme, initiated by Ministry of Communications and IT under the "Telecom Centre of Excellence programme."

1.2 Objectives and Research Questions

- **To identify the motivations, pathways and implications of University Industry linkages**
  1. What are the factors, which motivate Universities and Industries to collaborate?
  2. What are the pathways of these collaborations?
  3. What are the implications of universities' increased engagement with industry or commercialisation of research on the core-academic functions?

  These questions are answered based on the review of the literature.

- **To understand the University-Industry Relations within the theoretical framework of NSI and Triple Helix in case of India**
  1. What role do Universities play in India's NSI?
  2. Are universities in India becoming entrepreneurial in nature?

1.3 Method & Data

The research follows an exploratory method based on secondary data and policy analysis. A systematic review of the literature has been carried out to identify the motivations, pathways and implications for University-Industry Linkages. The concept of 'National System of Innovation' is used to determine the role of Universities in India's innovation system. Universities use diverse pathways to transmit knowledge generated by them. A Bibliometric analysis is carried out to understand the trend in scientific output from India using the web of science database.

In India, there is no systematic database available on the commercial activities of HEIs. We construct a new dataset using the disclosures made by participating institutions in the National Institutional Ranking Framework (NIRF). This provides us data across four categories of institutions, University, Engineering, Management and Pharmaceuticals. An individual file in the PDF is uploaded for the top HEI in each category. There are 100 each in University and Engineering, while Management and Pharmacy each have 50 institutions. One more category of institutions, 'Colleges' is also covered by NIRF. However, we do not use this category as only limited research, is carried out in Indian Colleges. There were in total 300 files, which were extracted into MS Excel. After carrying out the formatting, the data was cross-checked for correctness manually.

The following indicators were extracted:

Table 1.1: List of Indicators from NIRF, 2017

Indicators	HEI Category	Years	Source of Data
Patents Published	University, Engineering, Pharmacy	Last 3 years[5] Aggregate	Thomson Innovation
Patents Granted	University, Engineering, Pharmacy	Last 3 years Aggregate	Thomson Innovation
Earnings from Patents	University, Engineering, Pharmacy	Last 3 years Aggregate	Reported by HEI
Publications + Citations	University, Engineering, Management, Pharmacy	Last 3 years Aggregate	Web of Science, Scopus, India Citation Index
Consultancy Projects (Revenue)	University, Engineering, Management, Pharmacy	Last 3 years - Year wise	Reported by HEI
Sponsored Projects (Revenue)	University, Engineering, Management, Pharmacy	Last 3 years – Year wise	Reported by HEI
Annual Total Expenditure	University, Engineering, Management, Pharmacy	Last 3 years – Year wise	Reported by HEI
Number of Faculties	University, Engineering, Management, Pharmacy	Latest	Reported by HEI

This database helps us to assess the entrepreneurial nature of Indian HEIs and analyse of the channels of interactions. The pathways adopted by different categories of institutions can also be discerned from the data set.

As per the NIRF, each participating institution is required to keep a more detailed version of the documents submitted on their website for three years. However, a significant number of institutions have not followed this. Sometimes data entries were cross checked with this files, wherever outliers in terms of too large a figure or discontinuity were observed, and back up data were available on the institutes website.

[5] The three years are 2013-14, 2014-15 and 2015-16

A word of caution is due here. As the data are self-reported and submitted for ranking, they may not present an accurate picture. One of the indicators collected was on 'Enterprise creation'. However, due to the difficulty in verifying the claims, the NIRF did not consider this criterion. The other factor is that while a much larger number of institutions participated in the ranking, the data is available for only the top ones in each category. Thus, it may present an upward bias. However, considering that it is accepted that only a limited number of HEI in India carry out research(Krishna, 2012) this may not be a major problem.

For additional data, we accessed the websites of select institutes and their annual reports to gain further information related to sources of funding and identify collaborations.

For analysis of the NSI, we used data from various Ministry and Departments' websites of Government of India, relating to various schemes, statistics, reports and policies were also accessed for relevant information. Further, for data on patenting in India, Controller General of Patents, Designs & Trade Marks web search facility was used. To carry out international comparison data from UNESCO Institute of Statistics was analysed. Further data from World Economic Forum's Global Competitiveness Index is also used.

1.4 Tentative Chapters

Chapter 1: Introduction

Chapter 2: University-Industry Linkages: A review

The review covers three sections. The first section looks at the changing role of the modern university. The second section briefly looks at the two conceptual frameworks used to understand UIL. The third section covers the empirical literature on the motivations, pathways and implications of increasing UIL.

Chapter 3: Role of Universities in India's National System of Innovation

This chapter focuses on India's National System of Innovation. Various indicators relating to expenditure on research, research by sector, and India's ranking in the global innovation are analysed. The chapter also includes a section on India's Higher education sector and its role in the NSI. Further data on India's publication output using Scopus database is analysed. Other indicators related to joint publications and patent citations are referred to understand the knowledge linkages at the macro level.

Chapter 4: Academic Entrepreneurship and University-Industry Linkages in India

This chapter analyses the on capitalisation of research and research services. We look at three key indicators related to patent and royalty earnings, income from consulting services and sponsored research across a different disciplinary category of institutes. We also look closely analyse the performance of one of the Business Incubators to understand the role of University Spinoffs in knowledge transfer.

Chapter 5: Summary & Conclusion

2 University-Industry Linkages: A Review

The review in the following section is divided into three parts. The first part discusses the changing role of the University, from primarily a teaching and research organisation to an entrepreneurial university. The second part has a review is on the innovation systems mainly discussing two conceptual frameworks- National Systems of Innovation and the Triple Helix Model. The University- Industry linkages are defined in these frameworks and are directly relevant to the current study. Third, we discuss the empirical literature covering the three key aspects of the University-Industry linkages: the motivations, pathways and implications.

2.1 Changing role of University

While it is taken for granted that Universities have two fundamental roles to play in the society-: teaching and research. However, the dual role of the university is a recent phenomenon, only three century old, when compared from the time the first university was founded at Bologna in 1088(Scott, 2006). The role of the earlier universities was limited to teaching and training for professionals in the church, legal system and medicine (Clancy & Dill, 2009). It was only in the late eighteenth century that the university acquired the dual role of carrying out research and teaching. This model was first adopted in the University of Berlin under the leadership of Prussian administrator Willhelm von Humboldt. This is now famously characterised as the 'Humboldtian model' of self-governance and academic freedom(Knill & Dobbins, 2009). It is based on three principles of academic freedom: 'freedom for students to learn according to their inclination (*Lernfreiheit*), freedom for teachers to teach according to teacher's conviction (*Lehrfreiheit)* and freedom to carry out research according to one's interest'(Boyer, 2002). The unity of teaching and research were the main outcome of this model, and it continues to be the dominant ideal, which universities try to emulate. However, as we will see in our discussion on India, the separation of teaching and research has hampered the growth of research in Indian Universities. It is estimated that only around 15 to 20 percent of the total universities conduct research activity(Krishna, 2012).

The current call for Universities to contribute to the economic development did not emerge until the nineteenth century when the insights of academic research were applied to the improvement of agriculture in some countries (Lundvall & Borrás, 2005). There are other instances where the German government funded the universities actively and encouraged the application of research discoveries in organic chemistry to help industry (Clancy & Dill, 2009). The rise of the land grant universities in the United States, where the universities were expected to provide a solution to the regional problems are other examples of University research geared towards solving practical issues.

The publication of “Science: The Endless Frontier” (Bush 1945), often considered to be one of the most influential reports pushed for government funding in science(Clancy & Dill, 2009). The report argued that the evidence from the war years suggest if the public investment were made in basic research, it would seamlessly translate to applied research, technological development, leading to innovation. This in turn would result in substantial social benefits in the form of increased wealth, health, and national security would automatically follow. This came to be dubbed as a linear model. As most basic research was done in Universities, it had major implications for the future of research in the US and the rest of the World.

Martin (2012) highlights the key characteristics of the Vannevar Bush social contract are:

> (i) that there should be a high level of autonomy, with few ‘strings’ being attached to funds;
> (ii) the institutionalisation of peer review to allocate resources to researchers; (iii) belief that basic research is best done in universities.

This model dominated the policy circles across much of the developed world until the end of the 1980s. During the1980s, the major economies of the world faced slow down in productivity rates, especially the US. Around the same time, the number of market economies increased globally resulting in fierce competition. The decline in the overall productivity of major economies prompted a rethink of the linear model (Clancy & Dill, 2009). Around the same time, there was increasing demand for public spending to be diverted to fulfil other social commitments.

On the backdrop of declining funding and increasing competition for research grants, some of the Universities aggressively sought out new avenues for generating resources(Sampat & Mowery, 2004). An important strategy in this was enhancing University-Industry Linkages and becoming more entrepreneurial by capitalising on the intellectual property generated by their research (Meyer, 2003). The passing of Bayh-Dole Act in 1980 was further expected to enhance the capability of Universities to generate additional resources and contribute directly to the economic development. This was further aided by two significant events, first was the development of the new field of biotechnology, and the second was a more accommodative policy towards patenting bio-organisms, molecules, and research techniques emerging from biotechnology(Mowery, Nelson, Sampat, & Ziedonis, 2001). The majority of patents from Universities continue to be in this field.

The change in University outlook from pursuing the Humbolditan ideal of disinterested scientists to entrepreneurial researchers is becoming more visible. Mowery and Sampat (2004) observe that:

> "rather than 'ivory towers' devoted to the pursuit of knowledge for its sake, a growing number of industrial economy and developing economy governments seek to use universities as instruments for knowledge-based economic development and change".

Associated concerns about the quality and productivity of universities motivated the development of new national policies for evaluating and assessing the outputs of academic research (Geuna & Martin, 2003). The outputs are increasingly linked to the contribution to direct the economy. As Universities continue to become more closely connected with the market driven process, they increasingly face competition from other knowledge producers(Lundvall, 2002).

The economic discourse regarding the government's role has gone considerable change with endogenous growth models, highlighting the role of policies in enhancing growth. Further frameworks like National Systems of Innovation[6] (NSI) and Triple Helix model (THM), which are evolutionary, highlight the role of Universities in the broader economy. Government policy has increasingly come to recognise the role of universities in national and regional systems of innovation(Smith, 2006). A range of policies encouraging the development and strengthening of links between universities and other actors in the

[6] In many instances, National Innovation System is used instead of National System of Innovation.

system of innovation, e.g. through collaborative research, patenting and the commercialisation of academic research and other forms of technology transfer and exploitation are being taken by many countries (Martin 2012). While research intensity varies across sectors, as nations move closer to their technological frontier R&D becomes essential in every industry, because the survival and growth of all industries are dependent upon their ability to innovate.

There is an increasing reliance on technical and scientific knowledge for economic growth. It is in this backdrop the interaction between the academia and industry has become dynamic. The static linear model, largely based on the division of labour, where Universities produce research, while firms develop those research into technology and the government provides the governance are no longer adequate for explaining the contemporary phenomenon. New frameworks, based on the endogenous growth models and evolutionary economics are increasingly being deployed to explain these changes and design better policies.

2.2 Government Funding of Research

The rationale for public funding of research is mainly based on the public finance literature of market failure. Nelson (1959) and Arrow (1962) did the two influential works in the area of economics of science. They emphasised that certain characteristics of scientific knowledge can be viewed as a public good:

- *Non-Rival* – others can use the knowledge without reducing the knowledge of the producers
- *Non-excludable* – other firms cannot be stopped from using the information (codified knowledge) or is expensive to do so.
- *Expansibility* - The possibilities of multiple transfers make it possible to distribute information very widely without loss.

Due to these characteristics, scientific knowledge has the potential for large spill over, and hence the gains arising from this are not completely appropriable by the producer or generator of the knowledge. Thus, left alone to the market, the knowledge generated will be lower than the optimum level desired for society. While patents to a certain extent provide the necessary safeguard for creating monopoly conditions to encourage the private sector, they are not seen to be effective in a range of situations (Foray, 2004). In the case of developing countries, the lack of demand for high technology products, under developed capital markets for financing innovation and high regulatory barriers may further increase the chances of market failure. Further, developing countries also lack 'non-market' institutions that may lower the risk of market failure (Stiglitz 1989).

A fundamental difference between the neoclassical and evolutionary economics relates to the conceptualisation of the innovation process. The neo-classical economists see the process of innovation being linear in nature, where outcomes are determined by a specific set of inputs(Kline & Rosenberg, 1986). In contrast evolutionary economics views innovation as an outcome of a complex process of interaction between many actors like firms, universities, R&D departments, suppliers and consumers. In other words, innovation is seen as being systemic(R. Nelson, 2008).

2.3 National System of Innovation (NSI)

The National System of Innovation as an analytical framework developed from the works of evolutionary economists in the second half of the 1980s. The initial major work came from Freeman (1987) while analysing the success of the Japanese economy in the post war period. He defines NSI as "the network of institutions in the public and private sectors, whose activities and interactions initiate, modify and diffuse new technologies". Lundvall (1992) defines NSI as" .. 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." Metcalfe (1995) defines NSI 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 artefacts which define new technologies."

Lundvall (1992) brings in the concept of learning as being central to the process of innovation. Innovation is seen as ‘a learning process that requires the interaction between markets and public agents’. A nation’s innovation process is an aggregate of these interactions at micro-levels.

The NSI identifies innovation not as a discrete, but a continuously evolving process. Government policies are seen as central to enhance the linkages between various actors. A NSI is reflective of various policy decisions undertaken to shape the economic environment to gain a comparative advantage. Thus, the main differentiating factors among countries’ innovation capabilities are not only the scientific resources of a nation but the distribution power of its innovation systems(OECD, 1997).

2.3.1 Universities in the National System Innovation

Nelson (1993) observes that “ ...universities play an extremely important role in technical advance, not only as places where industrial scientists and engineers are trained but as a source of research findings and techniques of considerable relevance to technical advance in the industry”. From a NSI perspective, University research has the potential to not only contribute directly in the form of technological innovations, new products, and services but also under their ‘third mission’ help in the growth of the business sector(Lundvall, 2002).

The extent of the Universities contribution to the NSI depends on a number of factors. The key factors relate to the amount of funding available to Universities for research, the structure and extent of other public research institutes. For instance in India, the majority of government funding for research is captured by public research laboratories, and Universities only receive a fraction of the R&D budget(Krishna, 2012). This has resulted in a very narrow base of research in the country. Another important factor is the structure of the domestic economy. The absorptive capacity of the business sector to a large extent determines its ability to collaborate and exploit the knowledge generated by the Universities(Cohen, Wesley M. Levinthal, 1989).

As Universities become more entrepreneurial, their contribution and relation to the business sector will become more complex. The linkages are no longer only in the form of knowledge transfer and resource transfer, but Universities and Industry collaborate on co-creation of knowledge. In addition, as Universities become more market oriented, they face increasing competition from other knowledge producers.

One of the biggest challenges in using the NSI is the availability of the data. OECD (1997) in its framework for analysing the NSI proposes tracking the flow of knowledge through following channels:

- Interactions among enterprises;
- Interactions among enterprises, universities and public research laboratories;
- Diffusion of knowledge and technology to firms; and
- Movement of personnel

However, such data is available only for limited countries only. Sampat & Mowery (2004) observe:

> The development of useful theoretical or conceptual tools or models for analysing universities as economic or other institutions within knowledge-based economies is severely hampered by the lack of data on the roles of universities that enable comparisons across time or national systems of innovation barring few developed countries.

However, many studies based on survey data have tried to capture the flow of knowledge between University and Industry context in developing countries as well.

2.4 The Triple Helix Model (THM)

Like the NSI, the THM also provides a nonlinear and evolutionary framework to explain the changing relationship and role of Industry-University-Government in the knowledge economy. Industry and Government played a much larger role in the industrial society. In a knowledge driven economy, the university as a knowledge generating and circulating institution plays a more important role in innovation system (Etzkowitz, 2003a). In the THM the role of the Industry and Government continue to be important. Industry's role continues to be a locus of production, while government functions as a source of contractual relations that guarantee stable interactions and exchange and the University is the key source of knowledge and technology(Etzkowitz, 2008).

The interactions in the THM are dynamic with each actor taking the role of the other, even as they continue to play their primary roles and yet maintain distinct identities(Etzkowitz, 2008). Universities actively take part in the development of new firms based on their research and become entrepreneurial by introducing "the capitalization of knowledge" as part of their main goal. Firms develop training to ever-higher levels and share knowledge through joint ventures. Governments directly support entrepreneurship by easing regulatory hurdles, providing access to finance and incentivizing new firm creation. Even as each institution continues to carry out their core functions, the interaction with other members enhances their functionality.

The relationship between Industry-Government-Industry, leading up to the triple helix model can be explained from two different starting points. The first model is known as a 'statist' model (Figure 2.1). It describes a scenario in which the government takes the central role in coordinating University-industry linkages. However it also limits their ability to innovate and initiate transformations. University is mainly seen as a source of trained workforce for the other two spheres. It may carry out research but is not expected to be entrepreneurial. Examples include Russia, Latin America, China, countries, where the central planning played a major role(Etzkowitz, 2008). India before the liberalisation would fit into this model.

The second model is the *laissez-faire* model in which, each member is independent, and with strong defining boundaries, there is only a modest link between them (Figure 2.2). In this model, there is no or minimal government interference. Innovation is the domain of industry, while government and university act as an ancillary support with an only limited role in innovative activities. The role of the University is to develop the human capital and provide basic research, while the government's role was limited to providing regulatory oversight. These models are prevalent in the United States and other Western European economies (Ranga & Etzkowitz, 2013).

Figure 2.1:Statist Model

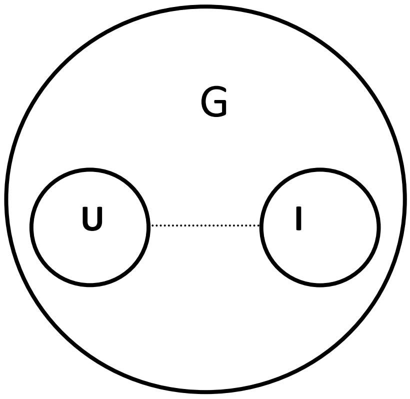
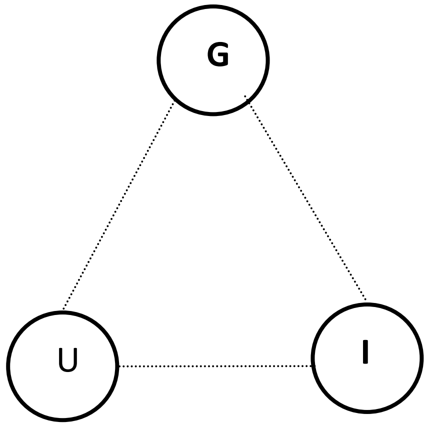


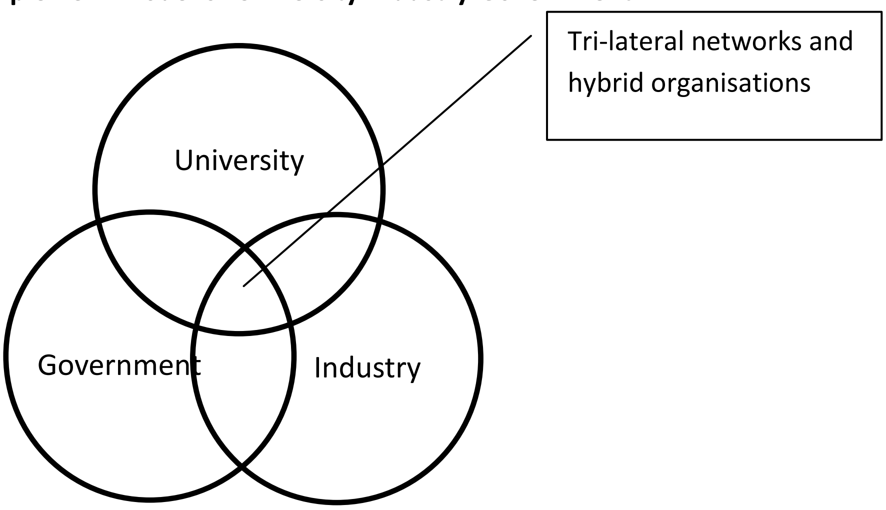
Figure 2.2: Laissez Faire Model



Source: Etzkowitz (2008)

The triple helix model (see Figure 2.3) is the most conducive for innovation. In this, the sphere overlap and each member takes on the role of other, and hybrid organisations emerge at the interface (Etzkowitz & Leydesdorff, 2000). As already discussed, in the knowledge based economy, the University works in close partnership with Industry and the Government, and it may take the lead in innovation.

Figure 2.3: The triple helix model of University-Industry-Government



Source: Etzkowitz (2003)

The successful interactions between the three spheres have led to the creation of the venture capital firm, the incubator, and the science park(Etzkowitz, 2008). The confluence of all three spheres can be seen as an evolving and aspirational aspect for countries transcending across the globe. The THM provides a strong conceptual framework to analyse the changes in University-Industry-Government relations taking place in India.

2.5 Motivations for University-Industry Linkages

This section tries to identify what are the factors, which motivate university-industry linkages. There are different actors involved in the decision to participate in the engagement process. At the macro level, the policymakers may try to motivate the institutions to interact in a meaningful partnership. An instance of this is passing of policies like Bayh-Dole Act(Sampat & Mowery, 2004). Governments also support the creation of infrastructures for enhancing collaboration in the form of support for research parks or business incubators attached to Universities (Etzkowitz, 2008).
Government policies like lowering of funding to HEIs also encourage Universities to look for collaboration opportunities. Further, changes in the economic and technological landscape have resulted in structural changes in the economy.

Similarly, at the meso level, Universities and Industry are looking to engage more with each other, some in response to the government policies, a move towards a knowledge economy, gain competitive advantage or diversify their source of funding. Universities and their technology transfer offices (TTO) are increasingly more active in canvassing the existing stock of research within their institutions that can be commercialised. Industry R&D managers continue to look for knowledge inputs outside their firms(Open innovation).At the micro level, the individual actors like faculty and student are motivated to collaborate or commercialise their research output and increase their visibility (Academic entrepreneurship). However, each of the stakeholders involved may have different motivations, which may not always align and can act as a barrier for UIL.

The following section reviews the existing literature on motivations for UIL. Our core focus is on the perspectives of University and Industry. We also discuss the individual motivations of faculty members. Further, the characteristics of the collaborators who engage in UIL are also explored.

A good place to start the discussion on motivations within the UIL is to appreciate the fact that both Universities and Industries have traditionally different goals and hence different motivations. Each of the aspect identified can act as an obstacle in the U-I collaboration in research. There is a strong belief that a change in any of the aspects identified could compromise on the core ethos of the Universities. These ethos are based on Merton, (1942) "'The Ethos of Science', which relate to Communalism, Universalism, Disinterestedness, and Scepticism". A system of sanctions and rewards ensure that the scientists (academicians) adhere to these tenets. On the other hand, the firms operate from economic principle of profit or revenue maximisation. The differences between the motive for University and Industry Research are tabulated in Table 2.1.

Table 2.1: Differences in University and Industrial Research

Typical Aspects	University	Industry
Basic rationale	Advance knowledge	Increase efficiency
Research Focus	Curiosity Oriented, Basic Research	Applied Research; Experimental Development
Aim	New ideas	Profits
Characteristics	Idea-centred	Practical; product centred
Framework	Open	Closed, confidential
Evaluation	By peers	By the superior
Schedule	Open-ended	Tight, predetermined
Recognition	Scientific honours	Salary increases

Source: Blais (1990) as cited in Parker (1992)

The most contentious and often discussed difference relates to the 'aim' of the University and Industry research. Firms carry out research to maximise their profit or sales by improving efficiency or launching new products. On the other hand, the aim of the academic research is to generate new ideas by pushing the frontier of knowledge. From an institutional point of view, the academic system has created a mechanism for generating reliable and public knowledge that benefits the society. In exchange, it receives continuous support from the government for research to expand the pool of (useful) knowledge (Geuna, Salter, & Steinmueller, 2003). Further, academics believe in the idea of 'Universalism' that knowledge belongs to everyone, that it has characteristics of a public good. While, firms believe in monopolising the knowledge to generate competitive advantage(Dasgupta & David, 1994).

However, even without reconciliation of these differences, the linkages were maintained in some aspects. The linear model was the dominant paradigm and continues to be so for the majority of institutions. The basic research supported by public funding was carried out in the Universities, which was expected to flow to the industry[7]. These beliefs did not hamper the transfer of knowledge in the form of trained student. Other forms of interactions like those related to using of facilities, using the expertise of faculty and inflow of resources from Industry to Universities could continue despite the different perspectives held by each party. However, there is a perceptible change, which emerged first in the US, and then extending its way to other developed countries and now to developing countries as well. There are more industries and university administrators, which have warmed up to the idea of close collaborations. Government policies are encouraging UIL as they believe the spillovers will benefit the wider economy.

Despite differences, there exist benefits for collaboration between Universities and Industries. The existence of benefits for each of the actors provides the motivation for collaboration.

2.5.1 Academia's Motivation to Engage With Industry

D'Este & Perkmann (2011) in an analysis of UK faculty members in physical and engineering sciences find varying reasons for the motivation to engage with the industry. They broadly classify these motivations into Learning, Commercialisation, Access to in-kind Resources, and Access to funding(see Table 2.2). They find that the majority of the respondents, around 75 percent identified 'applicability of research' as the highly important reason. A very small percentage of the respondents identified commercial gains to be an important cause. Similar results are reported for Germany, where the respondent identified 'knowledge exchange' to be the very important reason for engaging with the Industry (Meyer-Krahmer & Schmoch, 1998).

[7] Linear model is discussed in much greater detail in the earlier chapter

Table 2.2: Motivations for engaging in entrepreneurial activities and collaborating with Industry

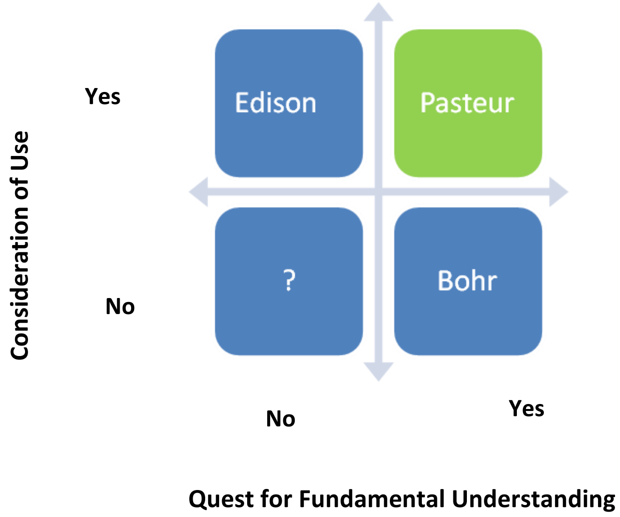
Motivational Items	Motivations
Source of Personal Income Seeking IPR	**Commercialisation**
Information on industry problems Feedback from industry Information on industry research Applicability of research Becoming part of network	**Learning**
Access to materials Access to research expertise Access to equipment	**Access to in-kind resources**
Research income from industry Research income from Government	**Access to funding**

Source: D'Este & Perkmann, 2011

Researchers are often motivated towards solving a real world issue. Interaction with industry repeatedly provides them with the opportunity to work on an applied problem(Hurmelinna, 2004). Further, collaborative projects allow the researchers to work on areas that are termed as Pasteur's quadrant (see Figure 2.4). A large part of the University research is motivated by considerations of both, the use (applied research) and at the same time, the pursuit of fundamental understanding (basic research) of knowledge.

The diagram represents the kind of work done by the scientists, whose names represent each quadrant. Edison's work was characterised by the focus on application, while Bohr's work was solely of the fundamental nature. However, Pasteur's work was a combination of both applied and basic nature. His research focussed on advancing vaccination (a "product" of immediate value) and at the same time microbiology (contribution to fundamental understanding, pushing the boundary of knowledge). A large number of University faculties are motivated to carry out their work in the Pasteur's quadrant and hence collaborate with the Industry(D'Este & Perkmann, 2011).

Figure 2.4: Pasteur's Quadrant



Source: Stokes, 1997; Smith, 2006

In an environment of declining, funding and the increasing cost of carrying out scientific research, Universities increasingly are looking for additional financial resources. Hence, access to resources is seen as an important motivator for Universities. As additional funding for research can help in furtherance of their academic goals(Etzkowitz, 2010). Thus, access to financing is consistently cited as an important reason for collaboration with Industry by academicians (D'Este & Perkmann, 2011; Meyer-Krahmer & Schmoch, 1998). Collaboration with Industry can complement the government grants to conduct research.

The financial support can manifest in multiple forms. Mechanisms[8] for funding involve contract research, research grants for sponsored projects, scholarships/ sponsorship for Doctoral and Post-Doctoral students and salary of project staff (Maria & Valentin, 2000). Industries also provide universities with in-kind support, which may not be of commercial nature but tend to save costs to Universities. They include support for laboratories, equipment, software, sponsoring awards, Sponsoring Chairs, Centre of Excellence, etc.

It is important to differentiate between financing for projects and commercial gains for the individual faculty. D'Este & Perkmann (2011) make this distinction, and they find commercial motives tend to rank lowest compared to other motives for engaging with the

[8] The mechanisms are discussed in detail under the pathways.

Industry for the individual academic. Another important point is that the motives can vary depending on the channels of interaction as well.

An essential distinction, which needs to be made is the differences in the motivation of University and individual faculty. While being on the same side, their relationship is complex. The institutionalisation of technology transfer efforts from the University resulted in the formulation of specialised technology transfer offices(TTOs)(Siegel, Waldman, & Link, 2003). This was accelerated by passing of Bayh-Dole Act, 1980 which allowed Universities to have the ownership of patents generated from public funding. In our discussion on the different motives of research in University and Industry becomes more complex and nuanced with the TTOs in the picture. While the researchers may continue to work from the perspective of advancement of knowledge, the TTO aims to commercialise the research(see Table 2.3).

Table 2.3: Characteristics of University-Industry Technology Transfer Stakeholders

Stakeholder	Action	Primary Motive	Secondary Motive	Perspective
University Faculty/ Scientist	Discovery of new knowledge	Recognition within the scientific community	Financial gain and desire to secure additional funding for research	Scientific
Technology Transfer Office	works with faculty members and firms/entrepreneurs to structure deals	protect and market the universities' intellectual property	facilitate technological diffusion and secure additional research funding	Bureaucratic
Firm/ Entrepreneur	Commercializes new technology	Financial gains	Maintain control of intellectual property/ technologies	Organic/ Entrepreneurial

Source: Siegel et al., 2003

Characteristics of University researcher who collaborate with Industry

Some studies have tried to find the differences in characteristics of the collaborators. For individual faculty, the studies have focussed on age and gender. There are two points of view on how age might affect the probability of interaction between the faculty and the industry. First, the younger faculty are likely to focus on publications as they concentrate on building their career by working towards attaining tenure(D'Este & Patel, 2007). This view suggests older faculty members want to capitalise on their knowledge and exploit social capital. This view largely emanates from the human capital theory(Levin & Stephan, 1991). The second view, on the other hand, comes more from the cultural aspect. The younger faculty might be more open to the idea of interacting with the industry due to the existing channels of which they might be part of, while the older faculty who may not be open to such ideas(Giuliani & Arza, 2009).

P. D'Este & Patel, (2007) in their analysis found that the individual characteristics of the academician involved are much relevant in explaining the linkages with industry as compared to departmental factors. They conclude that an inverse relationship exists between the age of the researcher and their engagement with the industry both in terms of variety of pathways as well as the frequency of interaction. Similarly, Giuliani, Morrison, Pietrobelli, & Rabellotti (2010) in a study of wine sector in Chile, South Africa and Italy find that younger researchers are more likely to form linkages with the industry as compared to their older counterpart. They posit that this may be due to the increasing emphasis from the policymakers highlighting the importance of interaction with the industry. It might be a reflection of the reward system, which may inadvertently be promoting linkage with the industry. They raise an important question but do not answer, what is the impact of engaging with industry at the early stage of career on the core academic outputs like publications?

However, Haeussler & Colyvas (2011) in their study of German and British academic scientists in the Life sciences field find a positive relationship between age and the entrepreneurial activity- consulting, patenting and founding new firms. Thus, their result varies from the earlier two studies discussed.

Regarding gender, again the results are mixed. Some of the studies find that the male scientists are more likely to engage in entrepreneurial activities and are successful as compared to their female colleagues(Perkmann, Tartari, McKelvey, Autio, et al., 2013). However, only a few studies find that find that controlling for age females scientists are more likely to establish linkages with the industry relative to their male colleagues(Giuliani et al., 2010).

2.5.2 Industry's Motivation to Engage with Academia

From the NSI perspective, one of the key sources of innovation for the firms can be the research generated in the universities(R. Nelson, 1993). However, only a limited number of studies look at the motivations from a firm's point of view for collaborating with the University. Of the few studies that exist the results are of mixed nature and vary depending according to the industry and firm's characteristics. There seems to be a disconnect between the expectation and the outcome of firm's when collaborating with the Universities.

Industries usually do not rely on direct financial inflows from Universities. However, there are government programmes where the partnership between University and Industry are encouraged, and a joint bidding may be required for the research grant. Thus, Industries that require public subsidies are likely to collaborate with Universities. R&D incentives from governments, in the form of tax breaks, can often encourage industries to work with Universities(Parker & Zilberman, 1993). From a much longer term point of view, Industries can expect to save in R&D expenditure by exploiting scale economies in R&D and further reducing duplication of R&D investments(Smith, 2006). Development of new technology and patents can result in substantial gains for both the parties.

The key motivations for firms to collaborate with the University are related to access the knowledge base and expertise to improve their research on product development, a partner in exploratory research for new technology, designing of prototypes and solve technical problems(Lee, 2000). Cohen et al. (2002) find that public research is critical to industrial R&D in a small number of industries and importantly affects industrial R&D across much of the manufacturing sector. Further, they also find that public research both suggests new R&D projects and contributes to the completion of existing projects in roughly equal measure overall.

Laursen & Salter (2004) examine the relationship between universities and innovation in firms using a sample of 2655 manufacturing firms drawn from the UK Innovation Survey. Their dependent variable measures the degree to which firms draw from knowledge generated at universities in their innovative activities. Only 27 percent firms said they relied on some information from the universities, of which, 17 percent of the firms reported ‘low’ importance of universities as a source of innovative information. Most firms relied on internal research, followed by suppliers and client and customers.

Joseph and Abraham (2009) in their study of 460 firms across four states of India find similar results. Only 17 percent of the firms interviewed said that Universities were an important source of knowledge.

2.6 Pathways of University-Industry Relations

Although universities are being looked like a potential source of innovations by industry, many of the firms nevertheless view them primarily as a source of trained persons and skills, and as centres for problem-solving. However, the interaction between University-Industry goes well beyond supplying of trained workforce and extends to a large number of areas. Further, there are multiple channels or pathways in which these interactions take place (see Appendix I). The channels tend to vary according to the industrial sector (Bekkers & Freitas, 2008; Cohen, Nelson, & Walsh, 2002) as well as the individual characteristics of the academician(Villanueva-Felez, Bekkers, & Molas-Gallart, 2010). In this section, we review the literature to identify the important pathways through which university-industry collaboration takes place.

Cohen, Nelson, & Walsh, (2002) in their survey of 1478 R&D managers in the US ask them to rank the impact of public research on their product development in last three years, as well as the most important channel of public research for them. In their results, they find that the most important channels reported were publications and reports followed by Informal information exchange, public meetings or conferences, and consulting. The channels relating to publications and reports, along with public meetings or conferences are open channels of knowledge flow. Informal information exchange and consulting are more decentralised. Excessive focus only on formal measurable channels like patents licensing and University spin-off may be misleading, as other pathways of linkages may be more relevant in UIL (Agrawal & Henderson, 2002; D’Este & Patel, 2007; Perkmann, Tartari, McKelvey, Autio, et al., 2013; Ramos-vielba & Fernandez-esquinas, 2012).

However, as is the case with the studies based on surveys, the results seem to be context dependent. In a sample covering seven EU countries, Meyer-Krahmer and Schmoch

(1998) find that collaborative research and informal contacts are the most important channels of communication.

The level of linkages also seems to vary across the countries. Joseph & Abraham (2009) find only limited linkages between University research as a source of information in case of India. The limited linkages are of a formal type and open nature as compared to informal nature found by other studies (see Cohen et al., 2002). Formal linkages include: contract research with universities, joint or cooperative R&D projects, participation in networks that involve universities, temporary personnel exchanges, science and/or technology parks, the firm is owned by a university, firm is a spin-off of a university. The open channels are publications and reports, public conferences and meetings and informal information exchange. This study does not carry out a sector level analysis.

Bekkers & Freitas (2008) in their study conducted a survey of 454 industry researchers and 575 academic researchers in the Netherlands. This study identifies 23 different channels of knowledge flows from University to Industry. There are two important factors in the design of their study for comparing the results of other similar studies. First, their industrial respondents are the researchers and not research managers as other studies have done. Thus, they may better absorb the flow of information as compared to research administrators. Second, the sectors covered are chemical, pharmaceutical, electrical, and machinery. Thus at the aggregate level, their results may considerably vary from those studies which focus on a much larger number of sectors. They find that publications, informal contacts, patents, joint projects, student movements and conferences were all reported by more than fifty percent of the industry researchers as being very important. They further do not find any mismatch between the perceived importance of channels between Industry researchers and University researchers. However, a significant finding is that University researchers tend to perceive a larger number of channels to be important as compared to their industry counterpart.

The results seem to vary across the sectors in which the firms operate. For instance, in the Cohen et al., (2002) not only the results vary across the pathways, but the importance of particular pathway may also vary across the sector. In the case of patents, while only 17 percent of all the firms surveyed identified it as moderately important, in the case of 'Drugs' the number goes up to around 50 percent. Similar variations can be seen in other sectors as well. However, in the case of Bekkers & Freitas (2008) study, the perceived importance of channels, do not vary across the sectors.

University resources in developed and developing country may vary, and hence the engagement channels are likely to be different. Within the same countries, they can be different based on the type or key mission of the University(Guimón, 2013).Table 2.4 provides some of the key differences in pathways of UIL, which may exist between Developed and Least Developed Countries (LDCs) and the variation across different missions of the University.

Developing countries like India show a mix of channels depending on the resource endowment of the Universities. For Instance, IITs are likely to be much nearer the developed country entrepreneurial universities, then a state university. These differences are important to note, especially when the available literature are largely based on Developed countries. Thus, the type of linkages, which policymakers try to promote, without appreciating the context may result in an adverse outcome. For instance, while the Bayh-Dole had success in enhancing the roles of patents as some argue, may not be effective in countries like India where other channels may be more prevalent.

Table 2.4: Priorities for university-industry partnerships at different stages of economic development and key mission of the University

	Developed Countries	Least Developed Countries
Teaching University	-Private participation in graduate programs -Joint supervision of PhD students	-Curricula development to improve undergraduate and graduate studies -Student internships
Research University	-Research consortia and long term research partnerships to conduct frontier research	-Building absorptive capacity to adopt and diffuse already existing technologies -Focus on appropriate technologies to respond to local needs
Entrepreneurial University	-Spin-off companies, patent licensing -Entrepreneurship education	-Business incubation services -Entrepreneurship education

Guimón, 2013

2.7 Barriers for University-Industry Collaboration

As discussed, a major impediment for University-Industry Collaboration stems from their differences in orientation towards research. In the empirical literature as well, firms continuously highlight some of these factors, in their reluctance to collaborate with the University. The barriers are usually classified in terms of differences in 'orientation 'or 'cultural differences' and those related to transactions costs(Bruneel, D'Este, & Salter, 2010; Joseph & Abraham, 2009).

Bruneel et al., (2010) in a survey of 503 firms in the UK try to find the type of barriers, which firms face while interacting with University. They conclude that the barriers mainly emanate from the differences in the orientation and transaction related (see Table 2.5). On an average, transaction barriers are highlighted as being more important than orientation related. The difference in time horizon, where universities have long-term orientation and firms look forward to a much shorter time the horizon is identified as the most significant barrier.

In transactions related barriers the 'rules and regulations imposed by the universities or government funding agencies' are identified as being most important. While in terms of firm size, they do not find much difference between small and large firms, they do find differences across sectors.

Table 2.5: Type of barriers to university interaction

Orientation Related	Transaction Related
University research is exceedingly orientated towards pure science	Industrial liaison offices tend to oversell research or have unrealistic expectations,
Long-term orientation of university research (concerns over lower sense of urgency of university researchers compared to industry researchers),	Potential conflicts with university regarding royalty payments from patents or other intellectual property rights and concerns about confidentiality,
Mutual lack of understanding about expectations and working practices	Rules and regulations imposed by universities or government funding agencies
	Absence or low profile of industrial liaison offices in the university (reverse coded)

Source: Bruneel et al., 2010

Joseph & Abraham (2009) in their study of Indian firms find that a very small fraction of their sampled firms collaborated with Universities. They find in addition to 'cultural' and 'transaction' related barriers, firms in their sample mainly relied on in-house R&D. Around 38 percent of the firms reported 'our firm's R&D is enough to innovate' as the main reason for not interacting with the University (Table 2.6). While they classify it as a firm specific reason, it could as well be reflective of a closed research culture within Indian firms. Further, contrary to belief they do not find, 'Geographic distance' or 'Difficulties in Dialogue' to be an important barrier.

Table 2.6: Firm's reasons for not interacting with Universities

REASONS	Most Relevant	Context
Our firm's R&D is enough to innovate	37.8	Firm specific Cultural
Universities have no understanding of our line of business	23.78	Cultural
Intellectual properties issues	20.43	Transaction costs
Lack of Trust	18.9	Transaction costs
Contractual agreements are difficult	17.99	Transaction costs
University concerned only with big science	17.13	Lack of trust
Quality of research is low	14.68	Other
Difficulties in dialogue	10.67	Transaction costs
Geographic distance	10.06	Other

Source : Joseph & Abraham, 2009

The transaction related barriers are likely to go up in areas like 'intellectual property' and 'compliance of regulations' as Universities become more assertive of their rights. Often these regulations are imposed by the government to improve the commercialisation of University research (Siegel et al., 2003).

2.8 Implications of University-Industry Linkages on Academia

One of the major concerns comes from the increased focus on patenting by the Universities. Beginning with the passing of Bayh-Dole Act in the US in the 1980s, many countries followed suit in some form. Not only the developed countries but also many developing countries have brought about policies similar to Bayh-Dole Act (Graff, 2007; Paraskevopoulou, 2013; Pluvia Zuniga, 2011). Many have feared that these might have unintended consequences on the long term growth of science and innovation in the developing countries(Forero-Pineda, 2006). Even in the United States, it has been conclusively shown that patenting behaviour among Universities started much earlier than the Bayh-Dole Act in 1980(Mowery et al., 2001).

Patents have become the most controversial of all the channels. They are symbolic of the differences, which are the antithesis of the Open Science. As per our review of literature until this point, patents are among the least preferred channel of knowledge transfer(Agrawal & Henderson, 2002; Cohen et al., 2002; D'Este & Patel, 2007; Perkmann, Tartari, McKelvey, & Autio, 2013). Policymakers, firms and University administrators continue to focus disproportionately on patents as being central to enhancing University-Industry Linkages(Ramos-vielba & Fernandez-esquinas, 2012). In the following paragraphs, we discuss, the rationale for patents and the challenges it creates. We also discuss in brief the salient features of Bayh-Dole Act. We then return to our discussions on the University patenting and its implications.

2.8.1 The economics of patents

The main rationale for IPR comes from the idea that it improves disclosure of the invention while protecting the commercial interests of the inventor for a limited period. Thus, those who support the idea of IPR protection argue that in its absence the inventor has no incentive to disclose. Thus, patents by granting monopoly rights to the inventor provide a solution to the public good problem(Foray, 2004). The ability to transfer rights by way of licensing allows for a more efficient use of patents by those who require it by compensating the owner. Theoretically, this is expected to enhance the flow of knowledge in the society.

In spite of its benefits, the monopoly rights granted by the patent system create a deadweight loss, when the monopolist charges a high price restricting those who wish to utilise the invention. From the societal point of view, the monopoly rights block the flow of knowledge, even when there is no additional cost(Foray, 2004). The problem becomes acute if the terms of patents cover a broader aspect of knowledge hampering the future inventions. They tend to increase, if not completely restrict the flow of knowledge, increasing the transaction costs of future R&D(Williams, 2013). The other problem is when the patent is too narrow. Effectively no individual can exploit it and yet can block others from the usage. It is popularly called as 'Tragedy of the Anti-Commons'(Foray, 2004). Some of the available empirical research has shown that the 'Anti-Commons' phenomenon may slow down the course of scientific advancements. Williams (2013) in her study of human genome sequencing finds that a short-term patent granted to a private firm for a section of genes sequenced by them delayed the advancement of public researchers by as much as 30 percent.

2.8.2 Implications of University Patenting

We review the empirical literature of increasing focus on patenting has on the core functions of the University. Table 2.7 is based on a compilation of Zuniga & Wunsch-Vincent(2012). It provides a brief snapshot of potential benefits and costs associated with intellectual property based technological transfer strategies adopted by Universities, first on the 'broader impacts' and second on 'innovation and growth'. The points made are more indicative and should be treated as a hypothesis than factual statements.

While most of the impacts are self-explanatory, the point on the success of patenting revenue's impact on the overall government funding of University needs some more explanation. Excessive focus on patent's earning may lead to two critical scenarios. In the first scenario, a smaller number of successful universities are seen as being representative of the patenting phenomenon across academia. This may lead the government wrongly to believe that public funding to Universities, could be further reduced as they are becoming more self-sufficient, starving a larger number of institutions for funds in the process. In the second scenario, if patents start playing a dominant role in terms of getting funding, the resource gap among the universities may further increase (Geuna & Nesta, 2006).

Table 2.7: Systemic impacts of IP-based technology transfer policies

Impact	Potential Benefits	Potential Costs
Broader impacts	1. **Increased impact of more focused and relevant applied research** 2. **Improved innovation system linkages** • Efficient division of labour in the generation and commercialization of new inventions • Private sector contribution to funding basic and applied research 3. **Improvement in the quality of research and education**	1. **Reorientation of research** • Overemphasis on applied, short-term, commercial research • Less diversity of research resulting from greater focus on patentable outcomes • Other university missions, such as teaching and training, are neglected 2. **Negative impacts on open science** • Crowds out the use of other knowledge transfer channels to industry • Publication delays increased secrecy, less sharing, including the withholding of data • Decrease in international scientific exchanges 3. **The promise of university income can reduce government commitment to funding**
Innovation and growth	1. **Commercialization of inventions with economic and social impacts** Increase in consumer welfare and business productivity via access to innovative products and processes 2. **(Localised) positive impacts on R&D, technology spillovers, entrepreneurship, employment, and growth** 3. **Higher competitive position of country in the global market**	1. **Long-run adverse effect as attention is diverted away from academic knowledge production** 2. **Long-run adverse effects of IP on open science and follow-on innovation** • Patenting of broad upstream inventions, platform technologies, and research tools increases the cost of follow-on research and innovation • Reduction in the diversity of research 3. **Focus on IP might inhibit rather than promote commercialization of inventions**

Source: Zuniga & Wunsch-Vincent, 2012

The next section looks at the impact of patenting on other channels of interactions, including publications.

2.8.2.1 Substitution between patenting and other pathways of interaction with Industry

A hypothesis often tested is does patenting substitute publication. Some studies identify that patenting complements publishing(Agrawal & Henderson, 2002; Crespi, Este, Fontana, & Geuna, 2008; Geuna & Nesta, 2006; Thursby & Thursby, 2011).

Thursby & Thursby (2011) in their analysis of faculty publishing and patenting behaviour from 1982 to 1999 of eight US Universities, find a positive relationship between patenting and publishing. Further, they test the impact of Bayh-Dole Act on the change in orientation of research from basic to applied. Three hypotheses are tested. First, there was no impact. Second, a negative consequences i.e. more applied research at the expense of basic research. Third, both applied and basic research increased. To test their hypotheses, they construct several research production functions. They conclude that both basic and applied research is greater when faculty can benefit from commercialization of their research effort. They find a positive relationship between patenting and publishing. Stephan, Gurmu, Sumell, & Black (2005) also find comparable results for doctorate recipients in US universities.

Crespi et al., (2008) find similar results for top researchers in the UK. They report that stock of patents has positive impact on all the channels of interaction, barring "industry sponsored meetings." However, they find that beyond a threshold level, the increase in patenting has a negative impact on the probability of engaging in other channels of technology transfer "joint research, contract research and consultancy with business." However, they find a non-declining relationship between patenting and taking equity interests in spin-offs. Also, they conclude that these results vary across disciplines, while department size does not seem to have any impact.

2.8.2.2 Impact of funding on academic performance

There are only limited studies, which have analysed the impact of industrial funding on the performance of researchers. Bozeman & Gaughan (2007) in a study of 1564 researchers in the US find that the impact of grants received by the research has a positive impact on their engagement with the industry, compared to those who did not get any grants. Further, those who receive grants from industry are more likely to engage with industry than those only got government grants. The responsiveness to the funding seems to vary across disciplines.

3 Role of Universities in India's National System of Innovation

Indian economy has undergone considerable change in the last quarter of a century. The structural shifts in the economy, along with its demographic transition put India in a critical juncture. Innovation is increasingly seen as an important aspect of its development strategy[9].

India's NSI comprises of Universities, Research Institutions and Laboratories maintained by Central and State Governments, and in house R&D in both public and private industries. There are pockets of success in each of the categories. However, the lack of interlinkages among each component has hampered the knowledge flows among them(Reddy, 2011).

As discussed in the previous chapter, Universities play a major role in NSI. The most important role played by Universities is in the form of providing skilled human resources. Further, it also provides output in the form of research, which is transmitted through different channels. However, the ability of the University to play its role effectively in the NSI depends on a number of factors, especially the resource allocation. Further, the level of economic development of a country also defines the pathways of knowledge transfer. Thus, the current chapter tries to look at the role of Universities in India's NSI.

We first begin by a brief understanding of the formation of India's NSI in the post independence to pre-liberalisation. Next section focuses on the post liberalisation and look at the role of each actor- Government, Businesses and the University briefly. The focus is on the allocation of resources, as well as the distribution of the scientific workforce. Following this, the higher education system and its changing structure are discussed in some detail. Subsequently, we look at India's performance in the World Economic Forum's competitiveness index, with a focus on 'Innovation'. We also look at some of the indicators of knowledge generation and flows in the economy. Finally, we look at a successful example of University-Industry-Government linkages in India.

[9] See Science, Technology & Innovation Policy, 2013

3.1 Pre-liberalization

In the pre-liberalization period, almost 80 percent of R&D was dominated by the publicly funded research institutes(Forbes, 1999). Much of this was in the strategic sectors of atomic energy, defence and space research, resulting in some of the most advanced capabilities in these areas in the developing world. The scientific research in universities was undermined as the priority was accorded to mission-oriented research and development of nuclear and industrial research institutes to solve immediate problems of development(Raina & Jain, 1997). Even among the research labs set up under the Council of Scientific & Industrial Research (CSIR) to do work of relevance to industry remained limited and such technological capabilities as were created remained largely confined to the laboratories themselves.

India was among the few developing countries, which had formulated a science policy as early as the 1950s. The Scientific Policy Resolution of 1958 reflected the realities, and the need was to build a workforce of scientists and engineers, needed to rebuild the country after independence. Thus, multiple Indian Institutes of Technology (IIT) were setup. The IITs were setup on the model of MIT. By the end of the 1980s, India had perhaps the strongest scientific and technological infrastructure among developing countries (Krishnan 2003). However, the slow growth rate of the preceding decades meant, the absorptive capacity of the industrial sector was low. The period beginning from the 1970s is characterised by the migration of the highly qualified professionals(HQP), a phenomenon known as Brain Drain(Krishna & Khadria, 1997). It is important to note that the phenomenon was not restricted to India but a generalised trend, where HQP migrated from developing to developed countries.

The Indian Patents Act of 1970 was to have a major impact on the growth of India’s pharmaceutical sector. By moving from product to process, oriented patent regime and shortening the life of protection awarded.

An important policy adopted to encourage entrepreneurship among the science and engineering graduates(NSTEDB, 2014). The establishment of The National Science & Technology Entrepreneurship Development Board (NSTEDB), under the aegis of Department of Science & Technology, was established in 1982. Its main aim was to promote knowledge intensive enterprises. A number of Science Technology & Entrepreneurship Parks (STEPs) were also set-up in select Universities to improve knowledge flows to the firms in the parks.

After a gap of 30 years, India came out with the Science & Technology Policy, 1983 with the emphasis on self-reliance. It also called for increased linkages between "educational institutions, R&D establishments, industry and governmental machinery".
A number of initiatives to promote R&D in the industrial sectors were initiated in 1985, the umbrella programme being 'The Technology Promotion, Development and Utilization (TPDU) Programme'. Programmes on fiscal incentive fell under 'Industrial R&D Promotion Programme', managed by Department of Scientific & Industrial Research (DSIR). The programme also recognises R&D units in Universities.

3.2 Post-Liberalization

India's expenditure on research and development has grown gradually over the last two and half decades. In 1991, India's Gross Expenditure on Research and Development (GERD) as a percentage of GDP was 0.64 percent, which had increased marginally to 0.74 percent by 2000.At the end of 2010, India was spending only about 0.80 percent. As per the latest data available, it has grown to 0.88 percent[10]. India's Science & Technology Policy, 2013 has set a target of increasing the GERD to 2 percent of GDP by the end of the 12th FYP.

Around 1991, India and China spent around the similar percentage of their GDP on R&D, with India's figure being slightly higher than China's. However, from 1999 onwards, China has continuously increased its expenditure on R&D, while the figure for India has stagnated around the same level. By 2013, China's GERD crossed the figure of 2 percent of its GDP, while India languished less than one percent of the GDP.

As per the latest available data, India and China are the fastest-growing major economy. However, India's share in the world GERD has not grown much. In 1996, India's share in

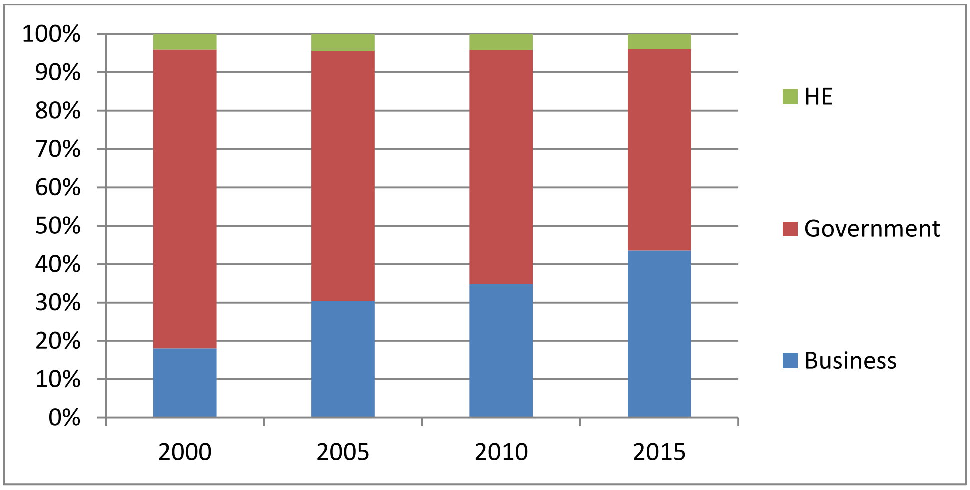
[10] The latest official data available from Department of Science & Technology, India is for 2011-12. Figure 1 uses the data provided by R&D magazine for the period 2012- 2014 for India. Rest of the data is from UIS.

the world GERD was around 1.8 percent when measured in constant PPP terms, which grew to 3.2 percent by 2011. During the same period, China's share increased from 2.5 percent to 16.5 percent. Among the major economies, India's expenditure on R&D is one of the lowest in the world. If India has any chance of catching up with China, it must consider increasing its resources on R&D.

3.2.1 Government Sector

In India, the majority of research financing is carried out in the Government sector, followed by the business enterprises and higher education sector (see Figure 3.1). The share of Government sector has been coming down gradually over the years. In 1991, Government accounted for 86 percent of R&D expenditure. However, by 2001 the figure had declined to 76 percent, and by 2015, the government's share had further fallen to around 52 percent, which is a positive development. This sector compromises of both Central and State Government Institutions, public sector units, national research laboratories and large autonomous institutions like ISRO, DAE and DRDO. These autonomous institutions corner majority of the budgetary allocation on S&T.

Figure 3.1: Sector-wise share in GERD



Source: UNESCO INSTITUTE STATISTICS, DST INDIA

The share of States in total GERD has remained constant averaging around 8 percent over the years. Their focus has largely remained on agricultural research. State Science Technology Councils (SSTC) was set up in 1971 to boost the role of States and Union

Territories in R&D. Currently, there are 36 such SSTC in India[11]. However, it is only in recent years they have started becoming proactive (Krishna, 2012).

3.2.2 Business Enterprises

In recognition of the lower private investment in R&D, the government focus increasingly moved towards encouraging the private sector research beginning from the 1980s. There were also programmes to support collaboration between technical institutions (like national laboratories or institutions of higher technical education) and industrial enterprises.

The share of Business Enterprises in research has increased after liberalisation of the economy in 1991. Their share rose from 14 percent in 1991 to 26.6 percent by 1998. However, there was a decline in their share for the next four years. From 2002 to 2007, a rapid increase in the R&D expenditure saw the share of BE in R&D increasing to 37.5 percent. Moreover, subsequently increasing to around 44 percent in 2015.

Indian firms are increasingly competing globally, and hence investment in R&D is likely to increase as well. The success stories are present in traditional sectors like automobiles and pharmaceuticals, and on the other hand, knowledge intensive sectors like biotechnology, Computers and Electronics, and Information &Telecommunication sectors. While the recent increase is commendable when compared to major economies globally the share of Indian Business Enterprises in R&D is one of the lowest. In any innovative economy, businesses are expected to lead in R&D activities. For instance, around 77 percent of China's R&D takes place within the Business enterprises. The R&D intensity of the corporate sector has remained low.

Some factors can explain the lack of R&D in Business enterprises as legacy issues. At the time of independence, India was an agrarian economy. There was a strong emphasis on rebuilding the nation, and industrial development especially related to heavy machinery was emphasised. The economic policies adopted were inward looking, and hence the

[11] http://www.dst.gov.in/scientific-programmes/st-and-socio-economic-development/state-science-technology-programme

desire to lower dependence on foreign powers played a major role. The centralised planning adopted meant a large public sector firms had to be established. This meant Indian firms were not competing with their global peers in developing new technology. Further, measures like import substitution and license raj resulted in creating artificial monopolies, and the firms were shielded from competition. Further, the stagnation of the manufacturing shares in the GDP for the last three decades also does not augur well for the R&D.

3.2.2.1 Global R&D in India

Another important aspect of research in the private sector is the increasing R&D being conducted by foreign firms in India. India has been a major beneficiary of the globalisation of R&D and has developed a niche in certain sectors due to the availability of high-quality workforce available at a fraction of the cost. Some foreign firms have established their R&D centres in India. Many government programmes like ‘Make in India’ are encouraging foreign companies to set up manufacturing operations in India. They are likely to lead towards more innovative research. India has emerged as a major player in the global player and increasingly looks set to become a major hub for R&D. Foreign subsidiaries of MNCs are filing an increasing number of patents both in India and abroad(Basant & Mani, 2012). Many publications are also originating from these R&D centres in India(Gupta & Gupta, 2014).

The DST does not report data on the share of foreign firms in India’s GERD. As early as 2007 it was estimated that the proportion of foreign companies in India’s Business Enterprise(Private Sector) investment in R&D was 20 percent (Basant & Mani, 2012). This number is likely to be much higher now. A study conducted by Zinnov Consultancy in 2013 estimated the number of foreign R&D centres in India at around 1100. They have also become a source for a large number of job creation for Indian researchers (Mrinalini, Nath, & Sandhya, 2013).

An indicative data available from the NSF of United States provides data on R&D performed by US firms outside their country. As per the latest available data, India was the third largest recipient of investments in R&D, behind only the United Kingdom and

Germany (see Table 3.1). India received around USD 5.86 billion accounting for almost 8 percent of the total R&D expenditure conducted by US firms outside of their country.

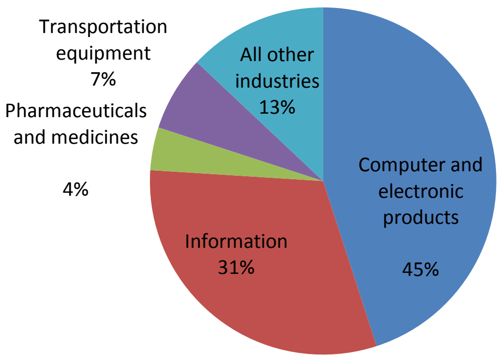
Table 3.1: R&D paid for by the company and others and performed by the company outside of the United States, by selected location: 2013[12]

Rank	Country	Amount in Million (USD)	% share out of total
1	United Kingdom	8949	12.24
2	Germany	8637	11.82
3	India	5860	8.02
4	China	5774	7.90
5	Canada	5265	7.20
	Total(World)	73100	

Source: NSF, 2017

Figure 3.2 provides the top sector-wise distribution of the R&D funds invested in India by US MNCs and their affiliates. Computers & Electronic products account for as much as 45 percent of the total inflow, followed by information accounting for 31 percent. In Computers & Electronics, US MNCs have invested the highest amount in India (NSF, 2017).All these sectors are part of the knowledge economy. This reflects the nature of high-end research work taking place in India.

Figure 3.2: Industry profile of top R&D paid for by the company and others and performed by the US companies or their affiliates in India, 2013



Source: National Science Foundation, 2017[13]

[12] Data available at https://www.nsf.gov/statistics/2017/nsf17317/#tab3

[13] Data available at https://www.nsf.gov/statistics/2017/nsf17317/#tab3

3.2.3 Research in Higher Education Sector

The share of higher education in GERD has averaged around 4 percent. In 1997, around 3.4 percent of the total GERD took place in the higher education sector. For the period which data is available, it peaked around 4.43 percent in 2003, and by 2011 it reached 4.04 percent. This abysmally low number is a major concern for India. Globally Universities have an important role in the advancement of research and have a much larger share of GERD. China's share of Higher Education in the GERD is just under 7 percent, which has gradually declined from 11.32 percent in 1997. However, in absolute terms, China's higher education sector spent around ten times more than India in 2011.

Just before independence, India took major decisions in setting up public sector laboratories under CSIR for the advancement of scientific research. The result of this policy meant that scientific research in universities was neglected as the majority of funds were transferred to these labs. Among other things, the majority of the budget for R&D was allocated to few major institutes like ISRO, DRDO and DAE. The focus on 'Big Science' over an extended period meant that majority of higher education institutes never had enough resources to attract either the talent or develop a research culture.

India's higher education system has significant variations regarding quality. In the publicly funded institutions, at one end of the spectrum, there are elite institutions, mainly financed by the Central government, like IITs that have much higher autonomy, better funding and world-class faculty and research facilities. At the other end are fund-starved state universities, with inadequate infrastructure and inability to compete for either good faculties or students. Further, there are private institutions, which have struggled to provide good teaching facilities, and barring a few have not made much impact in the research areas.

The following section discusses the R&D and subsequent knowledge generation in Indian Higher Education sector. The approach here is first to describe the size and scale of HE sector in India, tracing the growth in the sector over the years.

3.3 Expansion of Higher Education in India

India is the second most populous country in the World, with a population of around 1.25 Billion people. The demographic profile is very favourable, as India has one of the best dependency ratios among the major economies. Around 600 million of the total population is under the age of 25 years[14]. The median age of the population is around 26.6 percent, meaning half the population is under this age[15].The demographic dividend, which India enjoys as a significant number of the young population enters the workforce, depends on providing effective training and higher education. The demand for higher education has been rising, as the per capita income has grown and the middle class has swelled so has the aspiration. India already runs one of the largest higher education systems in the World, only second to China(Heslop, 2014). The system is expected to expand further, as the current enrolment ratio of around 24 percent will rise further as the completion rates in the secondary education sector are also growing and given the demographic profile, it is likely to continue for some years to come.

This factor presents a major resource allocation challenge for the Government. Many committees, over the years, have recommended that 6 percent of GDP should be allocated annually towards the education sector. However, this percentage has never crossed beyond 4 percent. Education in India comes under the Concurrent list, meaning that both the Central and the State governments can frame regulations on this subject. To reduce the burden on public exchequer, many of the states allowed indiscriminate expansion of private institutions, at the same time starving publicly funded State Universities. The qualities of many of the private institutions have come under questioning.

3.3.1 Types and Growth of Higher Educational Institutes in India

As mentioned in the earlier section, there are multiple types of HEI in India. They are mostly divided on the type of funding, and their establishment. Table 3.2 provides the details of types of HEI functions in India along with a brief description, their main source of financing and the relative autonomy. In addition to the types presented in Table 3.2, there are Open Universities, which provide correspondence and hybrid courses at both National and State Levels.

[14] UN Population Database
[15] Ibid.

Table 3.2: Types of Higher Education Institutions in India

Sl No.	Types of Institutions	Description	Funding	Autonomy
1	Central University	A university established or incorporated by a Central Act.	Public Funding	Medium
2	State University	A university established or incorporated by a Provincial Act or by a State Act.	State Funding	Low
3	Private University	A university established through a State/Central Act by a sponsoring body viz. A Society registered under the Societies Registration Act 1860, or any other corresponding law for the time being in force in a State or a Public Trust or a Company registered under Section 25 of the Companies Act, 1956.	Private Funding	High
4	Deemed-to-be University	An Institution Deemed to be University, commonly known as Deemed University, refers to a high-performing institution, which has been so declared by Central Government under Section 3 of the University Grants Commission (UGC) Act, 1956.	Private/ Public Funding	High
5	Institution of National Importance	An Institution established by Act of Parliament and declared as Institution of National Importance (INI)	Public Funding	High
6	Institution under State Legislature Act	An Institution established or incorporated by a State Legislature Act.	Public Funding	Low
8	Affiliated Colleges[16]	- Aided Colleges[17] -Unaided Colleges	-Public -Private	Low

Source: MHRD; UGC; Author's compilation

At the time of independence, India's HE system was a legacy of colonial rule. The efforts to build the education system had started before the independence. The scale of work required was immense. Table 3.3 shows the growth of HEI in India from 1950-51 to 2015-16. The GER increased from 1.5 percent in 1960-61 to 24.5 percent in 2015-16. The 12th FYP had set a target of achieving a GER of around 30 percent by the end of 2017. However, this does not seem likely in the face of slowing down in the growth rate of GER.

[16] They can be affiliated to categories in serial number 1, 2, and 3.

[17] Colleges under section 2 (f)& 12(B) of the UGC Act 1956

In a meeting of Vice Chancellor's of Central Universities in 2016, the target was extended to 2020(UGC, 2016).

From a decadal growth perspective, the first major acceleration was seen between 1960-61 to 1970-71. The number of State Universities continued their growth from the previous decade and almost doubled from 41 to 79. The number of colleges also increased by 80 percent during this period as the expansion of education system continued across the country. The GER also increased just under three times during the decade.

The next ten years from 1970-71 to 1980-81 saw the growth rate slowing down. The GER registered a marginal increase in this period from 4.2 to 4.7 percent. One of the reasons was the declining rate of return on education due to low employment opportunities(Blaug, Layard, & Woodhall, 1969). A significant development during the 1970's was the entry of private colleges(Varghes, 2015). The majority of these colleges offered courses in the more lucrative area of technical and professional education.

The next decade, from 1980-81 to 1990-91, saw the revival of the expansion in HEIs. Enrolments during this decade increased at a CAGR of 6 percent. Due to lack of resources, the government encouraged private players to expand further during this period(Krishna, 2012). The growth in enrollment picked up especially from 1987-88 to 1990-91, maintaining an average growth of 7 percent (see Table 3.3)

Despite recommendations from Kothari commission (1966) and others to increase expenditure on education to 6 percent of GDP, the figures were still elusive. In response to this, some of the publicly funded HEIs tried to diversify their resources by introducing self-financing courses(Varghes, 2015).

Following the economic liberalisation, saw a major expansion of HEIs across the board. GER almost doubled from 5.9 to 11 percent from 1990-91 to 2000-01. The number of colleges also doubled in this decade. However, the base effect started catching up, and in terms of CAGR, it slowed down from 6 percent in the previous decade to 5.5 percent.

The turn of the new millennium brought about a rapid expansion. The decade from 2000-01 saw almost a vertical growth in the enrolment rates, with massive expansion taking place, especially in the private sector. GER increased from under 8 percent to 19.4 percent. The enrolment increased at a CAGR of 8.3 percent during 2000-01 to 2010-11. Consider this while 8.4 million students entered the HEI in at the beginning of the decade, the numbers had increased to 18.4 million students entering in 2010-11, the steep climb in annual growth rate is visible for the period from 2002-03 to 2009-10(see Table 3.3, Figure 3.3)

In 2004, legislative changes were made to allow private universities to be set up. The decade saw a phenomenal growth in the number of these universities (see Table 3.3). Privatisation further got momentum from this moves, the number of students in private institutions now outweighed those of public institutions. For instance, at the end of 11th Five Year Plan (FYP), around 58 percent of higher education institutes in India were non-government[18].

Table 3.3: Expansion of Higher Educational Institutions in India

Years	Central Univ.	State Univ.	Private Univ.	Deemed-Univ.[19]	INI	Colleges	GER (%)
1950-51	3	24		…		578	
1960-61	4	41		2	2	1819	1.5
1970-71	5	79		9	9	3277	4.2
1980-81	7	105		11	9	4577	4.7
1990-91	10	137		29	9	6627	5.9
2000-01	17	183		52	12	13150	7.9[20]
2010-11	41	281	87	131	59	32974	19.4
2011-12	42	286	105	128	59	34852	20.8
2012-13	42	292	122	127	62	35525	21.5
2013-14	42	309	153	127	68	36634	23.0
2014-15	43	316	181	122	75	38498	24.3
2015-16	43	329	197	122	75	39071	24.5

Source: UGC Annual Report (2016); MHRD AISHE 2015-16; Varghes (2015); World Bank

[18] 12th FYP Plan document

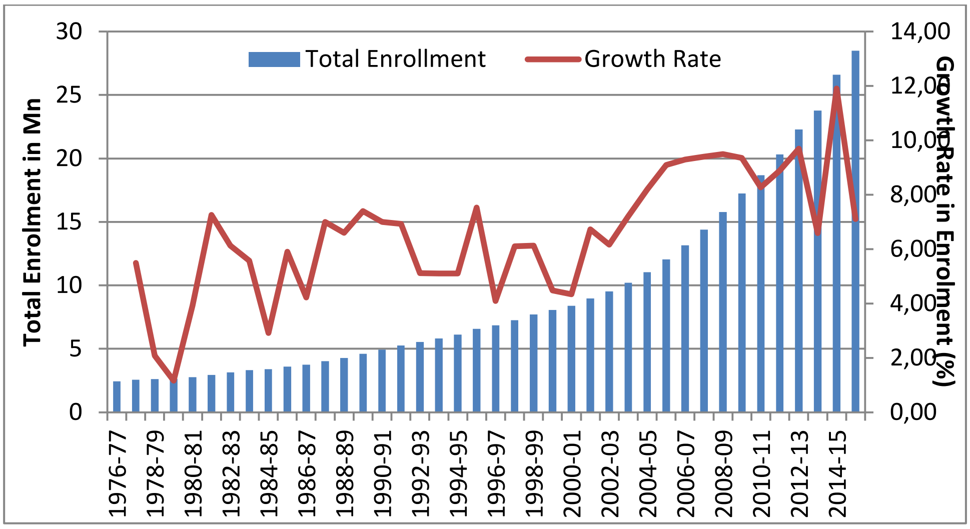
[19] Includes both private, aided and government 'Deemed to be Universities'

[20] http://siteresources.worldbank.org/EDUCATION/Resources/278200-1121703274255/1439264-1193249163062/India_CountrySummary.pdf

In the public expansions were carried out under the 11th FYP, as there were increasing concerns relating to the quality of graduates turning up from private HEI. The budgetary allocation to higher education was highest ever under this plan. A large number of Central Universities were opened up, taking their numbers to 41 by 2010-11 compared to 17 in 2000-01. This decade also saw a major jump in the number of INI from 12 to 59.

The expansion followed the National Knowledge Commission (NKC) recommendations. One of the key recommendations of the NKC was to expand the enrolment rates in higher education. When the NKC submitted its 'Report to Nation' in 2006, it recommended a target of 15 percent GER in higher education by 2015 from around 7 percent in 2006[21]. The commission advised this could be achieved by increasing the number of Universities to 1500. Another important recommendation, which seemed to have a major impact was establishing of 50 Central Universities. The expansion of private universities can also be traced back to NKC. The number of Private Universities including 91 Private Deemed to be Universities increased from none in 2000-01 to 178 by 2010-11.

Figure 3.3: Growth in Enrolment in Higher Education[22]



Source: UGC Annual Reports (Various years)

21 The data from UNESCO is much higher at around 11.54 percent.

22 Figures of student enrolment pertain to regular courses in Universities and Colleges (excluding Polytechnics, other diploma awarding Institutions & Non-formal system of Higher Education.). Data for 2014-15 and 2015-16 are based on provisional figures.

From 2010-11 to 2014-15 the growth in terms of enrolments and expansion of institutions has continued (see Table 3.3, Figure 3.3). The GER increased from 19.4 percent to 24.3 percent between these periods. However, the estimates for 2015-16, show only a marginal increase in the GER to 24.5 percent. As can be seen from Figure 3.3, the growth rates in enrollments have fluctuated a lot in recent years. The CAGR for GER in this period was 8.82 percent, with a highest annual growth rate of 11.9 percent achieved in 2014-15 compared to the previous year. For the last 15 years, the enrolment in higher education has grown at a CAGR of 8.5 percent. Despite the impressive growth in GER, it remains below the world average of 26 percent, and much below the advanced economies like UK and US.

3.3.2 Expansion of Private Sector in Higher Education

In 2001, private unaided institutes accounted for 42.6 percent of all higher education institutes with 32.8 per cent share in total enrolments. Currently, the private sector accounts for 58 percent of total higher education institutes (HEI) with 64 percent of total enrolments. The rise of the private sector is a result of many factors. First, the government's focus was on improving access to school education. Accordingly, the majority of the budget expenditure was geared towards school education. Second, India's rapid economic growth after the liberalisation meant increased skilled workforce requirement by many domestic industries and global firms. The demand was mainly for management and engineering graduates. The private sector moved in quickly to fill the void and invested in these areas of higher education.The rise of the neoliberal framework, with reducing role for the public sector, meant trends in higher education paralleling the rest of the economy where private sector's role has increased, and the role of public sector in a relative sense has declined.

While these numbers are appreciable, it has been seen as the State shirking its responsibility to provide higher education to everyone. The future supply of higher education is likely to continue to come from the private sector.

The rapid expansion of the HE system created massive pitfalls as well. The single-minded focus on quantitative expansion led to a deterioration in the quality of education. National Association of Software and Services Companies (NASSCOM) and McKinsey, a management consulting firm, carried out the most famous and widely cited survey in 2005, with only 25% of the engineering education graduates being employable by multinational companies in India. Some factors like outdated curriculum, lack of good teaching staff resulting in the antiquated method of rote learning and not enough focus on applied knowledge are identified for poor performance of the graduates. The gap between the top and the bottom institutes have widened over the period.

The move towards increasing privatisation has been haphazard[23]. The corporate sector has largely been absent from the higher education sector, and only a few handfuls are engaged. In recent times some committees and commissions have been set up towards increasing the participation of the private sector[24]. The most recent of these being the "Committee on Corporate Participation in Higher Education", also known as the "NR Narayana Murthy Committee" (NMC) constituted by the erstwhile Planning Commission. The committee comprised of Industrialists, bureaucrats, academicians and private foundations. It is important to highlight that among the academicians, the representation was only from the IITs and IIMs.

The NMC report begins by identifying factors impacting the Indian Higher Education Sector:

> *the higher education system seems to be plagued by several problems –inadequate number of institutions to educate eligible students, poor employability of the graduates produced by the universities, low and declining standards of academic research, an unwieldy affiliating system, an inflexible academic structure, an archaic regulatory environment, eroding autonomy and low levels of public funding, to name a few (pp i)*

The role for corporate sector becomes clear as the report mentions:

> *"The key challenge facing the government and policy makers is how to maintain quality while increasing the reach of the current system without exerting more*

[23] Kapur, D., & Mehta, P. B. (2004). Indian Higher Education Reform: from half-baked socialism to half-baked capitalism. *Center for international development working paper*, *103*.

[24] "Report on Policy Framework for Reforms in Education (2000)", and National Knowledge Commission (2006-9) emphasize increasing role for the private sector. While NKC had a much wider scope, an important recommendation was on enhancing the role of Private Sector in HEI.

pressure on public finances and how to create world-class universities in India to bring in competitiveness and enhance innovation" (pp i).

Thus for each of these issues, the corporate sector is expected to provide a panacea. The panacea can range from providing financial resources to existing institutes to owning new universities. The NMC makes a number of recommendations to facilitate the entry of corporate sector into higher education. It further differentiates the criteria for the existing public sector institutes, which may attract funding from the corporate, and the privately owned universities. Thus, the report not only advocates changes for the entry of corporate sector but also identifies the changes to be brought to the public sector universities.

The model of education, globally and even in India have worked on the principle of not for profit organisation. This has an important implication. Not for profit nature means, there are no shareholders who are to be given dividends. Even universities which work on the principle of cost recovery tend to reinvest the funds towards the development of institutes. In a similar vein, the Twelfth FYP has recommended allowing the educational institutes to be set up under section 25 of the Companies Act, 1956. However as Tilak (2011) notes: *"It is widely felt that these institutions [Private unaided colleges], though de jure are described as charitable or not profit-seeking institutions, are de facto profit-making institutions*". A serious mistrust exists towards the private education providers among the academicians.

3.3.3 Structure of Higher Education in India

The enrolment rates are heavily skewed towards an undergraduate level, as is to be expected. Around 81 percent of the enrolment is at the undergraduate level. The percentage of postgraduate students enrolled is around 9 percent, while at M.Phil it is 0.14 percent and PhD is at 0.41 percent. Rest are at Diploma and Certificate levels. From a research perspective, the number of students entering PhD is extremely low. There are large-scale dropouts even in elite institutions, as students tend to get better opportunities in the labour market[25]. Also, opportunities in academia and research available after completion of PhD remain low(Cyranoski, Gilbert, Ledford, Nayar, & Yahia, 2011). In terms of outturn, India produced 24,171 PhDs in 2015-16. Large numbers of faculty

[25] " 2k students drop out of IITs, IIMs in 2 years" Available at: http://timesofindia.indiatimes.com/india/2k-students-drop-out-of-IITs-IIMs-in-2-years/articleshow/53792357.cms

vacancies remain unfilled even among the best institutes(Basu, 2015). The quality of PhDs coming out from many of the institutions is highly questionable as well[26].

Table 3.4 shows the discipline wise enrolments at Postgraduate and above level. While the number of postgraduates is highest in social sciences, the numbers of PhDs are higher in Science, followed by Engineering & Technology.

Table 3.4: Discipline wise enrolment of Postgraduates

	PhD	M.Phil	Post Graduate
Science	33197	10790	507320
Engineering & Technology	30587	62	261065
Social Science	15885	8222	683907
Management	6358	838	596431
Medical Science	5237	175	130088
Agriculture	4849	63	22132
IT & Computer	2768	2016	242908
Others	27570	20357	1459526
Total	126451	42523	3903377

Source: AISHE, 2015-16, MHRD

3.3.4 Expenditure on Education

The Kothari Commission report put the desired level of spending on education at 6 percent of GDP. However, it did not specify the distribution between different levels of education. This target of 6 percent has never been achieved (see Table 3.5). Further, major burden of financing of higher education lies with the state governments, even though the share of Centre has increased in last decade (see Table 3.6).

[26] "Panel raises questions about quality of Ph.D holders in India" Available at : http://www.thehindu.com/features/education/parliamentary-panel-raises-questions-about-quality-of-phd-holders-in-india/article7166920.ece

Table 3.5: Share of State and Centre in expenditure on education as a percentage of GDP

	States	Centre	States + Centre
2000-01	2.74	0.4	3.14
2005-06	2.26	0.53	2.79
2006-07	2.19	0.6	2.79
2007-08	2.15	0.58	2.74
2008-09	2.23	0.65	2.88
2009-10	2.46	0.65	3.11
2010-11	2.51	0.72	3.22
2011-12	2.64	0.73	3.37
2012-13	2.72	0.71	3.43
2013-14(RE)	2.74	0.75	3.49

Table 3.6: Share of State and Centre in Higher Education Expenditure

	Centre (%)	State (%)
1980-81	20	80
1985-86	20	80
1990-91	21	79
1994-95	19	81
1999-00	27	73
2004-05	22	78
2009-10	35	65
2014-15	35	65

Source: MHRD, Author Calculation

The increase in budgetary allocations at the nominal rate may seem high. However, when adjusted for inflation they are not impressive. In fact, at a per capita level, the expenditure at state universities are going down while that in Central Universities are rising. The number of students enrolled in Central Universities accounts for only six percent. However, they receive 35 percent of the budgetary allocation[9]. Thus, we have created a two-layered system within public institutions. The Central institutes which are of the top quality, well funded, with good infrastructure on one hand and state universities which suffer from acute shortage of funds, deficit infrastructure and find difficulty in attracting good quality students and faculties. The deterioration of many of the state universities, which commanded immense respect in the past, has been relegated to low-quality institutes. What is clear is that the State has given up on reforming these institutes and relied on the private sector. However, the complexity of the system and close relation between politicians, regulators and the private capital has resulted in the creation of opaque institutes, which do not seem to have the well-being of students or the country.

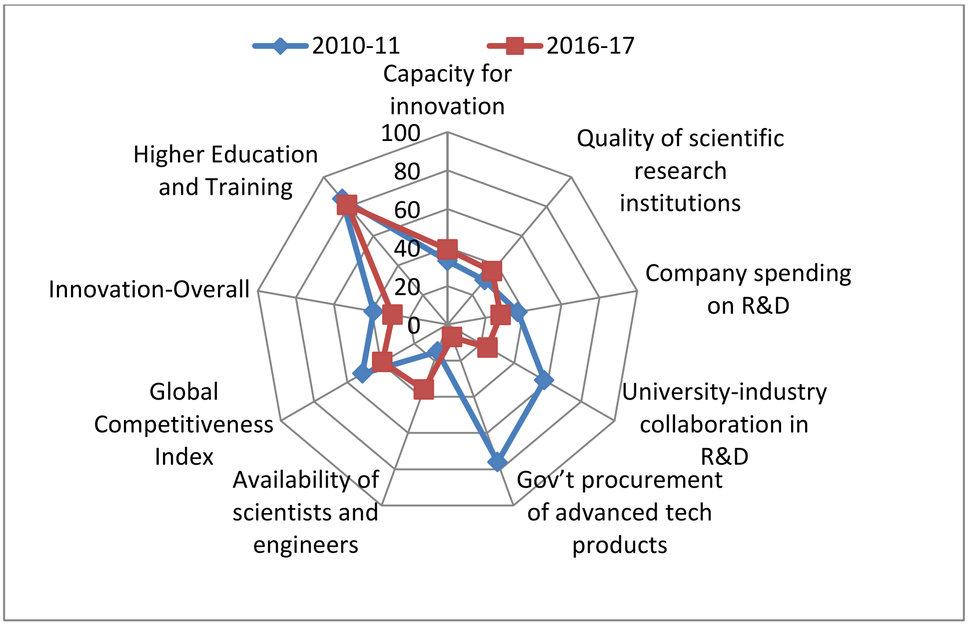
3.4 Innovation in India: Key factors

Like most countries, India is increasingly focussing on innovation to be the main driver of its economic growth. Some recent initiatives like the formation of National Knowledge Commission, National Innovation Council and the continued focus from NITI Aayog, erstwhile planning commission have all highlighted the role of innovation in the economy. Beyond commissions and committees, India's strategic visions related to innovation are provided in the Science & Technology policies. The latest policy, which came out in 2013 added the term innovation as well. Thus the policy is now known as Science, Technology and Innovation Policy, 2013. India declared 2010 to 2020 as the 'Decade of Innovation' with a focus on inclusive growth. Many policies to improve India's innovation capacity has been announced by the Government to improve the country's competitiveness in the world.

The Global Competitiveness Report (GCR) 2016-17 brought out by the World Economic Forum (WEF) ranks India at the 39th position out of 138 countries. Among the BRICS nation, it lags behind only China, which is ranked 28th. India's ranked has improved from 51st position in 2010-11 out of 139 countries. While a host of factors covered in the GCR are important, our focus, however, is on the Innovation index and its sub-components. The WEF Innovation Index has seven components, which aim to gauge the innovation capabilities of the country.

Figure 3.4 provides details of India's Innovation ranking for two periods 201-11 to 2016-17. India's overall ranking in the Innovation has improved from 39 in 2010-11 to 29 in 2016-17. The improvement does seem impressive. However, a closer look reveals that the improvement has mainly occurred in two key areas. First, the ranking on the subcomponent of the index, 'Government procurement of Advanced Technology Products', has improved considerably from 76th position in 2010-11 to seventh position in 2011-12. This may be due to a number of changes announced by the government relating to programmes like Make in India.

Figure 3.4: India's Innovation Ranking, GCI



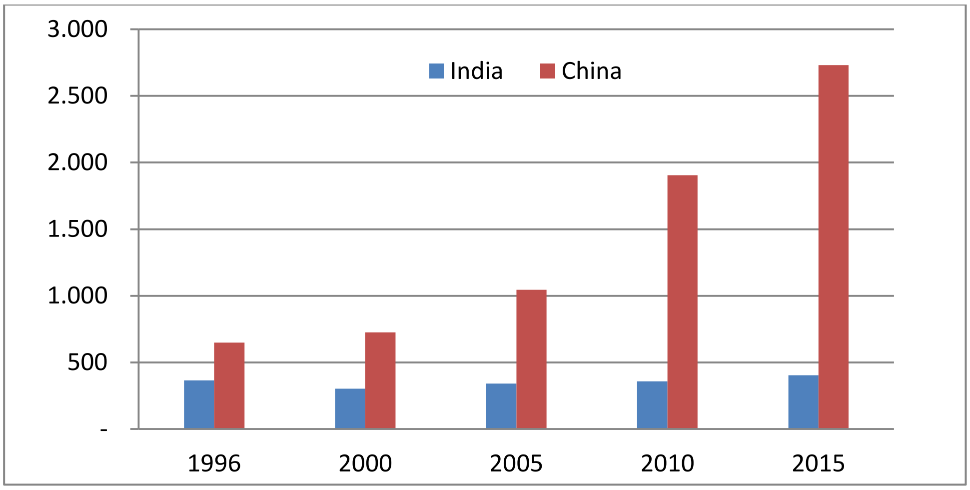
Source: The Global Competitiveness Report (GCR) 2016-17, WEF

The other large improvement is seen in the 'University-Industry Collaboration in R&D', where the rankings have improved from 58th to 24th in the period under consideration. This is contrarian to the popular belief that R&D cooperation between University and Industry is weak in India. A possible explanation for this could be the data is based on the survey of executives. A select number of institutions like the IITs and IISc may influence the opinions, where the collaboration is much stronger. However, these may not be reflective of other HEIs. Some basic indicators like joint publications point to improving collaboration between the University and Industry (discussed later in this section).

The major concern for India continues to be the Higher Education & Training; it ranks 81st in this criteria. This could seriously hamper the future supply of quality workforce. Up to a certain extent, this may already be visible as India's ranking on the availability of Scientists and Engineers has declined from 15th to 36th in the period under consideration. It can be attributed to a much larger problem of quality in Higher education. While the numbers of engineers coming to the market has increased the employability factor outside the top institutions has declined over the years. In the last couple of years, a number of private engineering institutes have shut down due to low demand. Around 600 unaided institutes have been approved for progressive closures[27].

In terms of Scientists, India has one of the lowest ratios of Total R&D personnel[28] per million inhabitants in the World (see Figure 3.5). Another problem is the migration of highly qualified scientists. It is estimated that almost 40 percent of India's scientists are working abroad(Van Noorden, 2012). Despite a rapid growth in the enrolment rates at the higher education level, the number of researchers adjusted for population growth increased only marginally from 364 in 1996 to around 403 by 2015. The only country comparable to India's size is China. Despite its larger size than India, it has managed to increase the number of R&D personnel per million inhabitants by a factor of four since 1996.

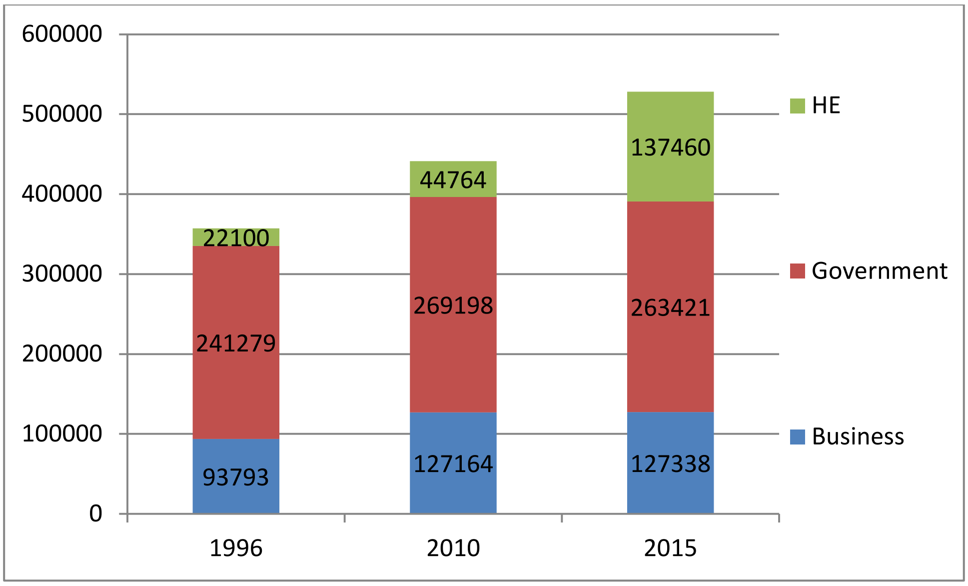
Figure 3.5: Total R&D personnel per million inhabitants (FTE)



Source: UNESCO Institute of Statistics, 2017

[27] See AICTE website available at http://www.aicte-india.org/dashboard/pages/closedinstitute.php
[28] The data is calculated in terms of Full Time Equivalent (FTE). FTE corresponds to one year's work by one person (for example, a person who devotes 50 % of his time to R&D is counted as 0.5 FTE).

Figure 3.6: No. of R&D personnel employed by Sector (FTE)



Source: UNESCO Institute of Statistics, 2017

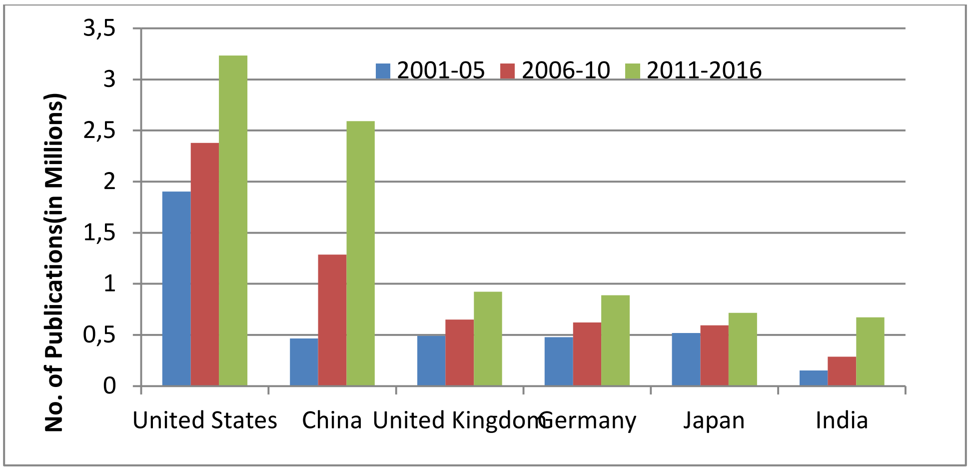
Figure 3.6 provides details on the R&D Personnel (FTE) employed by sector. The data reflects stagnation in terms of Government and Business sectors. The growth in the higher education sector is in the back of the number of new Central Universities, IITs and AIIMs. However, what is striking is the R&D expenditure. In spite of having the highest number of R&D personnel, HE sector spends only 4 percent of the total GERD.

Knowledge Output & Flows

In recent years, there has been considerable improvement in the publication output of the country, as well as the number of applications filed for patents under PCT have improved. This clearly reflects the improvement in the perception of 'scientific research institutions'.

The improvement in publications has been a major development (Figure 3.7). As it was evident from the literature review, Industry researchers consistently rank publication as one of the most important channels of knowledge transfer from University to Industry(Cohen et al., 2002; Perkmann, Tartari, McKelvey, & Autio, 2013). Even in the case of India, open channels like publication is ranked as an important source of academic research by Industry (Joseph & Abraham, 2009).

Figure 3.7: Number of Publication



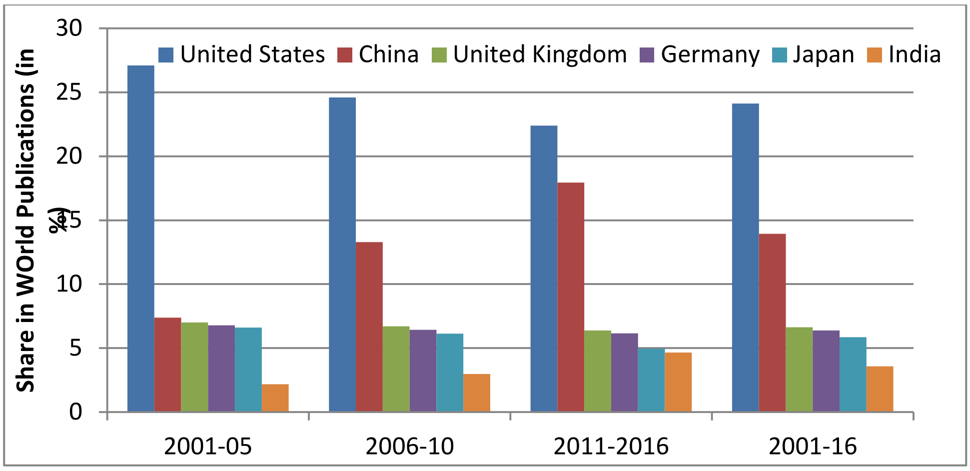
Source: Scopus Database, Author's calculations

India is the sixth largest scientific publishing country in the world[29]. The growth of publication has accelerated in recent years. For instance, from 2001-05 to 2006-10 the growth rate was 87 percent, and in the subsequent period 2011-2016 the output increased by 133 percent the fastest rate of growth in the World. There are two factors here. First, there is genuinely an increase in terms of publication. The second factor is the increase in the number of journals covered by Scopus. Thus, a lot more visibility is available for Indian researchers.

Subsequently, India's share in the number of published articles has consistently improved (see Figure 3.8). India's share has increased from 2.15 percent in 2001-05 to 4.65 percent by 2011-16. For the whole period 2001 to 2016, the share stands at 3.57 percent. In per capita population terms, India's output is much lower. However, the trend continues to be positive.

[29] The countries presented here are based on the cumulative publications from 2001-2016.

Figure 3.8: Share of publication in the world



Source: Scopus Database, Author's calculations

Table 3.7 shows the change in share of subject wise publications from 2001-2016. The share of Engineering has increased from 15.61 percent in 2001-05 to more than 22 percent in the 2011-16 period. Another major change is in the field of Computer Science, which was lower than 5 percent in 2001-05 has considerably increased its share in the recent years[30]. The other important subject areas are (a) Biochemistry, Genetics and Molecular Biology, (b) Pharmacology, Toxicology and Pharmaceutics, (c) Agricultural and Biological Sciences, (d) Chemical Engineering and (e) Mathematics

Table 3.7: Top five subject wise publications in India (in percentage)

Subjects	2001-2005	Subjects	2006-10	Subjects	2011-16
Medicine	17.47	**Engineering**	18.50	**Engineering**	22.25
Chemistry	16.90	**Medicine**	17.58	**Medicine**	19.30
Engineering	15.61	**Chemistry**	16.23	**Computer Sc.**	16.56
Physics and Astronomy	15.18	**Physics and Astronomy**	15.31	**Physics and Astronomy**	13.84
Materials Science	12.99	**Materials Science**	13.51	**Chemistry**	13.45
Others	21.85	**Others**	18.88	**Others**	14.61

Source: Scopus, Authors calculations

[30] Some of the papers are classified under multiple headings, and the total when added up may be much higher. For our purpose, we divide the number of papers in the concerned field by total publications for the year. Thus, the numbers in terms of concentration seem much higher.

To assess the quality of publication Bibliometric studies looks at the citation factors. In a study commissioned by NSTMIS, Thomson Reuters carried out a study to evaluate the quality of publications in India using their proprietary web-of-science database covering the period 2005-2014. Thomson Reuter's website defines the citation impact as:

> "The citation impact of a set of documents is calculated by dividing the total number of citations by the total number of publications. Citation impact shows the average number of citations that a document has received"[31].

The normalised citation simply sets the global average at one and normalises the values accordingly. India's average normalised citation for the period 2005 to 2013 was 0.74. This was thus lower than the global average. Thus, despite the increase in the quantity of publications, the quality has not improved correspondingly(Thomson Reuters, 2014).

Collaborative publications

One of the indicators used in assessing the linkages is by analysis of joint publications metrics(Lundberg, Tomson, Lundkvist, Skår, & Brommels, 2006). Rupika, Uddin, & Singh (2016) carried out a Bibliometric analysis of joint publications across different spheres of the triple helix in India. Table 3.8 shows year wise joint publication between University, Industry and Government at both bilateral and trilateral level adapted from their study.

The share of collaborative publication across different actors has increased from 2005, showing an improvement in joint knowledge production. UI joint publications grew at a CAGR of 18.3 percent from 2005 to 2014. This was marginally lower than the IG, which grew at a CAGR of 19.8 percent, on a much smaller base. The UG collaboration continues to account for the majority of the joint publication share. The trilateral collaboration between UIG has also increased. These figures present an encouraging sign.

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[31] Available at http://ipscience-help.thomsonreuters.com/inCites2Live/indicatorsGroup/aboutHandbook/usingCitationIndicatorsWisely/citationImpactDraft.html

Table 3.8: Collaboration in Publication

Year	Total	UI	% Share	UG	% Share	IG	% Share	UIG	% Share
2005	28,167	1321	4.69	4657	16.53	543	1.93	364	1.29
2006	31,645	1549	4.89	5509	17.41	635	2.01	444	1.4
2007	36,906	1934	5.24	6641	17.99	714	1.93	502	1.36
2008	43,425	3309	7.62	9662	22.25	1414	3.26	1125	2.59
2009	44,779	3718	8.3	10,619	23.71	1523	3.4	1263	2.82
2010	48,078	4208	8.75	11,633	24.2	1851	3.85	1525	3.17
2011	52,291	5019	9.6	13,109	25.07	2256	4.31	1926	3.68
2012	55,227	5454	9.88	14,444	26.15	2458	4.45	2078	3.76
2013	57,701	5800	10.05	14,909	25.84	2499	4.33	2122	3.68
2014	60,945	5970	9.8	16,489	27.06	2761	4.53	2361	3.87
Total	4,59,164	38,282	8.34	1,07,672	23.45	16,654	3.63	13,710	2.99

Source: Rupika, Uddin, & Singh, 2016

UI-University Industry, UG- University Government, IG-Industry-Government, UIG-University Industry Government

Patent Citations

Patent citations can be an important indicator of knowledge transfer. Much like the citations in publications, they are an acknowledgement of the previous work on which the current work builds on. The applicant is required to provide citations of the earlier works, both patent and non-patent.[32] An important function of the citation is to demarcate the extent of the rights provided to the patent holder. Trajtenberg & Henderson (1993) make a similar point "The patent represents a legal right conveying the incremental idea embodied in it, above the prior state of knowledge, which is represented by the citations".

Table 3.9 shows the country wise share of patent citations in the World. India's share in the world patent citation has increased marginally from 2.2 percent in 2009 to 2.9 percent in 2013. However, it continues to be low as compared to other economies. This is indicative of lower flows of knowledge. The majority of patent citations continue to come from the US, which accounts for more than 40 percent of total patent citations. China's share has improved from 8.5 percent to 12 percent[33].

[32] However, it may be the examiner who determines the citations to be included.

[33] In absolute numbers, there is a considerable decline in patent citations across countries. However, the report does not provide any reasons for the same.

Table 3.9: Share of Patent Citations in the World (in %)

Country	2009	2010	2011	2012	2013
USA	41.3	40.9	40.9	40.5	42.1
China	8.5	9.6	10.5	11	12
GBR	9.3	9.3	8.7	9.2	11
Germany	10.6	10.6	10.7	10.1	10.9
Japan	7.3	7.1	6.3	6	4.9
South Korea	3.3	3.9	4.5	4.6	4.9
India	2.2	2.4	2.4	2.9	2.9
Brazil	1.1	1	1	1.2	1

Source: International Comparison of India's Research Base, 2009-14 (Scopus & NSTIMS)

3.5 University-Industry-Government Partnership: A successful example

Telecom Centres of Excellence (TCOES)

India's telecommunication sector has achieved major success in providing affordable services to the masses. In the face of global competition, there is a need to improve the competitiveness and innovation of Indian industry. With this aspect in mind, Telecom Centres of Excellence were established, "to create synergies between academia and industry". There are currently eight TCOEs operating across top institutions

The main objectives of TCOEs are:

- Perform applied research relevant to the needs of telecom sectors.
- Work towards capacity building in terms of highly skilled workforce for the sector
- Act as a think tank for policy advocacy towards governance and regulation of telecom sector.
- Enhance India's say in influencing the global telecommunication standards, which are dominated by large manufacturing countries.
- Focus on enhancing entrepreneurship and innovation in the telecom sector. This is done through setting up of incubator facility, carrying out innovation meet and providing access to research platform for other industry players.

The Model

The PPP model works with funding from Government and the Industry, along with intellectual capital from the academia. The government provides 10 percent of the funding while remaining 90 percent comes from Industry. The outcomes are in terms of policy documents, research publications, technology patents and licensing. In some cases, the incubated companies have gone on to successfully commercialise the technology. Eight TCOEs began their operation in 2007, and one at IIT Roorkee commenced in 2013. The initial Memorandum of Understanding (MoU) was signed for five years and has been successfully extended twice for all the seven institutions, which began operation in 2007, while the MoU for IIT Roorkee and RailTel is in force until 2018.

Table 3.10: Telecom Centre of Excellence

S No	Name of TCOE	Academic Institute	Principal Sponsor
1	IIMA IDEA Telecom Centre of Excellence (IITCOE)	IIM, Ahmedabad	IDEA Cellular Ltd.
2	Vodafone IIT KGP Centre of Excellence in Telecommunications (VICET)	IIT Kharagpur	Vodafone India Ltd.
3	Reliance IITM Centre of Excellence (RITCOE)	IIT Madras	Reliance Communications Ltd.
4	Aircel IISc Centre of Excellence in Telecommunications (AIIScCET)	IISc, Bangalore	Aircel Ltd.
5	Airtel IIT Delhi Centre of Excellence in Telecommunications (AICET)	IIT Delhi	Bharti Airtel Ltd.
6	BSNL IITK Telecom Centre of Excellence (BITCOE)	IIT Kanpur	Bharat Sanchar Nigam Ltd.
7	Tata Teleservices IITB Centre of Excellence in Telecommunications (TICET)	IIT Bombay	Tata Teleservices Ltd.
8	RailTel IIT Roorkee Centre of Excellence in Telecom (RICET)	IIT Roorkee	RailTel India Corporation Ltd.

Outcomes

Table 3.11 provides the results of the collaborative projects. Out of 89 projects undertaken around 40 'proof of concepts' of different technologies have been developed and approved by the Industry sponsors. Out of the 40, hardware applications were seven, while the rest were in software applications. Similarly, the project has been able to develop intellectual properties, including domestic and international patents. One of the key objectives of setting up the TCOEs, especially one at the IIMA, was to produce research papers for policymakers and industry managers. Around 41 research papers covering different aspects of the telecom sectors have been published and made available in the public domain.

Table 3.11: Outcomes of Telecom Centres of Excellence

	Outcomes		Details
1	Proof- Of- Concept of different Technologies (approved by Sponsors)	40 (H/W= 7, Appln= 33)	- Out of 89 Ongoing projects
2	IPRs & Patents	14 + 20	- Including 6 US Patents
3	Research Papers in aid of Policy/Management Decisions	41	- Published in TCOE & IIMA website
4	Technology launched in Operator Network a) Digital Kisan Mandi -BSNL + IIT K b) Auto Customer Acquisition Form - RCom.+ IIT M c) Mobile Social Networking Platform - TTL + IIT B d) Network Opex Optimization - TTL + IIT B e) Unlicensed Band Radio (UBR) -TTL + IIT B	5	- launched in Haryana & Odisha - Being Commercialised - initiated in TTL's network - 10-15% Opex Saving demonstrated - Low-cost Wi-Fi + multiple usages
5	Products being manufactured a) Variable Phase Power Plant for Rural BTS- M/S VMC+IITK b) Unlicensed Band Radio (UBR)- M/S Primatel + IIT B	2	
6	Simulators a) Powering Cellular Base Station- IIT M b) Broadband Wireless Simulator- CEWiT+IITM+IITKgp+IITB+IITK	2	- For Power Management - For testing 4G, LTE Technologies
7	IPv6 Consultancy & Training	4	- Undertaken at BSNL & MHA
8	Entrepreneurship	(IITM: 2, IITB: 2)	-Panchsheel Research Pvt. Ltd. & DSP Works Ltd. incubated from IIT B in '13

Source: Department of Telecom, Government of India

From the industry partner point of view, five of the technologies are operational. We briefly discuss two of the technologies.

Digital Kisan Mandi: developed by researchers at BSNL-IIT Kanpur COE. The technology enables farmers to get daily ‘Mandi’ prices for the commodity of their interest.

BSNL is providing this service in Orissa and Haryana. The services are available in multiple languages.

Network Opex Optimization: developed by researchers at TTL-IIT Bombay COE. The technology helps in improving the efficiency of power and fuel costs of telecom wireless networks by around 30 percent. Considering that there are more than 10000 sites were such savings can be carried out, this could translate into major benefit for the industry. The technology makes use of "advanced machine learning analytics and optimisation techniques to make focused suggestions for each site[34]." This project is being commercialised by an incubated company "Panchsheel Technologies Private Ltd".

The collaborations have resulted in products, which are already at the manufacturing stage. Similarly, simulators that help in power management and testing of 4G, LTE technologies have also been developed at IIT Madras. Also, consultancy & training services have also been provided.The collaboration has also yielded in four incubated spin-offs, two each at IIT Bombay and IIT Madras. The initial plan did not envisage the creation of spin-offs and grew organically.

From our analysis of the UIG projects, these remains one of the most successful examples. A key determinant was the initial buy-in from the industry. The applicability of the product makes it directly relevant and beneficial to both the partners. The decision of the Government to coordinate in bringing both the partners together, with small initial financial contribution has proven to be extremely successful. The renewal of the projects, after the end of initial MOU also suggests that each partner has gained from the collaboration.

The current chapter focussed on India's NSI of innovation, especially the role played by the Universities. Their most significant contribution in the Universities is in the form of Human resources. Many of India's competitive sectors are increasingly in the knowledge domain, which will depend on the quality of the University graduates. However, there is a worrying trend as well. While the numbers have increased, the quality of the graduates entering the market is being questioned more and more. India has one of the lowest ratios

[34] Abhay Karandikar, Coordinator of TTSL-IIT Bombay Center for Excellence in Telecom (TICET). Available at https://www.ee.iitb.ac.in/~karandi/tech_dev.php

of R&D personnel to population if a course correction is not undertaken immediately could hamper the long-term innovative capacity of the country.

The increase in numbers of publications is a positive development. However, they are not that impressive when they are adjusted for the size of the GDP, or the population. The current research base of Universities is extremely low, with only 15 to 20 percent institutions engaging in research(Krishna, 2012).

Despite an early focus on S&T, the resource allocation has not matched policy wordings. The current aim of increasing GERD to two percent of GDP may not materialise. The recent funding cuts to publicly funded research institutions may not help the matter. Further, the aim to raise the share of R&D to increase to 50 percent by 2020 should not be on the back of shrinking of the public research.

In per capita terms, research expenditure per scientists in India is comparable to the best in the World. However, the output does not seem to match. These is mainly due to the skewed nature of expenditure. However, the productivity levels of HEIs in terms of knowledge generation are much higher[35]. Thus, there is an immediate need to increase funding to HEIs to enhance their research capabilities.

The next chapter looks at some of the indicators related to academic entrepreneurship in India.

[35] They account for more than 65 percent of publications in the country.

4 Academic Entrepreneurship and University-Industry Linkages in India

Universities in India are warming up to the idea of commercialising their knowledge base. However, as highlighted in the earlier chapters, only a few institutions engage in research. The research base is much lower(Krishna, 2012). The knowledge transfer largely is in the form of movement of students from Universities to the Industry. Similarly, only limited numbers of firms are engaging with the academia in India(Joseph & Abraham, 2009). Some remedial steps have been undertaken by the policymakers to encourage University-Industry Linkages in India.

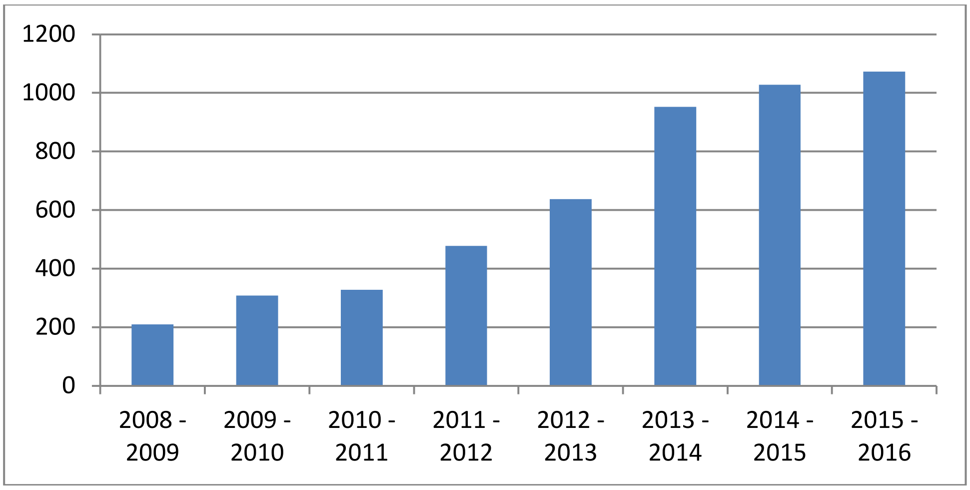
This chapter looks at the status of UIL in India and explores the channels through which these linkages operate. It is important to highlight that no systematic database is available on the UIL. Except for few centrally funded Universities and Institutions of National Importance, annual reports are also not available. Further, there has been only limited empirical studies, which have contributed to the available data. We thus use multiple sources[36] and rely on a limited number of institutions to understand the UIL.

4.1 University Patenting in India

As discussed earlier a large number of studies have used the data on patenting for analysing the entrepreneurial nature of the Universities. A large number of studies have shown that patents form a very small portion of the knowledge transfer channel from Universities to the Industry. The scenario in India does seem to be similar. However, the number of patent applications filed by HEI in India has been growing at a rapid rate (see Figure 4.1). In the year 2008-09 HEI filed 209 patent applications this number increased to 1073 by 2015-16. Patent filing during this period grew at a CAGR of 26.33 percent.

[36] For a detailed discussion on the data used see the section under 'Data' in the Introduction Chapter.

Figure 4.1: Patenting among HEI in India: Patent Applications



Source: Controller General of Patents, Designs & Trade Marks, GOI & Author's calculations

Here it is important to highlight a significant change in policy by one of the major funding agencies for research in HEI. India does not have legislation, which is equivalent to Bayh-Dole Act for ownership of IPR for publicly funded research. However, in March 2000 the Ministry of Science and Technology came with a guideline titled 'Instructions for Technology Transfer and Intellectual Property Rights[37]' on encouraging HEIs to seek protection of IPR generated from research supported by Ministry funding. In the absence of funding data, we cannot directly attribute the change to this one ruling, however, even if not directly this ruling would have meant a significant indication to the HEI encouraging patenting of publicly funded research.

The other important factor is the more proactive role of TTOs. For instance, the rate of patent filing in IIT Bombay has grown at a very rapid rate. The former dean of the R&D office attributed this to a change in strategy of the TTO to chase the students and faculty instead of waiting for them to approach the office. He made the following comment:

> The abstracts of the reports of M.Tech. project work is being assessed by the R&D office personnel every year, and shortlisted work is being reviewed in consultation with researchers for possible filing of patents. Further, the start-up culture has also improved over the years"[38].

[37] Available at: http://www.pfc.org.in/info/tt_ipr.htm Accessed on 03/06/ 2017

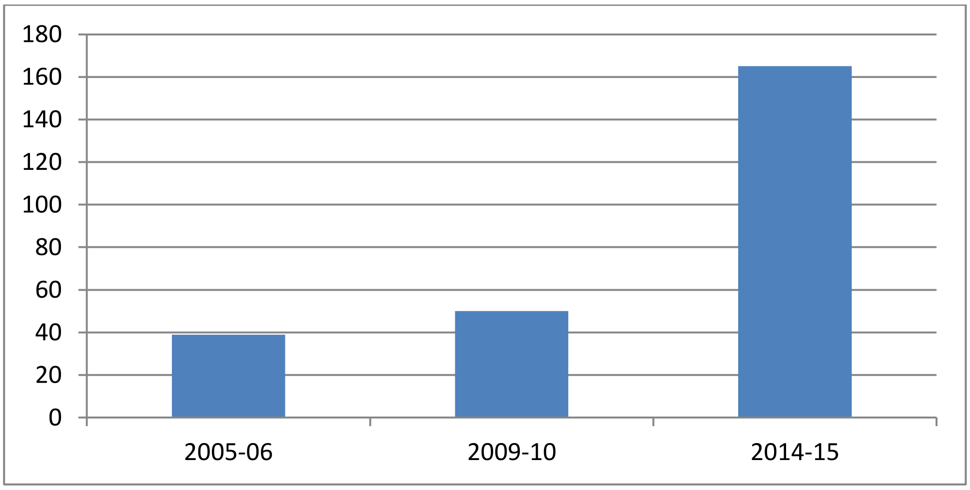
[38] "IIT Bombay leads with 400 per cent growth in patent filing", India Today Online, Available at : http://indiatoday.intoday.in/education/story/iit-bombay-leads-with-400-per-cent-growth-in-patent-filing/1/341476.html

The same article further notes:

> "The reasons behind the growth in patent filing are attributed to an in-house professional patent search facility. An extended panel of attorneys is available to help file IP patents, copyrights, designs and trademarks. Workshops and seminars are also expected to be conducted".

Thus, looking at the data and anecdotal evidence, we can conclude that albeit a smaller research base, the interest in patenting activity has gone up rapidly among the HEIs in India. Considering the size of the Indian HE system, the number of institutions taking part in patenting while increasing in percentage terms continue to be small in absolute term. Figure 4.2 shows the number of institutions, which filed at least one application in the given year.

Figure 4.2: Number of Institutions filing patent applications



Source: Author's Calculations

The number of HEIs involved in patenting has increased from 50 to 165 by 2014-15. However, the majority of the institutions have patent filings in low single digits. The majority of the filings have come from Indian Institute of Technology, Amity University, IISc and NIPER. The recent years have seen a surge from a number of private HEIs in addition to Amity. Some of the top private HEI with increased patenting activity are Saveetha School of Engineering Saveetha University, G.H.Raisoni College of

Engineering, Bharath University, from Janardan Rai Nagar Rajasthan Vidyapeeth (Deemed) University.

These figures do represent an increasing awareness about the patenting activity among a new set of HEIs. The private HEIs may also leverage the improvement in rankings to enhance collaboration with the Industry.

Divergence between application filed, published and granted

In India, once an application is filed, the patent is published within 18 months if an explicit priority publication request is not made. In the case of explicit publication requests, the patent can be published within one week of the application. The final granting of the patent can take at least four years, however, in practice takes much longer as well[39]. The process in other countries is similar to India. However, the timeline may vary across countries. It is important to understand that the number of granted applications reflect the research, which was carried out at least four years earlier and in some cases ten years.

Similarly, one needs to be a sceptic while looking at the patent publication data. For instance, a large number of patents, almost to the tune of 1/3rd, are rejected for every year. In a scenario where patent applications may count as an indicator of invention among HEIs may never materialise[40]. The patent represents a legal right conveying the incremental idea embodied in it, above the previous state of knowledge, which is represented by the citations (Jaffe et al., 1993).

The number of academic institutions engaging in patenting is a small fraction of the total HEIs. This seems to be the trend across globally. Even among institutes where patenting is more prevalent, only a small fraction of faculty tend to engage in patenting as compared to a number of faculties involved in publishing(Ramos-vielba & Fernandez-esquinas, 2012).

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[39] In some cases the delay has been as much as 10 years

4.2 Analysis of select HEIs' data on entrepreneurial activities

The following discussion is based on the data submitted by HEIs for the NIRF. Refer the section on 'Data & Methodology' in the introduction chapter for details. We focus on three indicators for entrepreneurial activities Patenting, Consultancy and Sponsored Research.

4.2.1 Patenting Activity

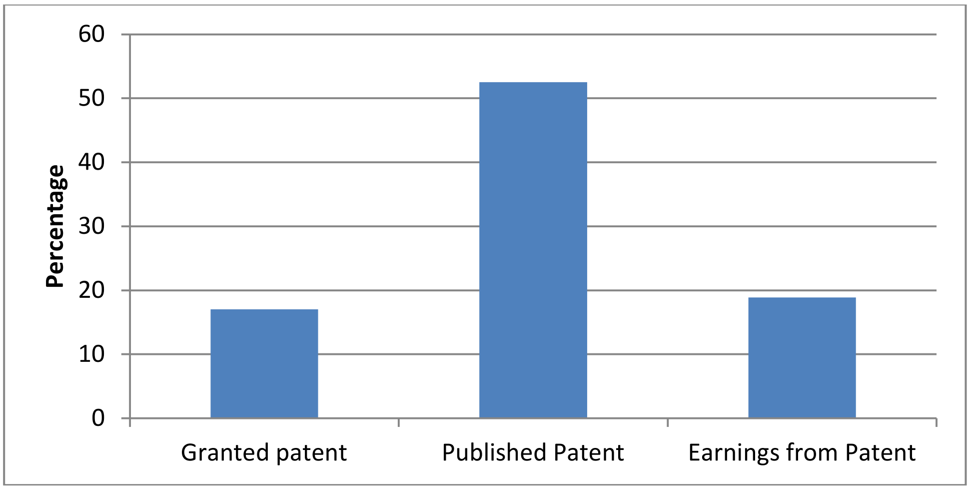
The following section uses data available from NIRF[41] 2017 to analyse the data on patenting behaviour. The NIRF data provides data in five categories- University, Engineering, Management, Pharmacy and Colleges. The data on patenting activity is available only across three categories- University, Engineering. There are some overlaps across some categories, as some of the institutes figure in two or three categories as well. After removing the data, we have 217 unique HEIs[42].

Out of this, only 17 percent of HEIs were granted at least one patent during the period 2013-14 to 2015-16(see Figure 4.3). The number of institutions, which published patents, is much higher at around 53 percent for the same period. There are two main reasons for this gap between publishing and granted patents. First, publications are more of a proposal and may never fructify, and hence are bound to be higher in number. Second, the patenting behaviour among Indian institutions took off around in 2009-10. The time gap from patent publication and granting can be as much as seven years. Hence, many of the published patents may be eventually granted are not captured in this data.

[41] The NIRF ranking system faces major limitations. However, for our purpose we only use the data and not the ranking. Still, if some of the institutions do not figure in the top 100 rankings for Engineering and University and top 50 for pharmaceutical it may not figure in the list.

[42] The duplicates are removed after matching the names and data under the three categories of patent- Patent Granted, Published and earnings from patents. If the data matches under all these three categories, one of the entries was deleted.

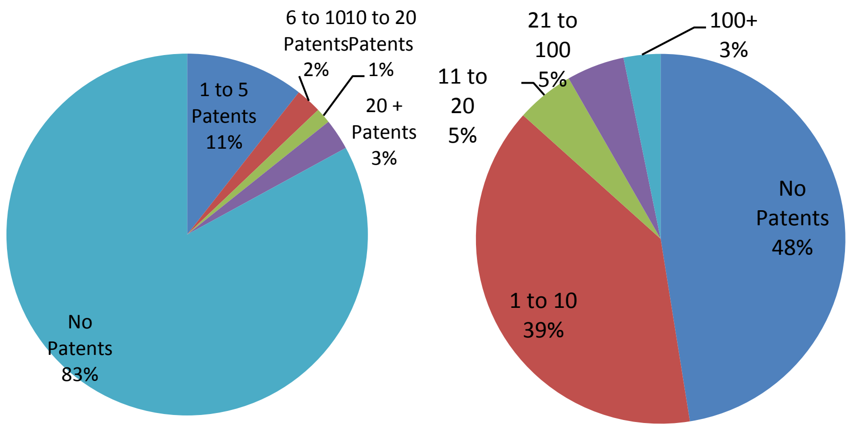
Figure 4.3: Patent Behaviour among NIRF Participating Institutions*



Source: Author's calculation based on NIRF, 2017 data **Total 217 institutions*

While the number 53 percent in this context may seem higher, it is important to understand that among the top ranked institutions only 114 have shown any interest in patenting. The distribution here as well remains extremely skewed (see Figure 4.4), with top five institutions accounting for 50 percent and top 10 contributing 70 percent of patents published in the given period. Further, 39 percent of the institutions have published 1-10 patents. Thus, the patenting behaviours remain concentrated among few institutions.

Figure 4.4: Distribution of Patents Granted and Published



Source: NIRF 2017

Table 4.1 provides the top 10 institutions based on the patents granted. IISc Bangalore tops the list followed by the four IITs.

Table 4.1: Top 10 HEIs based on Patent Granted

Rank	Name of the Institution	PatentGranted	Patent Published
1	IISc Bangalore	117	140
2	IIT Bombay	66	317
3	IIT Madras	33	234
4	IIT Delhi	32	95
5	IIT Kanpur	27	142
6	Calcutta University	22	79
7	IIT Kharagpur	11	102
8[43]	Anna University	11	17
9	Jadavpur University	10	3
10	Institute of Chemical Technology	8	4

Source: NIRF 2017

Figure 4.3 also provides data on HEIs, which reported any earnings from licensing of Patents[44]. Around 19 percent of the institutions report earnings from patents. These earnings can accrue over a much longer period. Hence, many of the institutions, which may not have any granted patents in the last three years, may license their previous patents or continue to earn royalty from prior licensing deals. This shows in our analysis as well.

The top 10 institutions ranked by their earnings from patents are provided in Table 4.2.The top five institutions account for as much as 67 percent of the average income from a patent for the period 2013-14 to 2015-16. There are few key takeaways. First, the rank in parenthesis shows that some of the institutions rank much lower in terms of granted patents, yet have higher earnings. Similarly, there are few notable HEIs, which have a higher number of patents granted (see Table 4.1) but are missing from the top-earning list. Second, the revenue generated from patents is relatively small, except in the case of Amrita Vishwa Vidyapeetham, when compared to other sources. A point we discuss further later in this chapter.

[43] Jawaharlal Nehru Centre for Advanced Scientific Research has 19 Patents granted and 85 Patents Published. However, we feel it is more of a research institute then an educational institution.

[44] The data are self-reported by the institutions. There is no external audit carried out by NIRF. While the data for public institutions are available in their Annual reports, the private institutions do not put their annual reports in the public domain.

Table 4.2: Top 10 institutions ranked based on earnings from patents 2013-14 to 2015-16

Rank	Name of the Institution (Rank*)	Earnings from Patents (in INR Million)	Average Yearly Earnings (in INR Million)
1	Amrita Vishwa Vidyapeetham	264.40	88.13
2	IIT Bombay (2)	57.20	19.07
3	IARI (52)	46.30	15.43
4	IIT Madras (3)	38.85	12.95
5	IIT Kanpur (5)	18.66	6.22
6	Institute of Chemical Technology (11)	15.00	5.00
7	Calcutta University (6)	13.13	4.38
8	Aligarh Muslim University (69)	12.31	4.10
9	IISc Bangalore (1)	10.13	3.38
10	IIT Kharagpur (8)	6.82	2.27

Source: Author's calculation based on NIRF, 2017

** Parenthesis show the ranking in terms of overall patents granted among 217 institutes*

There are many factors involved in earnings from patents. All patents do not necessarily generate income. Further, earnings from patents come in the form of royalty income and vary across patents and the licensing deal. Further, the time gap from laboratories to the market is much longer. Thus, an institution's earnings from patents can be highly volatile across time as well.

The role of TTOs is extremely important as well. India's top institutions like the IITs and IISc had institutional setups to engage with the industry from as early as 1970's (see Table 4.3).

Table 4.3: Institutionalisation of industry interaction

Institution	Industry Liaison Agency	Established
IIT Kharagpur	Sponsored Research and Industrial Consultancy (SRIC)	1971
IIT Madras	Centre for Industrial Consultancy and Sponsored Research (IC & SR)	1973
IIT Bombay	Industrial Research and Consultancy Centre (IRCC)	1974
IISc Bangalore	Centre for Scientific and Industrial Consultancy (CSIC)	1974
IIT Delhi	Foundation for Innovation and Technology Transfer (FIIT)	1992
IIT Kanpur	Office of Dean R&D	

Source: Compiled from websites of respective institutions

4.2.2 Institutional Consulting

One of the most important pathways of collaborations between Academia and Industry works in the form of consulting. The flow generally may be seen as unidirectional, where firms seek expertise from individual faculty or approach the institution. However, consulting assignments often provide the faculty members with interesting problems that in turn feeds into their research.

Despite being one of the leading forms of knowledge transfer between academia and industry, the role of consulting remains understudied (Perkmann & Walsh, 2008). The focus has largely remained on technology transfer in the form of patents and creation of university spin-offs, even when a small number of academics are involved in these activities(Ramos-vielba & Fernandez-esquinas, 2012). A much larger number of faculties are involved in consultancies.

Consulting is defined as a service provided by academicians to external organisations on commercial terms. They can take various forms like the advisory role for problem-solving, generation of new ideas, assimilation of new technology and even providing access to testing facilities. Consultancies tend to be formal and short-term. While individual faculty usually carries out consulting facilities, they can be institutionalised as well.

Industry generally involves faculty researchers to identify and solve specific problems or help the organisation in the assimilation of the technology licensed from the University. Academic involvement in consultancy plays an important part in the transfer of technology. For instance, due to the embryonic nature of the patented technology, licensing firms value the involvement of the academic researcher(Thursby, Jensen, & Thursby, 2000; Thursby & Thursby, 2004).

Consulting is usually a demand driven activity. Firms have specific issues on which expert advice may be needed. Faculties by virtue of their long-term interest in the field are in a good position to offer their expertise. HEI usually encourage their faculty to undertake consulting assignments, however, with certain safeguards. There is usualy a restriction on the amount of time, which a faculty can spend on consulting from his academic time. The standard practice is to allow not more than 20 percent or one day per week[45]. Institutions usually see consulting as an opportunity for faculty to supplement their income. In some instances, faculties may earn more than their regular salary from consulting[46].

Unlike the American Universities where consulting is seen as a prerogative of the individual faculty, HEIs in India have institutionalised consulting process[47]. The majority of HEIs in India, tend to have a revenue sharing arrangement with the faculty. The institutions share in the revenue may vary from 20 percent to 45 percent of the consultant's income. A standard consulting contract has an inbuilt overhead charge, as a percentage of total consulting cost, for using the university facilities. Thus, the consulting arrangements followed in Indian HEIs also ensure that they are a major source of revenue for them.

4.2.3 Motivations for Consultancy

The nature of consulting assignment would depend on the motivations of the individual researcher or the HEI involved in consulting. The point below is reproduced from the "Consulting Rules of IIT Bombay":

> All Consultancy and related Jobs need to be structured and executed in the spirit of promoting IIT-Industry Interactions, as a vehicle for augmenting (current) levels of excellence in teaching and research, for proper placement of IIT graduates (PhDs / M.Techs) and in the process, generating funds.

Before we begin our analysis of the above statement, let us consider the typology offered by Perkmann & Walsh (2008).They classify the motivations based on the income considerations, opportunities for commercialising inventions and possibility of generating new research avenues. The motivations in their model relate to the behaviour of individual researchers, where the institution is not involved. The involvement of the institution

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[45] IIT Bombay restricts this as 52 days a year, preferably at one day a week.

[46] IIM Professors earn more from consultancyAvailable at : http://economictimes.indiatimes.com/industry/services/consultancy-/-audit/iim-professors-earn-more-from-consultancy/articleshow/5122071.cms

[47] Consultancy also includes contract research in India, which is a separate category in US.

widens the canvas. The institutional motivations align with the individual motivations. Further, they focus on enhancing a longer-term relationship by facilitating the flow of knowledge to industry, as well may ensure labour market opportunities for the students involved in consultancy projects. Many students, particularly in the Masters and PhD level may work on consultancy projects with their professors.

4.2.4 Participation and Income from Consultancy in Indian HEIs

In India, no systematic data are available on the earnings from consultancies for the HEI. However, the NIRF report includes the data for the top-ranked institutions across the main categories. This data are available for the last three years. Table 4.4 shows the number of institutions, which provided consultancy in the last three years across different disciplines[48].

Table 4.4: Number of HEI reporting consulting earnings

	Total No. of Institutes	2013-14 (%)	2014-15 (%)	2015-16 (%)	At least once in 3 years
Engineering	100	89	95	94	95
University	100	81	81	84	88
Management	50	88	82	84	92
Pharmacy	50	60	66	68	74

Source: Compiled from NIRF 2017

The number of institutions involved in providing consultancy is much higher than the patenting activity. A discipline wise analysis shows that a much lower percentage of HEI in Pharmacy tend to participate in providing consultancy services.

Consultancy projects are mostly driven by three factors. These are reputation and expertise of the faculty, proximity of the HEI to the industry and the facilities offered by the HEI. Consultancy assignments are demand driven. In the absence of easily available information, firms are likely to rely on the reputation of the faculty. These can be based on his publicly available research work, informal interactions at seminars or conferences. Some top HEI in India has dedicated cells or TTO to engage with the industry. Former

[48] See the section on "Data and Methodology" in the introduction chapter

students can also be an important source of information in seeking out the faculty for a consultancy work, as they are more likely to be aware of the work carried out by the faculty.

Consulting assignments largely tend to be rooted in the local economy. Proximity to the industries may be a major factor, especially in assignments, which involve problem-solving, and areas in which long-term strategic relationship may be required. Due to advancement in ICT, advisory services are now provided over a longer distance as well.

The infrastructure facilities available at the HEI can be an important determinant for assignment, which requires testing facilities. Larger institutions are likely to have well-equipped laboratories and trained skilled faculty and technicians to carry out these services.

All the three factors identified are likely to be favourable to top institutions. This also shows up in the consultancy earnings, which are heavily skewed in favour of few institutions[49]. Table 4.5 to Table 4.8 present the summary statistics for Consultancy earnings reported across categories of Institutions-University, Engineering, Management and Pharmacy. While most of the indicators are self-explanatory, there are a couple of ratios, which need some explanation. First, the ratio is Aggregate Consultancy Income (ACI) as a percentage of Aggregate Total Expenditure[50] (ATE) incurred by the category of HEIs.

This is used to normalise the differences in resources available to the categories of institutions. Further, it also indicates, what percentage of the institution's expenditure was covered by consultancy income. Thus, it may highlight the importance of consultancy as a source of financing. The figure has a high correlation with the number of faculties as well. However, the faculty data is not available on a yearly basis but is that of the latest year. The second ratio is calculated as the average annual consulting income divided by the total number of faculties. These ratios help us in interpreting the importance of consultancies across different categories of institutions. We also discuss the range of these ratios for each category to know the variation, within a similar type of HEIs. As some of the

[49] It is important to highlight once again that the data are self-reported by institutions and not audited by any authority.

[50] We do not have figures for the income of the institutions.

institutions appear across categories, we do not aggregate all the figures, as it may show an inflated picture[51].

Table 4.5 provides the consulting income reported by the top 100 Universities. There were 88 Universities, which provided consultancy service at least once in the last three years. The average earnings show a rapid increase from 2013-14 to 2015-16.The main source of the increase comes from Savitribai Phule Pune University (SPPU), which reported earnings of INR 406 Million as compared to INR 30 million in the previous year[52]. The gap between the mean and median shows the concentration in earnings among the few top institutions.

Table 4.5: Consulting Earnings Reported by Universities

	2013-14	2014-15	2015-16	Avg of 3 years
Total Consulting Income (INR Million)	1,384.45	1,478.95	2,157.87	1,673.76
Number of Consulting Institutions	81	81	84	88
Average Consulting income (INR Million)	17.09	18.26	25.69	19.02
Median Consulting Income (INR Million)	2.27	2.49	2.92	3
Share of top 10 (%)	68.61	68.27	66.84	65.59
Number of Institutions earning more than INR 10 Million	21	21	31	25
Max (INR Million)	193.86	249.05	406.49	241.36
Consultancy Income/ Total Expenditure (%)	0.95	0.95	1.14	
Consultancy income/ Total Faculty (INR)				29216.03

Source: Author's calculation based on NIRF 2017

At the aggregate level, earnings from consulting meet around one percent of the total expenditures incurred by Universities. The range for these varies from a low of zero to

[51] While analysing the data for Patents it was possible to reduce the number of institutions, as there was consistency in data across categories. However, for consulting while the data for some years match others do not match. Hence, we calculate the data across categories separately.

[52] There is no information in the news media or institutes website to know the source of such a large increase.

around nine percent at the highest[53]. In per faculty terms the average earnings are only INR 29,216. The highest figure is around INR 426000 for SPPU.

Table 4.6 provides the summary statistics of top Engineering Institutions. Almost 95 Engineering institutions reported income from consulting in at least one of the previous three years. The average consulting income is highest among all the different categories of HEIs. The concentration among the engineering institutions is also high. Among all the type of HEIs, engineering institutes have the most varied interactions with industries. The research work also largely is of applied nature. Further, the current list is dominated by IITs, which has a huge advantage over other institutions. At the aggregate level, earnings from consulting meet around four percent of the total expenditures incurred by engineering institutions. The range for these varies from a low of zero to around 26 percent at the highest[54]. In per faculty terms the average earnings are INR 108,154. The highest figure is around INR 1.48 million for IIT Madras.

Table 4.6: Consulting Earnings Reported by Engineering Institutes

	2013-14	2014-15	2015-16	Avg of 3 years
Total Consulting Income (INR Million)	3,192.71	3,458.13	3,848.09	3,499.64
Number of Institutions	89	95	94	95
Average Consulting income (INR Million)	35.87	36.40	40.94	36.84
Median Consulting Income (INR Million)	5.05	4.15	6.79	5.42
Share of top 10 (%)	4.91	76.17	71.65	73.28
No. of Institutions earning more than INR 10 Million)	33	30	38	35
Max (INR Million)	585.90	662.70	631.50	626.70
Consultancy Income/ Total Expenditure (%)	4.04	4.29	4.09	-
Consultancy income/ Total Faculty (INR)				108,154

Source: Author's calculation based on NIRF 2017

[53] The ratio for IARI is around 65 percent, however, a look at their faculty size of 558 and average total annual expenditure of INR 41.3 crores indicates some error. As this translates into just Rs. 74000 per year in per capita terms

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Management institutions' consulting activities are very well sought after especially by the larger organisations, especially about strategic decision-making. Out of the fifty institutions covered, only four did not report any income from consulting for the period under study (see Table 4.6). Here as well the wide gap between the top organisations and others is visible in terms of earnings. The share of top five institutions in the average consulting income for three years was around 62 percent. Considering that management institutions do not invest in scientific equipment and laboratories, the consultancy income covers a much larger portion of their expenditure. The ratio of ACI to ATE for management institutions is the highest among all categories and averages more than seven percent for the whole category. In terms of average consultancy income per faculty, as well these institutions earn around INR 3, 72,000.

Table 4.7: Consulting Earnings Reported by Management Institutes

	2013-14	2014-15	2015-16	Avg. of 3 years
Total Consulting Income(INR Million)	856.67	1,009.30	1,127.91	997.96
Number of Institutions	44	41	42	46
Average Consulting income (INR Million)	19.47	24.62	26.86	21.69
Median Consulting Income (INR Million)	2.91	5.8	7.55	5.09
Share of top 5 (%)	69.98	61.38	62.52	61.99
No. of Institutions earning more than (INR 10 Million)	15	17	17	16
Max (INR Million)	268.3	337.54	364.08	323.31
Consultancy Income/ Total Expenditure (%)	7.19	7.42	7.75	
Consultancy income/ Total Faculty (INR)				3,72,095

Source: Author's calculation based on NIRF 2017

Among all the categories of HEIs considered, Pharmacy institutes reporting income from consulting was the lowest. Only 74 percent of the institutions reported any consulting income in the period under consideration (see Table 4.8). The maximum consultancy amount that is reported by any HEI is also the lowest among all four categories for Pharmacy institutes. One of the reasons for this may be the smaller size of these institutions as compared to other categories. Thus, when we normalise the measures, the indicators improve. The ratio of ACI to ATE is around 3.9 percent. Further, the per capita faculty income is around Rs 64,500. This is lower than other institutions offering professional courses but higher than the University category.

Table 4.8: Consulting Earnings Reported by Pharmacy Institutes

	2013-14	2014-15	2015-16	Mean
Total Consulting Income(INR Million)	**30.51**	**37**	**59.71**	**42.4**
Number of Institutions	**30**	**33**	**34**	**37**
Average Consulting income (INR Million)	**1.02**	**1.12**	**1.76**	**1.15**
Median Consulting Income (INR Million)	**0.26**	**0.30**	**0.63**	**0.43**
Share of top 5 (%)	**74.5**	**76.09**	**66.56**	**67.69**
Number of Institutions earning more than (INR 5 Million)	**2**	**3**	**3**	**3**
Max (INR Million)	**9.48**	**12.56**	**14.93**	**12.32**
Consultancy Income/ Total Expenditure (%)	**2.95**	**3.58**	**5.01**	
Consultancy income/ Total Faculty (INR)				**64,595.89**

Source: Author's calculation based on NIRF 2017

4.2.5 Sponsored Projects

A primary source of research funding for the HEIs comes in the form of sponsored research. These are in addition to grant in aid provided for the running of the HEIs. The major source of funding for sponsored projects in India is largely from Central Government Ministries. While Industry sponsored projects are also prevalent, they form a much smaller portion. Unlike consulting, sponsored projects tend to address questions that are more open-ended. The focus of research can be both basic as well as applied research. Further, they also are of longer duration and can be in the form of grants that run into multiple years. They are usually undertaken by a research team, rather than an individual faculty, as is usually the case with consulting. Sponsorships can also be in the form of funding a seminar or a conference, faculty chair and research competitions for students, etc.

In our analysis of details of sponsored projects for some of the institutions, it was observed that setting up of new departments, incubation facilities, research centres, centres of excellence and laboratories also form part of the sponsored projects. Thus, it is likely that earnings from sponsored projects may fluctuate a lot from year to year. Also, the industry supports in the form of office and laboratory equipment, which is more of in kind support than monetary may not be captured here.

Further, some programmes run by the government to encourage UIL require a joint proposal from University and Industry. Only partial funding is provided by the government agencies, and a partial funding has to be garnered from the industry support. These are prevalent in sectors like Drugs & Pharmaceuticals, Bio Technology, Computer, Telecommunication and Electronics. The other important sources of sponsored projects include the international agencies.

In the following section, we discuss the earnings from the sponsored projects reported by the HEIs ranked by the NIRF 2017. This exercise is similar to one carried out for the Consulting projects discussed in the previous section. Table 4.9 to Table 4.13 provide the summary statistics of earnings from sponsored projects reported by the participating institutions across four categories- University, Engineering, Management and Pharmacy.

Table 4.9: Sponsored Project Earnings Reported by Universities

	2013-14	2014-15	2015-16	Avg of 3 years
Total Sponsored (INR Million)	14,430	14,164	17,581	15,391
Number of Institutions	99	100	100	100
Average Sponsored income (INR Million)	146	142	176	154
Median Consulting Income (INR Million)	58	59	79	74
Share of top 10 (%)	51.64	50.47	47.63	47.21
Number of Institutions earning more than (INR 100 Million)	36	33	41	37
Max (INR Million)	2,113	2,554	3,192	2,620
Sponsored Income/ Total Expenditure (%)	8.71	7.59	8.5	
Sponsored income/ Total Faculty (INR)				2,54,008

Source: Author's calculation based on NIRF 2017

Table 4.9 provides the details of income from sponsored projects report by Universities. All the Universities report earnings from sponsored projects. Thus the participation is much higher than other modes like earnings from patents and consulting. The distribution while concentrated compares better than other modes. The mean to mode ratio for earnings from consulting for universities was around six, for sponsored projects this ratio is around two. The maximum earning reported by an Individual University is also larger than at around INR 3.2 billion for 2015-16 reported by IISc Bangalore. The ratio of Average income from sponsored projects (ASP) to Average Total expenditure for three years is around 8.3 percent. At the individual institutional level, the range for this indicator varies from less than one percent to around 71 percent for Jawaharlal Nehru Centre for Advanced Scientific Research[55]. Another important observation is that the Private HEIs in this category rank in the lower quartile. In terms of per faculty, the average sponsored earnings for the period under consideration is around INR 2, 54,000.

As an example of University- Industry Collaboration, let us analyse the sponsored outlays received from industry by IISc for the year 2013-2014. It shows the diverse nature of the relationship which exists between University and Industry (see Table 4.10). IISc received sponsored outlays from 100 organisations, which included government bodies, foundations and corporations. The number of corporate sponsors was 19, and the number of projects supported by them was 35. The total outlay was around INR 428 million, which accounted for 4.7 percent of the outlay received. By 2015-16, the absolute amount of outlays received from industries increased to INR 480 million, although the share declined marginally to 4.4 percent of the total outlays received. The majority of them are MNCs and in the frontier of high-end research and development. They are mostly in the field of Computing, Electronics, Aviation, Engineering and Pharmaceuticals. The nature of the project suggests they are of much longer duration, with some of the grants available for ten years.

[55] The figure for IARI comes at around 879 percent, however as explained earlier the total expenditure does not seem to tally. Also see FN. 23.

Table 4.10: Corporate sponsored projects at IISc (2013-2014)

Type of Engagement	Institutes involved	Details
Research Consortium	Boeing Company, Wipro Technologies and HCL Technologies	Aerospace Network Research Consortium (ANRC)
Research Centre	Robert Bosch Engineering and Business Solutions Limited	Robert Bosch Centre for Research in Cyber-Physical Systems
Collaborative Study	Merck and Co. Inc	
Faculty Award	AstraZeneca, IBM	AstraZeneca Excellence in Chemistry Award, IBM Faculty Award
Sponsored Research Projects	General Motor Technical Centre in India, Intel Technologies, Philips, Microsoft, Renault, Rolls Royce, etc.	
Research Award	IBM	IBM Shared University Research Award
Project Challenges	Freescale Semiconductor India Pvt. Ltd., Limberlink Technologies Pvt. Ltd	Smart Car Racing Competition, The Jed-I Project Challenge
PhD Fellowship*	IBM, Microsoft, Google, BMS, TCS, Bristol-Myers Squibb, etc.	

Source: IISc Annual Report (2013-14)

* *They may not reflect in the sponsored outlays received by the IISc.*

Table 4.11 provides the summary statistics for the sponsored project earnings for Engineering Institutes. Similar to the University category, the number of institutions reporting earnings from sponsored projects is also very high. Ninety-nine out of the hundred institutions reported earnings from sponsored projects in the last three years. The concentration among the top universities is evident as the top 10 institutions account for more than 70 percent. However, the distribution is relatively better as indicated by the mean to median ratio compared to consulting. The average ratio of sponsored income to total expenditure is much higher at around 14 percent. This is the highest among all categories of institutions. Among the individual engineering institutes, IIIT Hyderabad has coverage of around 91 percent followed by the Institute of Chemical Technology, Mumbai (ICT) at around 78 percent. Regarding per faculty sponsored earnings, the average for all the engineering institutes is INR 385614. The highest figure is reported by ICT, Mumbai at INR 6.2 million.

Table 4.11: Sponsored Project Earnings Reported by Engineering Institutes

	2013-14	2014-15	2015-16	Avg of 3 years
Total Sponsored (INR Million)	12,447	11,843	14,094	12,795
Number of Institutions	96	96	98	99
Average Sponsored income (INR Million)	130	123	144	129
Median Consulting Income (INR Million)	31	22	35	32
Share of top 10 (%)	74.24	74.34	71.07	71.84
Number of Institutions earning more than (INR 100 Million)	17	19	24	17
Max (INR Million)	1,952	2,132	2,512	2,045
Sponsored Income/ Total Expenditure (%)	15.41	13.01	14.69	14.34
Sponsored income/ Total Faculty (INR)				3,85,614

Source: Author's calculation based on NIRF 2017

Table 4.12 provides the summary of sponsored earnings reported by the Management Institutions[56]. The number of institutions reporting income from sponsored project varies from year to year. However, when we consider the whole three year period, around 47 institutions or 94 percent reported earnings from sponsored projects. When compared with consulting, the number of institutions participating in the first two years is lower for sponsored projects. The top five institutes account for around 69 percent of reported income. The mean to median ratio is around four, which is comparable to engineering institutions but higher than those reported by the Universities are. The ratio for consulting was similar at just over four percent for Management institutions. The average ratio of sponsored income to total expenditure is around 8.3 percent for the three years. This indicator is higher than that for consulting. The main reason for this is the way the averages have been calculated. We only consider the institutions, which report earnings

[56] The nature of consultancy projects and sponsored research in management discipline is extremely difficult task. For instance, a review of IIM Bangalore's annual report shows that there is only one list of projects undertaken, which comes under the heading consultancy. While the financial statements do have separate headings for consultancy and sponsored research, the mechanism followed for classification is difficult to decode, as project wise earnings are not available.

and not the total number of institutions. Regarding per faculty earnings from sponsored project comes out to around INR 3, 40,804.

Table 4.12: Sponsored Project Earnings Reported by Management Institutes

	2013-14	2014-15	2015-16	Avg of 3 years
Total Sponsored (INR Million)	330	292	386	336
Number of Institutions	37	34	44	47
Average Sponsored income (INR Million)	8.93	8.6	8.78	8.77
Median Consulting Income (INR Million)	3	2	2	2
Share of top 5 institutions (%)	68.24	74.1	64.3	68.9
Number of Institutions earning more than (INR 100 Million)	7	7	8	8
Max (INR Million)	124	110	93	109
Sponsored Income/ Total Expenditure (%)	8.5	8.55	7.88	8.31
Sponsored income/ Total Faculty (INR)				3,40,804

Source: Author's calculation based on NIRF 2017

Table 4.13 provides a summary of earnings from sponsored projects reported by Pharmacy Institutes. The number of institutes, which reported any earning from sponsored projects in the previous three years, is 49. However, there is a variation for each of the reported years, for the latest year, only 42 institutions reported earnings under sponsored projects. The ratio of mean to the median is lowest for pharmacy colleges, with a value under two, which shows a much lower dispersion compared to other categories. The average ratio of sponsored income to total expenditure for three years is around 10.6 percent. For individual institutions, the highest ratio is 44 percent for Department of Pharmaceutical Sciences, Dibrugarh University, followed by Jamia Hamdard at around 42 percent. The per-faculty amount for sponsored income comes around INR 1, 53, 285.

Table 4.13: Sponsored Project Earnings Reported by Pharmacy Institutes

	2013-14	2014-15	2015-16	Avg of 3 years
Total Sponsored (INR Million)	326	261	306	298
Number of Institutions	46	45	42	49
Average Sponsored income (INR Million)	7.08	5.81	7.29	6.08
Median Consulting Income (INR Million)	3.2	2.92	4.31	3.73
Share of top 5 (%)	40.19	45.39	40.03	40.09
Number of Institutions earning more than (INR 10 Million)	9	7	11	9
Max (INR Million)	29	39	34	28
Sponsored Income/ Total Expenditure (%)	11.81	9.15	10.8	10.57
Sponsored income/ Total Faculty (INR)				1,53,285

Source: Author's calculation based on NIRF 2017

4.3 Business Incubators and Research Park

Much of the focus surrounding enterprise foundation in universities mimics the focus on generating entrepreneurship related to science-based technologies. Thus, institutions like the National Science & Technology Entrepreneurship Development Board (NSTEDB), established in 1982 aimed at institutionalising the support for setting up technology driven knowledge intensive enterprises. This was in the backdrop of the economic conditions prevailing during that period, characterised by high unemployment among S&T graduates prompted the government to focus on entrepreneurship(NSTEDB, 2014).Universities were the places where most of the S&T work force was concentrated. One of the earliest measures undertaken to attract academicians to entrepreneurship was Science and Technology Entrepreneurship Park (STEP), started under the aegis of NSTEDB in 1984. Its key objective was to 'to forge linkages among academic and R&D institutions on the one hand and the industry on the other and also promote innovative enterprise through S&T persons.' The first one was sanctioned in Tiruchirappalli Regional Engineering College in 1986[57]. STEPs can be considered as a precursor for the Technology Business

[57] Available at : http://www.nstedb.com/institutional/step-centre.htm

Incubator (TBI). TBI programme got a major boost with the launch of Start up India Programme in 2016. By 2016-17, there were 125 STEP and TBI[58]. At the end of 2013, more than 75 percent of STEP and TBI operated from academic institutions, and 60 percent were located in the urban areas(NSTEDB, 2014). The majority of TBI in India operate under not for profit model. They have shown more promise, in particular among those attached with the top institutes. The incubator facilities provide additional support to the start-ups when they are more likely to be focused on the development of technology and may not have the business know how.

We highlight some of the recent initiatives by the government to increase the knowledge based entrepreneurial activities in the country.

DST-MHRD Collaboration:

As part of Start-up India scheme, a collaboration between DST and MHRD is setting up 13 Startup Centres, 16 Technology Business Incubators (TBIs) and Seven Research Parks[59]. The research parks are coming on the line of IIT Madras. The proposed parks will be setup at IIT Guwahati, IIT Hyderabad, IIT Kanpur, IIT Kharagpur, IISc Bangalore, IIT Gandhinagar, and IIT Delhi. The research park at IIT Bombay is already under construction, and partially functional. We use the term University Research Parks (URP) from now onwards, to distinguish them from those, which are not attached to academic institutions[60].

Link & Scott (2006) define a URP as follows:

> A university research park is a cluster of technology-based organisations that locate on or near a university campus to benefit from the university's knowledge base and ongoing research. The university not only transfers knowledge but expects to develop knowledge more effectively given the association with the tenants in the research park.

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[58] Available at : http://startupindia.gov.in/pdffile.php?title=List%20of%20Incubators&type=information&content_type=&q=list_of_incubators.pdf accessed on 10/06/2017

[59] Details available at: http://mhrd.gov.in/siap

[60] We borrow the terminology from (Link & Scott, 2006)

From the universities point of view, URPs are expected to act as an important mechanism for the transfer of academic research findings to industry and a source of knowledge spillovers(Link & Scott, 2007). Within the NSI, they can play an important role in economic growth by supporting start-ups in the small and medium enterprises (SMEs)(Tsai, Hsieh, Fang, & Lin, 2009). The economic rationale for URPs comes from the formation of knowledge clusters.

The guiding principles behind the setting up of URPs, identified by the Action Plan for Start-up India (2016) are as follows:

- Creating a collaborative environment between industry and academia through joint research
- Projects and consulting assignments
- Creating a self-sustaining and technologically fertile environment
- Encouraging and enabling R&D activities and Start-ups that are aligned to potential needs of the industry.
- Providing world-class infrastructure for R&D activities and incubation.
- Enabling development of high quality personnel and motivating professional growth for researchers in companies through part time Masters and PhD Programs.

Engaging the Corporate Sector

In an effort to encourage the corporate-sector to set up new TBIs or support the existing ones, the government has provided certain incentives. Schedule VII of the Companies Act, 2013 deals with the avenues where the corporation can spend the mandated two percent of their average net profit as part of the Corporate Social Responsibility (CSR). One of the avenues identified is “technology incubators located within academic institutions which are approved by the Central Government”. So far, only a few corporations have made use of this avenue to invest in CSR activities. Government has increased articulation in recent years, mainly under its Start-Up India Programme.

Government Policies for Entrepreneurship in Science & Technology

- **The NewGen Innovation and Entrepreneurship Development Centre (NewGen IEDC)[61]:** It aims to develop institutional mechanism to create entrepreneurial culture

in S&T academic institutions and to foster techno-entrepreneurship for generation of wealth and employment by S&T persons. The focus is mainly on encouraging students to undertake innovative projects.

- **National Initiative for Developing and Harnessing Innovations (NIDHI):** An umbrella programme started in 2016 'for nurturing ideas and innovations (knowledge-based and technology-driven) into successful start-ups'. The support is provided to students, existing entrepreneurs and TBI.Following are the different programmes under NIDHI :
    - NIDHI-GCC - Grand Challenges and Competitions for scouting innovations;
    - NIDHI-Promotion and Acceleration of Young and Aspiring technology entrepreneurs (NIDHI-PRAYAS) - Support from Idea to Prototype
    - NIDHI-Entrepreneur In Residence (NIDHI-EIR) - Support system to reduce risk
    - Startup-NIDHI through Innovation and Entrepreneurship Development Centres (IEDCs) in academic institutions; encouraging Students to promote start-ups[62]
    - Start-up Centre in collaboration with MHRD; inculcating a spirit of entrepreneurship in National Institutions of Higher Learning
    - NIDHI-Technology Business Incubator (TBI) - Converting Innovations to start-ups
    - NIDHI-Accelerator - Fast tracking a start-up through focused intervention.
    - NIDHI-Seed Support System (NIDHI-SSS)- Providing early stage investment
    - NIDHI Centres of Excellence (NIDHI-CoE) - A World class facility to help start-ups go global

[61] Details available at : http://www.nstedb.com/institutional/NewGen-IEDC.pdf

[62] This is similar to the NewGen IEDC.

To promote the University-Industry linkages in the Biotechnology sector, the DBT has set up Biotechnology Industry Research Assistance Council (BIRAC). Its core aim is to bring about the innovation excellence to make Indian Biotech sector globally competitive. It provides access to financing at different stages of development, technology transfer, IP management and hand-holding schemes through TBI.

4.3.1 University spin-offs and Business Incubators

The most direct channel for a university to undertake capitalization of its knowledge is through the creation of University spinoffs (USOs). They largely pertain to the creation of enterprise, which exploits the research activity undertaken in the University by the faculty, student or alumni. The motive may be profit or can be a socially motivated. The government funding backs many of these initiatives.

On the other hand incubators are, more of a support and guidance mechanism for any business, which may or may not rely on the research generated in the Universities. As Etzkowitz (2008) explains “The incubator is an expression of the university’s educational mission as well as its economic development and service missions.” Thus, even when the research from the University may not be at the core, the guidance provided by the firm helps in economic contribution. The following section uses the term USOs in this narrow sense and does not include the incubated firms, which may or may not be based on its research. However, we make the distinction by qualifying the involvement of the faculty, wherever applicable.

4.3.2 USOs in India

USOs are getting increasing attention from the policy makers and HEIs in India. The recent government schemes like start-up India, improvement in the availability of VC funding, and government’s willingness to provide financing through ‘Start-up India’ has helped in creating awareness. Some institutes have excellent business incubator facilities. However, it is important to note that only select institutes engage in the formation of USOs. There are insufficient numbers of study, which focus systemically on the USO formations in India. Basant & Chandra (2007) is one of the earliest studies that provide any insight into the enterprise formation in India. They find that out of the 16 institutions interviewed by them in Bangalore and Pune, only two institutions were involved in enterprise creation. The top three reasons cited were "lack of seed funding, the inappropriateness of research for commercialisation, and absence of institutional regulations to set up firm." Almost after a decade of their study coming out, the situation seems to have improved. As seen from the patent filing data, the interest towards commercialization of research is increasing among select HEIs in India, albeit the absolute numbers remaining small. Two specific areas where the situation seems to have changed relates to the availability of seed funding and regulatory clarity[63]. Some of the entrepreneurial activities in select HEIs, for which data are presented in Table 4.14.

Table 4.14: Enterprise Creation in Select Institutions

Institute	Graduated	Current
IIT Madras	33	42
IIT Madras-RTBI	16	33
IIT Delhi	26	21
IIT Kanpur	45	27
IIT Bombay	39	28
IISc Bangalore	15	NA
Amity University	14	8

Source: Compiled from websites and annual report of respective institutes

However, it is only in the last decade, they have increased the level of entrepreneurial activity. Some institutional changes have taken place to facilitate the commercialization of research. The formation of TTOs, setting up of business incubators, strong connection with alumni network are some examples. The recent visible changes are in the widening of this phenomenon to a much larger number of institutions. Different models are working in different institutions(Basant & Chandra, 2006).

The idea of promoting entrepreneurship among the students was emphasised even at the time of establishing the industry liaison offices. For instance, in 1974 a committee convened under Prof. R.P Singh in its report "On the Establishment of an Industrial

[63] Schemes like the one discussed in the earlier section, often seem to be a old wine in a new bottle. As the STEPs park started in 1980s.

Research & Consultancy Centre at Indian Institute of Technology Bombay" states one of the functions of IRCC as "to encourage self–employment and entrepreneurship among young Technologists and Engineers[64]". The approach was from a self-employment generation perspective. In this model, the role of the institute was more of an enabler. The majority of these changes emerge from the idea of academic entrepreneurship and now the triple helix framework. The expression of the third mission of Universities is most evident in the establishment of USOs.

Multiple factors determine the decision to set up a USO. A number of these factors and the processes involved may be similar to establishing a spin-off from an established commercial venture. A fundamental difference arises from the inherent tension, when the faculty is involved. The faculty needs to make the call between open mode of sharing and decision to commercialise. From a traditional point of view, academic institutions have been a non-commercial entity and may not have the necessary business acumen, organisational expertise and resources to start a commercial venture. The involvement of multiple stakeholders, university, the academic entrepreneur, the venture's management team and funding agencies, may have conflicting objectives, which can hamper the commercialization decision(Vohora, Wright, & Lockett, 2004). Similar to any start-up USO face substantial challenges to achieve commercial success and survive in the competitive environment.

4.3.3 Steps in formation of USOs

The models of USO formation in the literature describe them as a multistage model(Ndonzuau, Pirnay, & Surlemont, 2002; Shane, 2004; Vohora et al., 2004). For simplicity, they are often shown as a linear model, where each stage might seem independent of other. However, they are rarely so, and often interaction may continue between each stage. Even after the invention/ discovery is made and the decision to commercialise is undertaken, the path is not straightforward 'it is strewn with numerous obstacles, difficulties, impediments, hindrances, and other sources of resistance'(Ndonzuau et al., 2002).

[64] Report available at : http://www.ircc.iitb.ac.in/IRCC-Webpage/Report_IRCC_1974.html

The first step in the formation of the USO is the research idea. It is important to note, that the main aim of the research may not begin with an aim to commercialise the output and usually seeks to contribute to the advancement of the discipline. However, once an invention/discovery are made, a decision needs to be made on the path to be undertaken. The academic culture and the preferences of the researcher may dictate their decision to publish or seek an intellectual protection in the form of patents. These can again vary across organisations, and among researchers within same organisations. Further, there may be external actors, for instance, the funding agencies may dictate, even before the research has begun how the research output would be treated. A compulsory patenting of the outcome may be mandated based on the initial agreement. The DST, which sponsors the majority of the research in Indian institutes, encourages them to patent their findings. If they fail to do so within a reasonable period, the DST may initiate the patenting. Universities, where dedicated TTO are present, they may require the faculty to disclose the findings. However, some studies have shown the reluctance of academic faculties and researchers in sharing information with the TTOs(Shane, 2004). The presence of Bayh-Dole like regulation also can be a major factor in the disclosure norm. In the case of joint research with private firms, the decision to disclose the finding may again impinge on the initial understanding between the partnering institutions.

After the researcher decides to disclose its findings and expresses the desire for commercial possibilities, an internal screening for the technical and economic feasibility of the research output takes place. It is important to note that in the majority of cases universities do not have the mechanisms to detect promising ideas within their research centres and laboratories(Ndonzuau et al., 2002). In our review of the incubation processes of USO in Indian institutions also points towards a similar practice. While the trend has changed in some of the more active research universities in other countries, the situation continues to remain the same in India[65].

A decision to explore the commercial feasibility of technology may entail the requirement of protecting the intellectual property. While not a necessity but it does make a good business sense. The patenting decision may be an end in itself, with no further follow-ups.

[65] See the example of IIT Bombay discussed in this chapter under the heading on Patents.

The technology may be licensed, or the researcher may take the follow-up decision to start the venture on his own. The common practice at this stage is to review the technical aspect, and the ability to scale it beyond the laboratory. The TTO usually help the researchers with the decision further to assess if there is commercial value. The next stage involves, creating a business plan.

A business plan needs to be forward-looking. The Society for Innovation & Entrepreneurship (SINE) the business incubator of IIT Bombay suggests that a business plan should incorporate the following details:

> "The plan of activities is expected to cover the basics of the business, namely, value proposition, products and services, market analysis, competition analysis, funding requirements, capital structure, milestones and timelines, development and marketing plan, organisational structure, team, risk analysis and projected financials". (Policy and Procedures for Business Incubator, SINE, p. 4)

The complexity of the business plan may itself deter a large number of researchers to engage in the commercial plan. In spite the help from TTOs, it may be necessary to engage external consultants in the preparation of the Business Plan. For a novel technology, this may be a challenging task to carry out and is based on some assumptions that may or may not pan out as planned. However, as business plan becomes more concrete, it also may help the researcher to reflect and provide clarity on the viability of the commercial aspect of the research idea. A major challenge during this stage is the lack of financing. While academic entrepreneurs may have access to funding for conducting the research, protection of intellectual property, and subsequent seed money, it is the intermediate stage where funding is difficult to get(Ndonzuau et al., 2002). In the case of SINE as well there is no clarity on if the funding for developing a business plan is available as the funding only becomes available after entering the incubation process. From a Venture Capitalists perspective, the ideas are in very early stages to warrant any interest, especially considering the novelty of the technology.

> "Inventions from university research usually stem from research projects supported by government's grants that may not have anticipated the invention. Usually, some further work is needed to bring about a prototype, requiring a year, or part of a

year, of additional work. In the meantime, the inventor is left without support" (McQueen and Wallmark, 1985, as cited in (Ndonzuau et al., 2002))

As most of the institutions, in India, have started business incubation to promote the entrepreneurial activity, it is assumed that the USOs prefer this mode. While, the models that are discussed here do not incorporate the role of BI, for our purpose we do add this stage. Our analysis while based on SINE, IIT Bombay is reflective of similar models in other institutions in India.

Once, the business plan is ready, a team of experts within the institution internally scrutinises it. To get a professional opinion, external experts are also consulted to assess the viability of the business venture. SINE's assessment criteria are reproduced here:

1. *Strength of the product idea in terms of its technology content, innovation, timeliness and market potential*
2. *IP already generated and the potential of the idea for IP creation*
3. *Extent of involvement of IITB faculty, employees and students*
4. *Strength of the core business team*
5. *Funds requirement and viability of raising finance*
6. *Break-even period*

It is important to note that at this stage the academic tenet of novelty and contribution to the body of knowledge may not be the most important aspect. The focus is more from a business point of view. The aspects related to timeliness and market potential is fundamental. It has been consistently shown that there is a time lag between patenting and production of novel technology(Colyvas et al., 2002). These may again depend on the stage of research as well. For instance, research which may be downstream and hence a shorter turnaround time from research to market will be seen more favourably. While in upstream areas, there are more time lags and hence it may be difficult to get support even in an incubator. Incubators by their design are inclined to look at more downstream projects, which can get support from external funding agencies within a short period. Funding period is limited to two to three years at the most[66].

Other important considerations are the availability of funding. It is important to note that most academic institutions rely on government's grant-in-aid under specific projects, and usually have a cap at both the programme level as well as per project level. Thus, if the evaluators see a much higher cost, it may be difficult to get the necessary support, and the project might not be invited for the incubator. The risk capital available to the academic institutions is limited, as compared to a VC firm.

The next stage involves finding more resources, which can be both in the tangible and intangible form(Ndonzuau et al., 2002). In a set up where BI is present, the initial task does become easier. Once they are invited into the incubation programme, they get access to the institution's resources and networks. Some of the institutions also offer entrepreneurship programmes to the founders. Incubators help with seed funding, which can be in the form of a loan or a small equity. The equity percentage required by SINE is around 6 to 8 percent. The other access relates to using the laboratories and equipment, access to testing facilities. Some of these equipments and services may be common shared office spaces with basic facilities like high-speed internet and furniture[67].

However, the intangible resources can often be more valuable. The lack of managerial expertise beyond the lab and understanding of the market for a product means they may need to rely on external help. Further, the ability to raise financing, hiring right people or getting a mentor could also be determined by the 'social capital' of the new entrepreneurs(Vohora et al., 2004). The support from the university in this regard can be extremely beneficial for a new entrepreneur. The SINE, for instance, provides following intangible resources[68]:

- *Pool of mentors, experts in technology, legal, financial and related matters, with or without consideration,*
- *Organising events to help companies in networking and showcasing their technologies,*

[66] For instance, the TIDE programme expects graduation from the incubator in 2 -3 years.

[67] A rental is usually charged for using the facilities, which can be in cash or can be covered by the equity.

[68] Policy and Procedures for Business Incubator, SINE

- *Meetings with visitors of IITB (such as alumni, VCs, industry professionals)*

The role of Alumni is increasingly becoming important. In addition to providing the necessary ‘social capital’, it is also an important source of financing. IIT Bombay received INR 48 crores in 2014-15 in the form of donations, from corporate and alumni[69].

4.3.3.1 Leaving the nest

Incubators tend to have graduation criteria for incubatee firms. They can be time bound or in the form of reaching certain, level of revenue or level of capital raised. These criteria can be defined by the HEI or by the funding agencies, which support the incubators. A successful scale up is often dependent on the ability to raise external resources. These can be in the form of venture capital, a loan from banks, and acquisition by an existing firm or bootstrapping.

SINE IIT Bombay

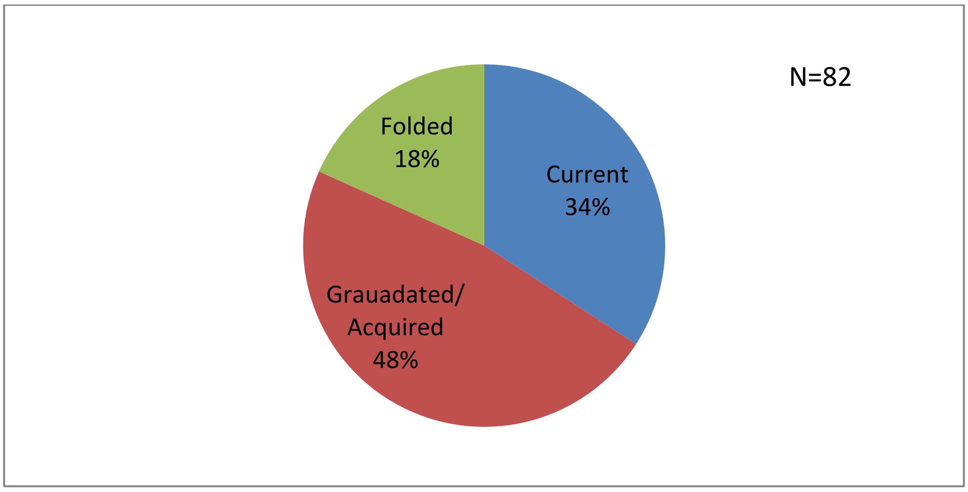
In the following section, we discuss some of the data from SINE’s experience in promoting enterprise creation. SINE was started in 2004, to encourage entrepreneurial activities among IIT Bombay faculty, alumni and students. However, in recent years the incubator facility accepts outside entrepreneurs as well.

Figure 4.5 provides the details of the incubated firms in SINE, since its inception in 2004. It has incubated 82 firms until date. An impressive 48 percent of the firms have been acquired/graduated from the incubator[70]. However, the data for the incubator operated by SINE shows that almost, 18 percent of the firms do not graduate and fold.

[69] IIT Bombay, Annual report 2014-15

[70] These numbers should not be taken as being reflective of all the incubators. IIT Bombay is among the most elite institutes not only in India but also in the world.

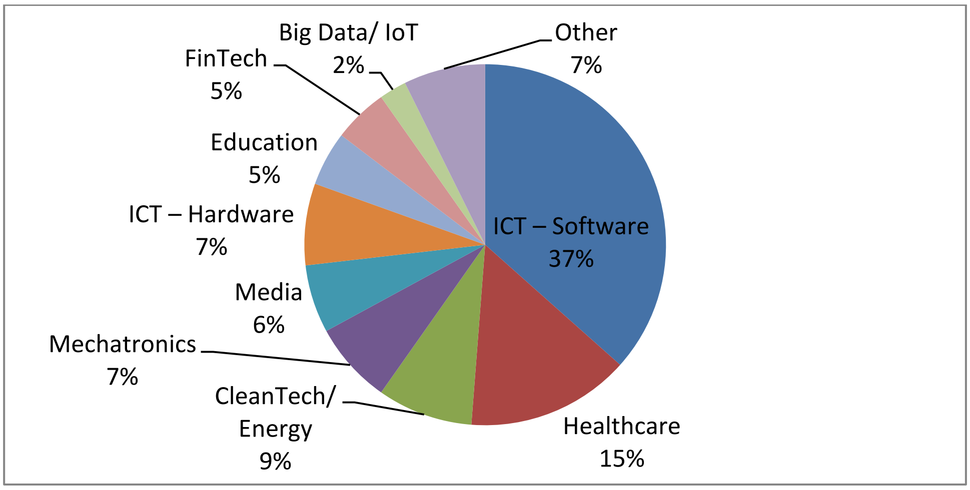
Figure 4.5: Number of Companies incubated at SINE, IIT Bombay (2004-Aug, 2016)



Source: SINE, IIT Bombay presentation

Figure 4.6 provides the sector wise distribution of the incubated companies. Most of the companies are in the software sector, followed by healthcare. New and upcoming areas like Big/ Data and Internet of things are also represented. Presence of social sectors like education and healthcare also reflect social innovation. There were five companies which were classified to be working in the area of social innovation. Areas like Clean Technologies and Energy also represent a focus on sustainable issues.

Figure 4.6: Sectors of Incubated Companies



Source: SINE Bombay

As discussed one of the primary aim of the USO is to commercialise the research generated in the HEIs. The USOs helped in commercialising 25 intellectual properties developed in IIT Bombay. Only 21 faculties were involved in start-up activities. This number is much lower as compared to other modes like consultancy. From the point of view of returns generated, through partial equity exits the numbers are not too impressive. The returns on USOs are usually much skewed as only a very limited number of firms go on to become big. In case of India, we do not have any of the USOs being publicly listed.

Table 4.15: SINE Business Incubator Impact

IITB IP commercialised	25
Faculty involved start-ups	21
Equity returns (partial exits)	INR 3 crores+
Jobs created during incubation	2000+

Source: SINE, IIT Bombay presentation

One of the main reasons for government support to the start-up is their ability to help in creation of jobs. During the incubation period, SINE incubates created more than 2000 jobs.

There can be multiple ways in which the USO can continue to be connected with the parent organisation, even after graduating from the incubator programme (Ndonzuau et al., 2002).

- Universities can hold some USOs' equity shares (financial resources);
- USOs can exploit a patented technology owned by universities (intangible resources);
- USOs can have access to some university facilities (material resources).

Each of these connections needs some more enquiries. While universities tend to hold equities in the USOs, they may not function like a VC. One of the most successful USO in the World is Google, the global search engine giant, which was founded by two PhD students Sergei Brin and Larry Page at Stanford University[71]. The University received around 1.8 million shares for allowing Google to use its facilities. It liquidated its investments at an average price of USD 187, earning a total of USD 336 million in 2005.

[71] http://www.redorbit.com/news/education/318480/stanford_earns_336_million_off_google_stock/

The Google share went up much higher and currently trades at USD 996, while no one can predict the future price and there is always a downside risk, Universities tend to have another aspect to consider- a conflict of interest. For instance, if a university stands to profit from a company's stock, researchers there might be less inclined to develop technology that competes with that company. Hence, it may be more prudent for universities to dilute their holdings. Looking at the IIT Bombay data, the earnings from their stakes in the incubator has only earned them a meagre Rs. 3 Crores, which is lower than the annual royalty earnings of the Institute. The data on equity holdings and earnings are not available publicly for USOs in India, which makes it extremely difficult to assess the return on investments. Further, unlike firms where the goal can be profit maximisation, universities do not see this as their main aim. However, a defined strategy may be needed for universities to generate additional revenues, which will help them in funding other endeavours as well.

The current chapter highlighted the level of involvement of select HEIs in India in entrepreneurial activities. Our analysis of the patent data showed, that patenting has increased among HEIs in recent years. However, in comparison to other channels of engagements with the economy, the importance is lower in terms of both frequency and revenue generated.

The success of the recent government initiatives to establish incubator facilities is an important development in widening the role of Universities. Some of the HEIs already are showing signs of becoming entrepreneurial. However, our analysis of SINE showed that even among at most successful institutions, the numbers of faculty involvement is limited.

5 Summary and Conclusion

The current thesis started by tracing the changing role of the Universities in the society. From organisations, which were mainly focussed on their core function of teaching and research, are now expected to take up the ‘third mission’ of contributing to the economic development. In their traditional roles, Universities have always contributed to the society by providing skilled human resources to the economy and being the custodian and source of knowledge. The linear model, which formed the basis of government funding for the University research came into questioning, as there was a decline in productivity in the Western countries. The linear model had advocated that investment in basic research in University would eventually translate into social and economic gains for the country.

The decline in funding prompted Universities to look for diversification of their resource base. While Industry support was increasingly sought, the other avenue was to capitalise on the research output. Further, the government policies like Bayh Dole Act, 1980 aimed to motivate Universities to patent and license the technologies emerging from their research. These changes were intended to improving the productivity of the US industries vis-a-vis an increasing competition from Japan. We discussed at some length on the challenges, which emerged in University-Industry Collaboration. The difference in their outlook towards the research was and is a major barrier to the collaboration. Universities were expected to carry out basic research, while industries were interested in the applied research and technology development. Another instance of difference emanates from the main motivation for conducting research. While firms are more interested in appropriating the knowledge for profit maximisation, the scientists are driven by the opportunity to be first in disclosing a finding. Thus, firm preferred patenting while the scientists prefer publishing. However, the differences were likely to be less in those fields, which fell under the Pasteur’s quadrant. It represents those research areas, which had immediate usefulness while contributing to the long-term understanding of the field(Stokes, 1997). The new sectors like Biotechnology and Computing provided such opportunities.

Around the same time, Industry was becoming more receptive towards outside research. One of the biggest challenges in the uptake of the technology was the time it took the industry to develop the research idea into a prototype. However, development of new fields like biotechnology where the University research was upstream and did not require major development attracted the industry to collaborate with the Universities. The change in the overall patent regime, which allowed the patenting of modified bio-organisms further make the interactions between University and Industry more profitable(Mowery et al., 2001).

Some Universities were becoming more entrepreneurial. There was a rapid acceleration in the patenting behaviour among these Universities. Some of them started earning substantial royalty earnings from licensing activities. The natural progression for the entrepreneurial University was to encourage spin-off firms, which were based on their research output. Again, these companies were largely concentrated in biotechnology and computing.

The research in Pasteur's quadrant offered opportunities for collaboration between Universities and Industry. However, there was a fear that this will lead to neglect of basic sciences. The role of basic sciences in economic development is not often directly visible, but it tends to provide a seed bed for development of new fields(A. J. Nelson, 2012).

The motivations for collaborations for industry and University were discussed in the review of literature chapter. The main motivation for the University researchers was to gain access to additional financial resources, to support their research. The other key motivation was the 'knowledge exchange', which would stimulate new research ideas and provide opportunities to test the application of existing theories.

From an industry point of view, the result seems to vary from study to study, based on the sample, sector and region covered. While some studies found that the role of knowledge generated from the University contributed to new product development, others reported that Universities ranked much lower in importance as a source of knowledge. The other important finding was the importance of channels of interaction. While multiple pathways exist in which the interaction takes place, the focus of early studies in the field and subsequent policies have been on commercialisation aspects. The two channels, which are encouraged by the policy makers, are licensing and firm creation. This undermines the various ways in which Universities transfer knowledge and interact with firms. Many studies report that only a few faculty members engage in patenting behaviour. A much smaller fraction of the faculty engages in spin-off activities. The majority of the interactions are informal and open. These interactions are at conferences, public meetings and consulting. The main channel, however, continues to be in the form of scientific and technical publications.

The implications of increased interaction with the industry have raised fear of affecting the core functionalities of the University. One of the main concerns was increased patenting was expected to substitute the culture of open science, where the preferred mode is publications of articles in journals(Dasgupta & David, 1994). However, the limited available research suggests that these fears may not have materialised at least in the developed economies. There is a positive relationship between the patenting and publishing activities(Thursby & Thursby, 2011). Researchers, who engage in commercialising, tend to publish more than their colleagues who do not participate in entrepreneurial activities. However, some studies tend to report an adverse effect after a threshold(Crespi et al., 2008).

The main fear has come in the form of University research being re-oriented towards applied research, at the expense of basic research. It was expected that the focus on short-term financial gains would hamper the work on fundamental research, which may not have immediate pecuniary gains. However, similar to results on patenting, there is no conclusive evidence in this regard.

The impact of industry funding on the research productivity of the faculty is found to be negatively related in some of the studies. Further, some studies report delays in disclosure of results by faculty members due to the contractual obligation with the industry partner. These results are prevalent in the field of upstream research like biotechnology and pharmacy.

The impact of large-scale patenting often creates the problem of ‘Anti-Commons’(Foray, 2004). Instead of the intended aim of encouraging knowledge transfer, it tends to create monopolies, which may hamper the progress of the field. Very few studies have explored this question empirically, due to the secrecy and difficulty in gaining the data. However, the available evidence from the human genome project suggests that the delay in gene sequencing was as much as 30 percent due to the other parting holding part of the patent(Williams, 2013). Thus, as patenting may not be the most effective way of encouraging knowledge flows.

After discussing the motivations, pathways and implications of University-Industry linkages, the study turned towards analysing India's NSI in Chapter 3. India's NSI consist of PFRI, University, and R&D in Private and Public Sector Industrial Units. An important pre-independence decision was to focus the majority of scientific research in publicly funded laboratories under CSIR. Universities role was restricted to conducting limited basic research and training graduates(Krishna, 2012). From the time of independence to the beginning of liberalisation, the role of the business sector in the research was limited. In an insulated environment of import substitution regime with high tariffs and lack of demand in the domestic sector, there was no need felt for innovation.

Business sectors share in total R&D was less than 20 percent. The main source of R&D funding was the government with 80 percent share in financing. The majority of this funding was directed towards Mission-oriented research, which focussed on development in atomic, space and defence sectors. This model of NSI represents the 'statist model' of triple helix framework(Etzkowitz, 2008). There was no linkage between University and Industry, except for the flow of trained workforce. Also, as the majority of the industrial activity was highly regulated and were the domain of the public sector units, innovation did not take place. Even the PFRI did not contribute much to the industrial development. The industry was more interested in importing technology then conducting in house R&D(Forbes, 1999). The share of expenditure on R&D as a percentage of GDP continued to remain low.

The focus on developing of Scientific and engineering workforce was given prime importance. It was believed that the rebuilding of the nation in a post independence era would depend heavily on its trained workforce. Despite multiple priorities, which required urgent attention, it was decided that five top class technical institutions to be established across the geographies and near the industrial sectors. These institutes were to be modelled on the line of Massachusetts Institute of Technology, one of the most reputed engineering institutions in the world(Krishna, 2012). Due to lack of funding these institutions were established with help from international aid organisation or foreign government grants. Some Regional Engineering Colleges were also set up across the country(Krishnan, 2003). However, an unintended consequence of this was a creation of a two-tiered system. While these institutions received adequate funding, the rest of the HEIs went into decline with a paucity of fund. Even in these institutions research picked up only at a later stage.

The expansion in HEIs continued during this period without much focus on research. Linkages with the industry were minimal, except for providing the workforce. In the 1970's among the top institutions like the IITs & IISc specialised industrial liaison offices were established to provide sponsored research and consultancy services. The initial focus was mainly on providing consultancy services.

India was in a unique situation where it had a large pool of qualified workforce in science and engineering (S&E) who could not be absorbed into employment(Krishnan, 2003). There was a large-scale migration, 'brain drain', of Highly Qualified Professionals during this period(Krishna & Khadria, 1997).

Some of the government schemes encouraged graduates from these fields to take the entrepreneurial role and become a job creator. This was on the back of slow economic growth rate characterised by high unemployment throughout the economy. Inorder to promote entrepreneurship in knowledge intensive sectors government setup The National Science & Technology Entrepreneurship Development Board (NSTEDB) in 1982. Under its aegis, a number of Science Technology Engineering Parks (STEPs) were established in the 1980s. Following on the model of the American research parks, the STEPs were attached to the HEIs. There were other programmes to provide financing, facilitate in patenting and guide potential entrepreneurs. The government was still the orchestrator of research and entrepreneurship activities.

The economic reforms, which began in the early 1980s, had to be accelerated in the aftermath of the balance of payment crisis in 1991. GERD as a percentage of GDP increased in the ten years after liberalisation marginally from 0.64 percent to 0.74 percent by 2000. Availability of well qualified low cost workforce attracted many MNC to establish their R&D centres in India. It was these institutions, which brought about the culture of working in close coordination with HEIs (Reddy, 2011).

In 1998, Samtel set up a joint research centre at IIT Kharagpur. Some collaboration between the MNC R&D centres with the local institutions came up in the 2000s. These partnerships were multi faceted with joint research cooperation, to providing equipment, student internship, faculty exchange and contract research programmes. However, these continued to be limited to the elite institutions. Some Indian firms also started entering into collaboration with these select institutions.

At the turn of the century, there was an impetus to encourage entrepreneurship through the formation of incubation centres around the year 2000. NSTDEB started providing support to many institutions to help entrepreneurs in the knowledge-dominated sectors. This was somewhat different from the STEPs started in the 1980s. The concept of incubation brought about hand holding of the firms in their initial stages. From a triple helix framework, the idea of incubation reflects a change from educating individuals to teaching organisations(Etzkowitz, 2008).

Another important change was a ruling by the Department of Science & Technology, in the year 2000, which encouraged institutions to seek patents on the projects funded by the department actively. Much like the Bayh-Dole Act, the patent was to be in the institution's name, by way of a royalty sharing arrangement with the inventor. As DST was the dominant funding agency, this ruling indicated a significant change in policy. Some institutions, however, already had such arrangements in place. For instance, IIT Delhi's first IPR policy was formulated in 1994. Other institutional mechanisms were also in place, like setting up of a Technology transfer offices (TTOs). IIT Madras by 1994 had started The Telecommunication and Computer Networking Group (TeNet), an informal group to create University spin-offs. Thus, a limited number of elite institutions were already engaging in the transfer of technology through various means. However, these cannot be generalised as these changes were taking place in a small number of institutions. Even among these institutions, the prevalent mode of knowledge transfer was publishing, consultancy and sponsored research.

A number of initiatives were started by different ministries to promote University-Industry linkages. These initiatives were in the form of joint funding, grant for establishing incubation centres and funding for long-term collaboration. One of the successful examples of University-Industry-Government interface comes from the Telecom Centres of Excellence (TCOEs) discussed in this study. The 10 percent funding support from the government and buy-in from the relevant industry players has not only led to commercially viable technologies and IPR, but also to policy documents and publications. Further, the spin-off generated from IIT-Bombay and IIT Madras shows an encouraging sign. The industry benefits by investing in such research ventures, as the potential for new technologies, is enhanced. On the other hand, TCOEs undertakes research in applied areas, where the industry requires technological solutions. The involvement of IIM in the project shows the wider range of institutions that can contribute to such initiatives. The establishment of incubation centres and opening up of the knowledge platform ensures that the benefit of research reaches the much wider target.

The entry of private Universities and rapid expansion of GER at the tertiary level has continued to fuel the focus only on education. The funding structure for R&D in the recent time has only changed marginally. The share of HEIs in total R&D remains around 4 percent. While the proportion of Business has increased to 44 percent and the Government's share is around 52 percent. Continuous efforts are being made to increase the share of Business R&D to 50 percent by 2020. As the Indian firms have become competitive globally, the investment in the R&D has also increased. However, as a share of their revenue, it still lags behind the global players. The majority of patenting in India is done by the pharmaceutical sector, followed by the ICT sector.

The Indian government has increased its focus on innovation in the last decade. On the recommendation of the National Knowledge Council, an innovation council was established in 2011, which declared the current decade as the decade of innovation. The Science, Technology & Innovation Policy 2013 calls for enhancing the GERD to two percent of GDP, which has further declined as per the latest data. Also, there is a call for increased collaboration between University and Industry.

The last decade has seen an increased patenting by the HEI in India. The growth continues to be led by a few institutions. However, a limited number of private HEIs are also aggressively filing patents, an indication of improving research activities in these institutions. The number of institutions filing patents has also increased in recent years.

The last chapter discusses the data from the NIRF survey. It shows that majority of HEIs are engaged in the dissemination of knowledge through traditional channels like consulting. The number of institutions involved in patenting is much smaller. However, the number of HEIs reporting patent publication is much higher, indicating that in the coming years the number of patents granted may go up. Except for a few institutions engaged in patenting, the majority have not earned any income from licensing. Even among those institutions that have earned licensing income in recent years, the share continues to be lower than other more traditional sources. These findings are consistent with the literature. Thus, the continuous focus on patenting and licensing as a mechanism of knowledge transfer may not be the best indicator of UIL.

The increased in patenting, may not be indicative of researchers becoming more entrepreneurial but can also be an outcome of the growing focus from the TTOs to seek opportunities actively. This was indicative from our example of increased patenting activity undertaken by IIT Bombay. Instead of waiting for disclosures from the faculty and students, the publications and thesis are analysed by the TTO to search for opportunities for patenting.

Another result from our analysis is that a high number of institutions in our sample engage in consultancy projects. However, the participation rate varies across the category of the institution. The participation rate was highest among the engineering institutions and lowest among pharmacy colleges. At the aggregate level, all the three categories report growth in yearly revenues.

The importance of consultancy as a source of revenue also varies across and within institutional categories. We calculated the ratio of the average consultancy revenue (ACR) received as a percentage of the total annual expenditure (ATE) reported by the institutions. Among the categories at the aggregate level, the management institutes report the highest figure at more than seven percent, while the Universities report the lowest figure around one percent. We also calculate the per faculty average revenue across categories, here similar pattern is seen with the management institutes earning are much higher compared to other categories of institutions.

Consultancies are a major channel of UIL. They can be formal as well as informal in nature. They tend to be more localised, and proximity may play a major role in the interaction between University and Industry. They are demand based and usually, have defined framework. While we do not have details on all the institutions, however, some of the larger institutions support faculty consultancy. In our analysis of the guidelines of IIT Bombay, it was clear that it allows twenty percent of faculty time for consultancy activities. It also has a revenue sharing mechanism with the faculty. There may be strong path dependence as well. Consultancies may help in building a long-term relationship between the firm and the faculty engaged. This may further lead to other opportunities for collaboration.

We also analysed the sponsored projects undertaken by the HEIs. Unlike consultancy projects, the main source of funding for sponsored projects comes from the government. Grants from different ministries support most of the research activities in Universities. However, some industries also collaborate with HEIs through sponsored projects. These projects are of much longer duration, and the nature of partnership may vary widely. An example of IISc's engagements in a particular year was presented to show the diverse nature of these relationships. They may range from funding of awards and competitions to supporting industrial consortia, long-term grant for research centres and contract research.

Almost all the Universities and Engineering institutions report taking part in the sponsored projects at least once in the previous three years. However, the participation rate among the management institutions and pharmacy colleges is slightly lower. Similar to the analysis of consultancy projects we calculate the average earnings from sponsored projects (AES) as a percentage of ATE. We find that this percentage is much higher compared to consultancy. Among the institutional categories, the aggregate figure is highest for engineering institutions followed by Pharmacy, University and Management Institutions.

A large number of HEIs in India are actively taking part in setting up incubators to help entrepreneurship. This is mainly backed by government initiatives under different programmes, which we have discussed. The data on the number of firms, their earnings and the success or failure rates for the incubated firms is not available. We looked at a specific case of IIT Bombay's Society for Innovation and Entrepreneurship (SINE), which was established in the year 2004. In our analysis, we find that the number of successful firms graduating from the incubations centre was 39, while the current incubate numbered around 28 and the number of firms, which folded, was 15. The annual average rate of graduating firms turns out to be around three firms every year. Also, around 21 faculties participated in these ventures, and 25 technologies developed at IIT Bombay were commercialised. From direct contribution to the economy, it is estimated that these firms have generated more than 2000 jobs. However, revenue generation from partial exits in these funds has been just above INR 30 million. This figure is much lower than the revenue it generates from consultancy and sponsored activities.

From our analysis, some important points emerge. First, India needs to improve its spending on R&D and at least bring it to the targeted two percent of the GDP. Second, Universities' share in the R&D budget needs to be increased from the current four percent of GERD. Third, the base of scientific research needs to be expanded, and more HEIs need to be encouraged to undertake research. The focus of government to create few institutions of excellence may be counterproductive in the long run, as the supply of scientific workforce will be hampered immensely. Fourth, while encouraging university-industry linkages, it must be realised that the spectrum of collaboration is much larger. A narrow focus on patenting and creating spin-offs may not be the best strategy. Fifth, while designing policies disciplinary differences must be kept in mind. The public funding support for basic sciences should continue. Sixth, there is a need for improving the availability of data on research done at universities in India. Further, data related to engagement with the industry should be made available for analysis.

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APPENDIX- A: Types of University-Industry Linkages

Transfer of non-commercial knowledge and expertise	***General research support***	***Co-operative research***	***Commercial ventures by universities***	**Commercial activities by academics, technicians and students**
Graduate Students	Speculative research paid for by industry in a university department	Interaction requiring some degree of co-operative planning	short-term contract research on a specific problem	consultancy
Research Publications	General Endowment	Knowledge Transfer Partnerships	industrial centres and units operating on a commercial basis	academics on boards of companies
Informal networks	Gifts of money provided for specific purposes	collaboration in specially supported programmes	testing services	Companies set up by academics and technicians to exploit intellectual property or to develop equipment needed by departments.
part-time secondment by academics to industry	Gifts of equipment	collaborators in international programmes	licensing of inventions	
part-time secondment of industrialists to academia		appointment of industrial fellows	joint industry/university ventures	
joint professorships in industry and academia		joint industry/university studentships	companies set up by universities/departments to exploit intellectual property	
Industrial liaison services		Continuing education programmes for managers/ employee of firms	university/colleges directly investing in local companies	

Source: adapted from (Smith, 2006)