An Arrested Virtuous Circle?
Higher Education and High-Tech Industries in India

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Abstract

We provide a brief but comprehensive overview of linkages between higher education and the high tech sector and study the major linkages in India. We find that the links outside of the labor market are weak. This is attributed to a regulatory structure that separates research from the university and discourages good faculty from joining, which erodes the quality of the intellectual capital necessary to generate new knowledge. In the labor market, we find a robust link between higher education and high-tech industry, but despite a strong private sector supply response to the growth of the high-tech industry, the quality leaves much to be desired. Poor university governance may be limiting both labor market and non-labor market linkages. Industry efforts to improve the quality of graduates are promising but over reliance on industry risks compromising workforce flexibility. Addressing the governance failures in higher education is necessary to strengthen the links between higher education and high tech industry.

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1. INTRODUCTION

For late industrializing countries the creation of a high-tech industrial base is critical for development. As the links between technology and development unfold, the potential role of higher education in contributing to the creation of such an industrial base is becoming a major policy focus[1]. In this context the links between high-tech and higher education become important. The available literature has not explored these linkages adequately, especially in the context of developing countries. This paper makes an effort to empirically explore such linkages in India. The rest of the paper is divided into seven broad sections. In section 2, we provide a brief but comprehensive overview of linkages between higher education and the high tech sector. This is followed in section 3 by a review of the structure of higher education in India. In the context of the recent growth of high-tech industry in India, section 4 provides some empirical evidence on the major linkages in India, while section 5 focuses on empirically illustrating the labor market channel in India for the information technology, financial services and high-end manufacturing sectors. Section 6 reviews the response of the higher education sector to developments in the labour market with a discussion of the differences between Indian states. It argues that this response has been restricted by the nature of regulation in India. Section 7 briefly discusses various issues raised in earlier sections in the context of South Asian countries other than India. Section 8 identifies a few policy lessons. The final section concludes.

2. LINKAGES BETWEEN HIGHER EDUCATION AND HIGH-TECH INDUSTRY

There are three broad conceptual frameworks that inform the analysis of the linkages between higher education and high-tech industry, viz. national innovation system (NIS); triple helix paradigm; and university-Industry Linkages (UILs).

The concept of NIS was developed to explain the differences in the innovative performances of industrialized countries. More recently, the framework has been applied to analyze the experiences of developing countries, especially the newly industrializing economies of East Asia. NIS characterizes a system of interacting agents – firms, universities (including research institutions) and government agencies – that are involved in the development and commercialization of science and technology. These interactions are undertaken within national

[1] This paper is confined to an instrumental view of education. Such a view is limiting, and in principle higher education must go well beyond and address much larger goals relating to the human condition, but that project seems remote, given the inability of the system to address even instrumental issues that we describe in this paper.

borders and encompass technical, commercial, legal, financial as well as social transactions.[2] Given this, the differences in innovative performance across nation states are ascribed to the differences in the way institutions combine/interact to generate, improve and diffuse new technologies – products, processes and practices. While initial work using this framework focused on nation states, it is increasingly being used to look at regional, local (cluster) and sectoral situations. Often it is also used to contextualize case studies of specific institutions – firms, universities and state agencies. It has been suggested that the literature in this tradition have focused more on the 'invention system' than on the 'innovation system' and has thus accorded less importance to understanding the complementary economic processes needed to convert invention into innovation and subsequent diffusion (Metcalfe and Ramlogan, 2008).

The triple-helix takes the framework of NIS further. In triple helix I, "the state encompasses industry and academia and directs relations between them". In triple helix II, the three actors are in individual and separate domains "with strong borders dividing them and highly circumscribed relations" among them. Triple Helix III generates a "knowledge infrastructure… with each taking the role of the other and with hybrid organizations at the interface" (Etzkowitz and Leydesdorff 2001). Thus, it develops a 'spiral model of innovation' that captures multiple reciprocal relationships among industry, university and the government at 'different points in the process of knowledge capitalization' (Etzkowitz, 2002). In doing this, the framework focuses on the 'internal transformation' of each of the helices and the influence of one helix on the other.

The recent literature on UILs appears at first glance to be both an extension and a combination of these two frameworks, as it focuses on two of the three components of NIS or two helices of the triple-helix system. However, there seem to be three dimensions where the UIL studies are somewhat different. First, UILs are typically analyzed in the context of geographically bound clusters, related to the literature on regional or cluster specific innovation systems. In adopting this focus, they tend to de-emphasize the macro-linkages between the educational system and industry. Second, UIL studies focus on the variety of industry-academia linkages and their measurement. Third, these studies are increasingly exploring the complementary economic processes that are required to facilitate and even push the invention-innovation-diffusion process. This exploration has led to the examination of different policy options that bring universities closer to the market and facilitate commercialization of technology developed at the university either through licensing or creation of startups. Thus, the emerging focus of this work

[2] See Metcalfe and Ramlogan (2008) for a succinct summary of the NIS literature.

is to understand the factors that help 'traditional universities' to become 'entrepreneurial universities'.[3]

Broadly, all these three streams of literature encompass the linkages between higher education and high-tech industries, with the UIL framework giving them more attention. However, these linkages remain largely under-explored in the context of developing countries and within them; labor market linkages have received inadequate attention – both in the local and national contexts. This is surprising because labor market linkages between industry and academia remains the most prominent link even in developed countries; where universities contribute relatively little to patenting, licensing and new enterprise creation, except probably in life sciences.[4] In developing countries, such linkages are even weaker. Conversely, industries too have the potential to affect higher education institutions through a variety of channels, and these relationships too have been explored rather little in the context of developing countries, where the relative capacities of the private sector and the state would differ from a developed country. The ability of institutions to respond positively to industry and create a virtuous feedback loop depends on the regulatory structure of higher education, especially the constraints on establishing new institutions, hiring faculty and salaries that can be paid to them, and ease of effecting changes in curriculum, i.e., the extent of agency possessed by the institution.

2.1. The Developing Country Context

It is useful to briefly describe the linkages between higher education and high-tech industries and how the nature of these linkages may differ in a developing country context.

2.1.1. From Higher Education Institutions to High-Tech Industries

Consider first, the links that flow *from higher education institutions to high-tech industries*.

(a) First, higher education institutions provide a common and possibly neutral platform for discussion about the broader goals of innovation policy and a forum where there can be relatively open interaction between industry and government. This may be valuable in developing countries where the relationship between the bureaucracy and industry is often either antagonistic or clientilist, both of which preclude productive dialogue. This function may be especially important in situations where the country is moving from one

[3] For some recent work in the area of UILs see Yusuf and Nabeshima (2007) and the special issue of World Development 35(6), 2007.

[4] ibid

type of industry-government relationship to another, e.g., during the process of liberalization. This is not a linkage we explore in this paper.[5]

(b) A second mundane link is through the *Supply of Services,* where institutions provide a variety of services like testing, training, certification, prototype development etc. This is especially important in developing countries for two reasons, where the size of the firms in developing countries is typically small and the number relatively large. First, as such, for a small firm developing such skill in-house is more difficult as compared to a large firm. Second, the talent pool is relatively limited and unable to cater to the large number of firms. Higher education institutions such as universities can potentially provide these services as a common pool resource, aggregating the limited talent and making it available to all firms on a fee for service basis. This too is not an area we explore here.[6]

(c) The third link is through an ostensibly primary function of higher education, the *Creation of Knowledge*, e.g., technology licensing, industry-institution R&D projects, etc. Given the relatively poor state of educational infrastructure in developing countries, the predominance of state funding for higher education and the low levels of funding of R&D by industry, this is unlikely to be a strong channel.

(d) A step beyond the creation of knowledge is its commercialization by the *Creation of New Enterprises* whereby technologies, developed in the institutions by either students or faculty, are commercialized through new enterprises. Often this is done through facilities like science parks and incubators that are created around research based academic institutions to facilitate this process. However, growth of high-tech industries needs inputs other than those from higher education institutions. For example, in order for a city to become a financial centre, human skills need to be combined with urban infrastructure. Similarly, the lack of availability of risk capital may strongly inhibit the growth of high-tech firms.

(e) Finally, and most importantly, higher education institutions provide the *Supply of Labor* for high-tech industries, wherein students trained at these institutions become part of the

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[5] For example, in addition to many workshops the Indian Institutes of Management have a number of short-term Management Development Programmes for senior civil servants as well as a Masters in Public Policy which is well attended by civil servants.

[6] One of the more commercially remunerative services supplied by higher education institutions is training, especially for management institutions. For many institutions offering management education this forms a substantial part of revenue.

labor pool, which may or may not be restricted to the region. This is not true just for service sectors commonly considered high-tech such as IT and financial services. In most types of manufacturing, a certain component of high-end skills is needed. As the higher education sector evolves, it acquires the capacity to handle more complex technologies, i.e., deepening, and its influence extends to more industries, i.e., broadening.

The focus of the UIL literature has been on the creation of knowledge, its commercialization and the creation of enterprises. The links through the supply of labour have, in some sense, been considered as too mundane. However, while the former types of links are possibly more important in countries where growth is driven by pushing the technological frontier, the labour market link may be significant in developing countries, where the growth of high-tech industry may depend more on how quickly existing technologies can be exploited. In industries such as software, this ability may well be constrained by the supply of highly-skilled labour, which will determine the cost and the pace of expansion.

2.1.2. From High-Tech Industries to Higher Education Institutions

Let us now turn to the links that emanate *from high-tech Industries to higher education*. These too can be grouped under five broad heads, viz.

(a) The first and most mundane is the supply of goods and services, e.g., high-tech industry provides specialized equipment to institutions and technicians to service the equipment. In developing countries, the servicing function is likely to be more important since much of the equipment may be imported and may also see much longer usage periods as compared to developed countries. We do not explore this link here.

(b) Second, in developing countries, where teachers are often in short supply, industry can potentially, and often does, supply teachers, wherein industry professionals serve as teaching staff. Of course, industry also affects the supply of teachers by being an alternative career choice for students, which could influence the both the quality and compensation of the teaching pool. This is especially true for technical and professional education, areas that are of closer relevance to high-tech industries.

(c) Third, industry can influence changes in curriculum, wherein industry works with government or higher education institutions to effect curriculum changes in line with industry requirements. To the extent that industry is more ‘outward-oriented’ than higher education institutions in developing countries, this can be a source of new ideas. However, it also runs the risk of making the education narrower.

(d) Fourth, high-tech industries can potentially be a source of funding for higher education. Given the stronger links between the educational inputs and success in industry, alumni in high-tech industries may be more predisposed towards giving back to the institution. Furthermore, industry is also a source of funding for research projects. Given the low levels of government funding, both generally and for research and the conditionalities that restrict the use of such funding, such contributions from industry can be more important in developing countries as compared to developed nations. In research especially, the added funding from industry can be a sizeable proportion of the overall research budget.

(e) Finally, the other side of labour supply is demand for labour from industry, which can then lead to demand for new institutions and expansion in the capacity of existing institutions. Depending on the response, this can affect the structure of higher education sector. If industry is concentrated in a few areas, as is more likely to happen in developing countries, this may similarly concentrate the structure of higher education.

3. HIGHER EDUCATION SECTOR IN INDIA

It is useful at this stage to briefly lay out the structure of the higher education system in India. There are several types of higher education institutions in India, viz. universities, deemed to be universities, colleges, institutions of national importance, post-graduate institutions (see Table 1 for estimates). Universities can be set up by an act of the Parliament or by the State Legislature. Only universities and deemed to be universities and the institutions of national importance are generally authorized to grant degrees. Other post-graduate institutions and polytechnics that are recognized by the All India Council of Technical Education (AICTE) can grant post graduate diplomas and diplomas. Detailed information on the structure, regulatory institutions, courses and processes of admissions in the Indian educational system is provided in Appendix 1. In what follows, we highlight a few key features of the higher education system.

3.1. Funding and Fee Regulation

Institutions of national importance and public Universities by act of Parliament or State Legislature are funded by States and/or by University Grants Commission (UGC). Private Universities established by State Legislature are funded privately. Further, the central funding is directed largely to central institutions and little of it supports higher education at the state level. Typically, the amount of fees that can be charged has to be justified by the institution before a quasi-judicial body in each state. While the popular perception is that the share of funding from fees is low, Agarwal (2006) shows that many public universities earn a substantial portion of their operating income from fees and presents data on fees in engineering and technology institutions that vary between Rs. 22,000 to Rs. 72,000 per year (p. 177). CABE (2005) also provides evidence to this effect (see Table 2). In addition, the growing number of student loans and rising share of private colleges testify to the importance of student fees as a financing source, especially for technical and professional education.

3.2. Uniform Compensation and Automatic Promotion of Faculty

The UGC specifies a salary structure for universities that receive its funding. This makes compensation across different universities uniform in nominal terms, except for minor differences in allowances. Most other publicly owned academic institutions also benchmark themselves to this salary structure, which implies that faculty at these institutions face a uniform compensation structure.[7] In addition, most institutions typically follow a process of time-bound automatic promotion of faculty. This is a departure from the past when the number of senior positions was limited, and recruitment to these positions was by open competition making it possible for faculty to be promoted early by applying for positions in other institutions.

3.3. Affiliated Colleges

Undergraduate teaching is mostly done at colleges affiliated to a university and is based on a pre-determined curriculum. These colleges can include professional education also. The evaluation of students is done externally through a university-wide examination. These colleges can also be autonomous accredited by NAAC but the number of autonomous colleges is not high relative to the total number of colleges. Usually admissions are done on the basis of performance at the qualifying school-leaving examination.

3.4. Separation of Teaching and Research

In the existing situation teaching and research are increasingly not co-located because of the establishment of specialized research institutions. The establishment of institutions in the area

[7] The Indian Institutes of Technology (IIT) and Indian Institutes of Management (IIM) and a few other designated institutions have a slightly higher salary structure than the normal UGC scale. There are also some differences in benefits between universities funded out of the central (federal) budget and those funded by the states (provinces). However, a nominally equivalent compensation does imply variations in real compensation because of differences in cost of living across locations are not fully adjusted.

of science and technology through the Council of Scientific Research (CSIR) and the creation of social science research institutes through the Indian Council of Social Science Research (ICSSR) resulted in the exodus of 'research oriented' faculty from universities to such institutions as the research facilities in these institutions were generally better. The consequent deterioration of the university system resulted in a self-reinforcing downward spiral that put the relationship between teaching and research further out of balance. One of the key adverse impacts of such a separation has been that under-graduate teaching primarily undertaken by affiliated colleges has become almost completely de-linked from research (see, Yarnell, 2006).

3.5. Specialized Institutes for Professional Education

Much of professional education is provided through specialized institutes at both the undergraduate and post-graduate level. These professional Institutions may be affiliated to a university but can be independently or often concomitantly approved by the All India Council of Technical Education (AICTE) or other professional councils like the Medical Council of India. These have flexibility in designing their curriculum and student evaluation is done in-house. Some of these are accredited by National Accreditation Board (NAB). Admissions in these institutions are done through highly selective nationwide or state-wide competitive examinations. However, in some states, the increasing supply of institutions has reduced the extent of selectivity overall, but since the quality of institutions varies considerably, the degree of selectivity remains quite high for better quality institutions. The fees of private educational institutions are currently regulated through a committee headed by a former high court judge. However, this mechanism allows considerable variation across institutions. Some institutions, including a few that are not in the private sector such as the IIMs, are able to charge market-related fees for professional education and these have been rising recently[8].

4. LINKAGES BETWEEN HIGHER EDUCATION AND HIGH-TECH INDUSTRY IN INDIA

The high-tech industry in India has seen some growth. Figure 1 shows that the share of communication and computer related services has increased in recent years. This growth may have resulted in an increase in demand for skilled workers as recent studies have found the presence of output-skill complementarities (Chamarbagwala and Sharma, 2007; Berman,

[8] The current fees at the Indian Institutes of Management are in the range of USD 20,000 per year.

Somanathan and Tang, 2005). Driven by growth in demand for skills, there is also some evidence for growing wage premiums for skilled workers.[9]

Development in sciences & technology and changes in global production and R&D networks are creating new opportunities for interaction between academic institutions and firms in India. The evidence reported in Basant and Chandra (2007a) suggests that some academic institutions and other entities in Pune and Bangalore cities have utilized these opportunities to build linkages and interact with the city clusters in a rich variety of ways. However, only a few institutions have the relevant knowledge base to undertake high-end knowledge networking activities with industrial entities. The survey data revealed a hierarchy of institutions in terms of the strengths of their linkages, viz. those that undertake only teaching (i.e., linkage through the labour market), those that do research and teaching and provide services such as testing (i.e., having linkages through all types mentioned earlier) and those that focus on specialized research (i.e., linkages that are predominantly driven by knowledge generation and dissemination). Given the existence of this hierarchy, reflecting low institutional capabilities, academic institutions rarely come together to advance these linkages collectively. Many are however gearing themselves up to participate in such linkages in a more systematic manner. The experience of these two cities broadly supports the idea that institutions, given some autonomy, and industry co-evolve to take advantage of emerging opportunities that arise.

4.1. Linkages: Higher Education to High-tech

4.1.1. Creation of Knowledge: Patenting and Research Output

Tables 3a, 3b and 3c present information about patents issued to Indian inventors in the US Patent database[10]. The data is grouped in six five year periods starting from 1976. A few broad trends are evident from this.

(a) First, patenting has increased over time, with a particular increase in recent periods. Indian universities too have increased their patenting over time in line with this trend but their share still remains low and is in fact a little less than what it was in 1976-80.

(b) Second, public sector research institutions constitute most of the Indian assignees and this share is steadily increasing, even more than that of private firms, whose patenting is also growing. Of these patents, the overwhelming majority, over 80% is assigned to the

[9] For some estimates see Unni and Rani (2008); Bargain, et.al. (2007); Azam (2007); Kijima (2007); and Chamarbagwala (2006)

[10] See Gupta (2008)

Council for Scientific and Industrial Research (CSIR), a network of publicly funded research laboratories around the country.11 These labs do not have educational functions and this characteristic of knowledge generation reflects a separation of teaching and research in Indian higher education.

(c) Third, the extent of research spillover from research outsourcing that seems to be indicated in the growing number of patents issued to foreign firms (though a declining share owing to the rise in patenting by domestic firms and public research labs) may be weak. This is an indirect effect of Indian higher education, since the foreign firms established research bases in India to utilize Indian researchers produced by the Indian higher education system.

Gupta (2008) provides an interesting insight. Of the top ten Indian public and private firms (excluding CSIR), who account for over half the patents, only one is in the semiconductor/ information technology area. The rest are in the pharmaceutical and chemicals sectors. However, of the top ten foreign firms who account for more than 40% of the total assignees, only three (including a foreign subsidiary of an Indian firm) are in the pharmaceutical and chemicals sectors and of the rest, five are IT firms and two, GE and Unilever are diversified. It would thus appear that the research areas of domestic and foreign firms do not overlap significantly. Recently, Athreye and Prevezer (2008) and Athreye and Puranam (2008)[12] provide more detailed evidence for this. Indian involvement is much higher in the chemistry oriented sectors than in information technology (see Table 4). The data also suggests that patenting activity has not matched industry growth in telecom and IT (Table 4).

This raises the question of the capacity of domestic industry to benefit from such spillovers, since it diminishes the likelihood that the domestic firm is receiver-active, in the sense of Kodama, et. al. (2007). Thus, while the direct generation of knowledge can largely be attributed to public research labs instead of the higher education institutions, the indirect generation of knowledge too seems to be in areas where linkages to domestic industry appear low. However, in the case of pharmaceutical-biotech industry, consistent with Gupta (2008) and Athreye and Prevezer (2008) and Athreye and Puranam (2008), there seems to an indication that these

[11] The data also showed that within the USPTO database, CSIR was the most dominant assignee for health-biotech field as well (See Kumar et al, 2004).

[12] Athreye and Puranam (2008) extract Patent data from 1 Jan 1976 to 1 June 2006 from the US Patent Office website www.uspto.gov, while data on scientific publications was collated from Thomson-ISI Science Citation Index. The latter data were compiled by Science Metrix Inc from Science Citation Index (SCI) data prepared by L'Observatoire des Sciences at des Technologies (OST).

linkages are beginning to form (see Box 1). This is consistent with the pattern in developed countries where there is a concentration of such linkages in the life sciences sector.

Box 1: University Industry Linkages in Bio-tech and Pharmaceutical Sectors

The Indian bio-tech/pharmaceutical industry has seen significant growth in recent years and there is ample evidence to show that its links with academia have also grown which have helped create 'training opportunities for in-house staff, improve access to research facilities and expensive equipment, expand clinical trial capabilities and provide access to government-sponsored research funds' (Frew et al, 2007: 408). The variety of linkages is large; partnerships are focused on developing products, drug delivery platforms, screening drug candidates, medical diagnostics, clinical trials, data management. A few educational institutions like Indian Institute of Science have also created new enterprises on the basis of technologies developed within the institution. Many partnerships are developing products to address India's local health needs, especially in the area of vaccines.[13]

Appendix 2 provides details of companies that have linkages with several universities and public research institutes. While the information should be seen only as illustrative as the coverage of alliances is not exhaustive, it reveals a very interesting phenomenon; only a select list of institutions and firms are actively engaged in such alliances. For example, IISc (Indian Institute of Science), ICGEB (International Centre for Genetic Engineering and Biotechnology), NII (National Institute of Immunology) AIIMS (All Indian Institute of Medical Sciences), IICT (Indian Institute of Chemical Technology) Hyderabad, and CCMB (Centre for Cellular and Molecular Biology) are the institutions most active in these alliances. Only one of these, the IISc is a university; the participation of other few universities like Jawaharlal Nehru University, Delhi Universities, Madurai and Osmania is fairly limited. Similarly, Shanta Biotech, Bharat Biotech, Bharat Biotech International, Nicholas Piramal, Dr Reddy's, and Ranbaxy are a few firms that are active in these partnerships. Thus, it appears that these linkages are still in their infancy stage and it will take some time before they deepen to make a significant impact on technology development and diffusion. Participation of only a select set of mainly specialized research institutions on the one hand highlights the quality constraints in most of the academic institutions to contribute to such alliances and on the other points to the adverse effect separation of research and teaching may have had on the ability of Indian universities to effectively participate in such collaborations..

4.1.2. Creation of Knowledge: Publications

Even in basic research, the capacity of universities is limited and skewed. About 80% of doctorates in engineering were from 20 universities, and about two-thirds of the science doctorates from 30 universities. Further, only about 20 universities have a fellow in one of the three science academies[14]. Even in social sciences, where presumably infrastructural

[13] Several studies describe these partnerships in detail. For example, see Frew et. al. (2007), Yarnell (2006), Kumar et al (2004) and Maria et. al. (2003).

[14] See Agarwal (2006)

constraints are less binding, just 26.2% of the 454 articles, published in a leading domestic social science journal between 1998-2000, were from universities, of that 13.9% was from three universities in Delhi and Mumbai, while specialized research institutes and organizations accounted for 27.3%[15]. Of the total publications of 15 most active Indian universities publishing in the areas of health-biotechnology field in internationally peer-reviewed journals during 1991-2002, 20.5% came from one university – the Indian Institute of Science (Kumar et. al., 2004). We will see below that this institution is also at the most dominant player in the linkages between academia and industry, especially in the filed of pharmaceuticals and biotechnology. Research has moved out of Indian universities and other academic institutions over the years. For many years, the public sector research institutions have been the main centers of research activity and universities have largely become teaching institutions.

4.1.3. Creation of Enterprises

Apart from working in high-tech industries as employees, persons with higher education can potentially set up enterprises in the high-tech sectors. The activity of enterprise creation as a part of UILs is still at a nascent stage in India and relationships outside of the labour market is limited to research support through consulting and other research projects. But the focus on enterprise creation is interesting and is creating a lot of excitement among the research oriented science, technology and management institutions. Conventional incubators are proliferating in India today. Virtually all well known technology institutions have one and some of the management institutions are also experimenting with incubation. Basant and Chandra (2007b) analyze the emerging enterprise creation role of academic institutions in India and the incubation models used by them. It is too early to assess the impact of enterprise creation efforts in educational institutions in India; most have started such activity within the last five years. One can say that no outstanding success has come to light but many incubators can boast of moderate success. While numbers are not available, many incubatee companies from technology institutions have survived the rigours of market competition after graduating from the incubators. At the moment the most important contribution of such efforts has been to highlight the possibility of creating technological innovation based enterprises in educational institutions. Their success, even moderate, also creates a sharper focus on technology based entrepreneurship as a career option.

[15] Chatterjee et. al. 2002. The universities include the Indian Institutes of Management, who account for 4.4% of all articles.

Appendix 3 provides some basic details on eleven incubators.[16] Apart from one incubator supported by alumni and another by a venture capital institution, the remaining are publicly supported. Nine of these incubators are associated with an educational institution. However, in this sample of incubators, most of the incubatees are from outside the educational institution and in eight of them all but one incubatee is from outside the institution. This is a form of UIL that is perhaps more akin to enterprise nurturing than creation[17]. While many of these incubatees have sought IP protection (especially in the incubator funded by a venture capital institution), many have not. While in this sample of incubators, most of the incubatees are 'outsiders' a large proportion of incubators in IITs and other nationally known institutes of technology incubate their own faculty and students, that is closer to 'enterprise creation' in the conventional sense of the term (see Basant and Chandra, 2007b for details).

An alternative model of enterprise creation through focused agenda based research, as is being pursued by the TeNet group at IIT Madras (http://www.tenet.res.in), appears an interesting alternative to the conventional model. However, this requires considerable motivation on the part of the research group and the ability to address the trade-off between publication and enterprise creation. Some R&D institutions have just started to grapple with this dilemma and therefore, the idea of enterprise creation might further sharpen this trade-off.

4.2. Linkages: High-tech to Higher Education

4.2.1. Supply of Teachers

As mentioned earlier, there has been very strong growth in the number of higher education institutions, especially professional institutions, most of them in the private sector. The number of teachers has not kept pace with this growth, as shown by the number of PhDs produced. Consequently, many of these institutions are staffed by part-time faculty or faculty whose experience has been more in industry than academia. While it is mandatory for institutions to disclose the qualifications of faculty[18] this information is not collated. However, a quick survey of institution websites reveals that a number of the faculty is without PhD degrees and the size

[16] This is based on a small survey of incubators. Of the 35 requests that were sent only 11 institutions responded. It is difficult to assess if there was a selection bias.

[17] It can be argued that this should be part of the supply of services rather than enterprise creation.

[18] See the Proforma for Mandatory Disclosure of Information about Accredited Programmes by Institutions that is issued by AICTE.

of the faculty is small. In fact, even at National Institutes of Technology, a large proportion of faculty is without a PhD.[19]

The supply of faculty from industry, both part-time, as well as those entering a second career is therefore a significant source of linkage. While this can strengthen industry-academia links, it is possible that, given the differences in compensation, many of those who are choosing to enter academia from industry are not doing so out of choice. As such, their links with erstwhile organizations may be weaker than would be initially evident.

4.2.2. Modifications to Curriculum

The IT industry has been in the forefront of demanding changes to the educational curriculum in India, since their perception of the quality of the existing graduates is low. According to NASSCOM[20], currently, only about 25% of technical graduates and 10-15% of general college graduates are suitable for employment in the offshore IT and BPO industries, respectively.[21] .

NASSCOM has signed MoUs with UGC and AICTE to strengthen professional education in line with the IT industry's requirements of demand for skilled professionals. A key component of this is a mentorship program between a higher education institution and a firm. Some examples of these mentoring relationships are: Zensar with VIT, Pune XANSA with Jammu University, Jammu, Pixtel Technologies Mentorship with ISB Engineering College, Ghaziabad, and Pixtel Technologies Mentorship with Galgotia College of Engineering, Greater NOIDA. In addition, companies such as ITC InfoTech, Accenture, SUN, MindTree, Microsoft and Patni are undertaking Faculty Training Programs.

NASSCOM is also piloting a "Finishing School" for engineering graduates who are still seeking employment. One pilot was conducted during May-June, 2007, for a period of eight weeks in eight institutions, including IIT Roorkee and seven National Institutes of Technology (NITs), viz.: Khozikode, Durgapur, Kurushetra, Jaipur, Surathkal, Thiruchirapalli and Warangal. The "Finishing School" addresses both technical and soft skills development delivered by trained faculty and practicing IT and ITES industry consultants. The students will get an opportunity to

[19] Some estimates, e.g., Banerjee and Muley (2008), show that percentage of faculty without PhD in Warangal (55%), Hamirpur (52%), Durgapur (44%), Surat (34%) is quite high.

[20] NASSCOM (National Association of Software and Service Companies), is a major trade body of the IT software and services industry in India with around 900 members, of which nearly 150 are global companies from the US, UK, EU, Japan, China and other countries. NASSCOM's member companies are in the business of software development, software services, and IT-enabled/BPO services.

[21] NASSCOM-McKinsey Report 2005- Extending India's leadership in the global IT and BPO Industries

reinforce key basic engineering skills and in addition, acquire industry-specific knowledge, soft skills, and management and employment skills[22].

Some NASSCOM members have intensively engaged with training and supplementary education for their recruits and employees. WIPRO has had an Academy of Software Excellence for over ten years and Infosys' Campus Connect program (see Box 2) is about five years old. The extent of remediation efforts being undertaken by the IT industry is an indication of the inappropriate training of graduating engineers from higher education institutions, at least from the point of view of the sector[23]. These industry initiatives are in addition to a private training industry that began to develop along with the growth of the IT sector and has now diversified into training for back office operations, retail employment, etc. These courses do not have a certification beyond the brand name of the institute[24]. The onus of quality assurance therefore rests on the student.

Some pharmaceutical firms have also developed linkages with universities, e.g., through continuing education Ph.D. programmes with universities for their lab researchers.[25] However, these linkages are restricted to a few institutions. Bhattacharya and Arora (2007) find that even in seven select universities, only three (IIT Delhi, Jawaharlal Nehru University and Delhi University) interacted actively with industry in curriculum design across departments; while in two (Pune and Jadavpur) such interaction was linked to a few departments and Hyderabad University and Indian Institute of Science did not report such linkages. These limited linkages may become weaker if the Ph.D. programme itself exits the university and moves to specialized institutions, as incipient trends indicate. National laboratories, rather than universities are becoming the locus of Ph.D. research, e.g., National Chemical Laboratory may well be the largest producer of Ph.D. in chemical sciences (see Yarnell 2006).

Industry participation in curriculum is now spreading to other areas too, foremost of which is vocational training, where the private sector already has a strong presence. India has many Industrial Training Institutes (ITIs) that offer a variety of courses, including long-term courses

[22] See NASSCOM (2007).

[23] In part, this can also be because the IT sector is trying to re-skill engineers who have been trained for other specializations like mechanical and chemical engineering, for the software industry.

[24] This is also true for one of India's newest and better known business schools, the Indian School of Business, which is not accredited by the AICTE.

[25] For example employees at Avesthagen are encouraged to pursue doctoral studies through a collaborative programme at Mysore University (Frew et al 2007). Dr Reddy's Lab, Ranbaxy and Nicholas Piramal have similar arrangements for their employees with other universities (Yarnell, 2006).

varying from two to three years, especially for the manufacturing sector. As part of an ongoing reform program, many industries and industry associations are now being involved in the management of these institutions and improving the industry-relevance of their instruction.[26]

Box 2: Infosys Campus Connect[27]

Infosys is a large Indian IT services provider with over 100,000 employees and an annual recruitment of more than 10,000 professionals. Campus Connect was launched by Infosys in May 2004 with 60 colleges, as an "industry-academia collaboration program to align engineering student competencies with industry needs". The program has grown rapidly and as of March 2008, it had grown to 500 colleges. It is present in nine cities in India and is now moving to China, Malaysia and Mexico. Over this period, Campus Connect has trained 25,000 students and enhanced the skills of 2000 faculty members.

The core of Campus Connect is the Foundation Program, which is a 130 classroom hour proprietary educational supplement for a batch size of 60-75 students that is integrated with the College's academic schedule and may include Industrial Visits to Infosys Development Centers.[28] The course material is provided by Infosys and is based on material it uses for its induction programs, including assignments, case studies and a Student Project Bank, that simulates live project situations, adapted for academic environments, but all other facilities are provided by the participating college. A companion Soft Skills Program is intended to develop students' skills in communication, team work, corporate work culture, etc. In contrast to the Foundation program, this is delivered by alliance partners at a cost.

The college is given incentives based on the performance of the number of graduates joining Infosys and is expected pass on the cash benefits received from Infosys to people, including faculty based on college-specific norms. Campus Connect also facilitates Faculty sabbaticals, sponsorships for paper presentations at conferences, etc.

By aligning the skill needs of IT services with the college curriculum, Campus Connect reduces the learning time and training cost after employment. However, Infosys does not guarantee that graduates of Campus Connect will be offered employment, nor is it incumbent upon the graduates to accept an Infosys offer, should it choose to make one. In determining its return on investment in Campus Connect, Infosys thus banks on its reputation as a superior employer and its large annual recruitment to ensure that a sufficient number of Campus Connect graduates accept Infosys offers to as to make its investment in the program worthwhile.

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[26] See CII (2007). The plan involves the creation of Institute Management Committees (IMC) chaired by a person from industry, who will be given financial and academic autonomy by the state governments to manage the ITIs. The Central government will provide a 10 year interest-free loan of up to Rs 25 million on the basis of an institute development plan prepared by the IMC. The state government will continue to regulate admissions and fees. See also Nichenametla (2007) and Mukhopadhyay (2008).

[27] The box is a summary of Campus Connect Program Overview. See Infosys (2007)

[28] The recommended semesters for a Foundation Program are the 5th and the 7th semesters of an 8 semester course of study, while that for the Soft Skills Program is the 3rd, 4th and 5th semester.

While the system can be commended for allowing the growth of such initiatives by benignly neglecting to regulate them, their rise does raise questions about the ability of the formal higher education system to respond to market demand, especially in professional courses[29].

4.2.3. Improvement in Labour Quality

In addition to modifications to curriculum, the IT industry, through NASSCOM, has undertaken other initiatives to improve the quality of the labour supply, especially for the ITES sector where the degree of selectivity in the basic educational qualification, which comprises university education in all disciplines, is less than that of engineering, which is the base qualification in the IT sector. These initiatives can be grouped under two broad heads, viz. testing and verification.

The NASSCOM Assessment of Competence (NAC) aims to address the possible talent shortage by creating a robust and continuous pipeline of talent for the IT Enabled Services (ITES) industry through a standard assessment and certification program. The program tests the aptitude of a candidate on 7 different skill sets [30] NASSCOM has also partnered with other organizations to develop customized certification programs for frontline managers in this sector, e.g., CBQA (Certified BPO Quality Analyst) and CBTL-1 (Certified BPO Team Leader, Level-1). A test for the IT sector, NAC-Tech has also been developed. This need for such tests reflects the limited effectiveness of quality regulation with respect to educational institutions.

Labour quality is also affected by fraudulent reporting of qualifications. To help in more accurate verification of credentials, NASSCOM has fostered a National Skills Registry (NSR) to ensure that there is a verified database of the skill sets and talents of the human resources within the IT enabled services Industry. NSR is a database of details of the IT Professionals (ITPs) as entered by them with associated background check information. It includes personal, academic and employment details of individuals employed / to be employed (ITPs) in the IT and ITES industry. Every ITP registered in NSR is identified uniquely by finger-prints. The database also has the photograph of the ITP. Currently, 58 major companies and over 250,000 professionals have registered on NSR (see www.nationalskillsregistry.com).

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[29] Sometimes, even the private response is deemed inadequate by private sector clients. Reliance ADAG recently purchased NIS-Sparta, in an effort to vertically integrate backward into training its employees

[30] These include listening and keyboard Skills, verbal ability, spoken English, comprehension and writing ability, office software usage, numerical & analytical skills, and concentration & accuracy. For further details, see http://nac.nasscom.in/

4.2.4. Funding of Higher Education Institutions

While the overwhelming majority of funding of public institutions still comes from the government, there are some institutions where private funding has made noticeable contributions to public institutions. However, much of this is limited to the marquee institutions like the IITs and IIMs and on occasion, Indian industry has contributed to institutions abroad. It has been argued, e.g., by Kapur and Mehta (2007) that a burgeoning trend of private contribution may have been nipped in the bud by the government's desire to control the flows by insisting that they flow through a central fund – the Bharat Shiksha Kosh – whose use would be determined by the central Ministry of Education. There is however considerable private funding of higher education through the establishment of privately owned educational institutions which now constitute the majority of institutions in professional and technical education.

4.3. Relative Importance of Different Linkages

In the previous discussion, it was argued that the creation of knowledge and creation of enterprise were, at this point in time, relatively weak channels of interaction between industry and academia. The universities produce a very limited number of patents, and even the generation of publications is limited and concentrated in a few universities. As for enterprise creation, the role of educational institutions can best be described as nurturing rather than creation, where existing entrepreneurs are facilitated to pursue their goals. A select set of academic institutions are collaborating with a few pharmaceutical/biotech firms to develop technologies. At the same time, the growing interest of high-tech industry, especially IT, in remedial or supplementary education and in participating in the improvement of educational institutions lends support to the claim that the strongest link between higher-education and high-tech industry in developing countries like India is likely to be through the labour market and it is this link that is of immediate concern to industry at this time.

5. THE LABOUR MARKET LINKAGES

To investigate then nature of this linkage, we analyze the unit level data from the 61st round of the National Sample Survey data for the year 2004-05.[31] If the labor market links between higher education and high-tech industry are strong, one would expect that persons with higher education have a higher propensity to be employed in high-tech industry.

[31] The analysis covers usual status principal as well as subsidiary workers.

5.1. Defining High-tech Industries

Following the OECD classification of industries into Low, Medium, Medium-High or High Technology groups,[32] we have grouped sixty manufacturing industries into three categories (see Table 5). Steherer and Worz (2003) on the other hand have categorized industries into four categories: low-tech; medium-low; medium-high; and high-tech. While this categorization is not as disaggregated as the OECD grouping, a comparison of the two shows that several groups categorized as medium-tech by OECD are part of high-tech in the other categorization. At the 3-digit industry group level re-classification of the OECD high-tech into medium-high and high-tech might be too arbitrary. Consequently, for our purposes, all manufacturing industries categorized as medium high-tech in the OECD classification are considered as high-tech.

The "high-tech equivalent" in the services sector is categorized as financial and information technology related services. Anecdotal evidence suggests that in recent years a large proportion of persons with higher-education have joined these sectors, especially those who have technical degrees. Financial intermediation, which includes banking, insurance and pension funds etc. (SIC codes 65-67) is used as one of the high-tech services. The other being computer related activities (SIC code 72) which includes software and hardware consulting. This category also captures IT outsourcing of various kinds. Given this conceptualization of high-tech industry, our empirical exercise distinguishes between three types of high-tech industries:

(a) All high-tech industry (manufacturing, financial services and IT);

(b) High-tech manufacturing; and

(c) High-tech services (financial intermediation and computer and computer related activities which mainly includes IT services).

5.2. Defining Higher Education

The key purpose of the exercise is to ascertain if higher-education increases the probability of being employed in the high-tech sectors. For doing this we need to define higher education. The NSSO 61st round data allows us to distinguish between general education and technical education. Within these two categories graduate and post-graduate education provides

[32] The OECD classification is based on R&D intensity for 12 OECD countries, viz. United States, Canada, Japan, Denmark, Finland, France, Germany, Ireland, Italy, Spain, Sweden, and the United Kingdom. The OECD groups of high and medium high have been aggregated together into the High category.

education related information.[33] Combining these two types of education, the following higher education categories have been created:

(a) *All types of higher education*: Any graduate (or equivalent) qualification and above. This includes those with a general education level of graduate or postgraduate and above or have a technical degree or a technical diploma/certificate (graduate and above);

(b) *Non-technical higher education*: Graduate (or above) in general education category;

(c) *Technical higher-education*: Technical degree or graduate and above level diploma/certificate courses; and

(d) *Non-technical higher-education with technical non-graduate diplomas*: Graduate (or above) in general education with below graduate level technical diplomas or certificates.

5.3. Other Explanatory Variables

To explore if non-graduate technical education influences the chances of employment in high-tech industries, such workers are also distinguished. Apart from the level of education of the worker, several other factors may potentially influence the probability of a worker employed in high-tech industry. At the individual level we have included age and gender as two control variables. At the regional/state level, apart from place of residence (rural/urban), we have included variables to capture importance of high-tech employment in the region and its infrastructural characteristics.

a) Importance of high-tech employment in the region: If a region has a large high-tech sector, the possibility of a worker being located in that region being employed in that sector goes up. To capture this 'demand' effect we have used the share of high-tech employment in total employment in the state as a variable.

b) Infrastructural facilities: Good infrastructure is often a pre-requisite for industrialization of a region to take place. This is especially true for high-tech industries which are typically infrastructure intensive. Availability of good infrastructure can facilitate the emergence and growth of high-tech industries in a region. In that sense, it can enhance the share of high-

[33] In the survey instrument, the general educational level categories include: not literate; literate without formal schooling; literate (below primary); primary; middle; secondary; higher secondary; diploma/certificate course; graduate; postgraduate and above. The technical educational level is categorized as: no technical education; technical degree in agriculture/ engineering/ technology/medicine, etc; diploma or certificate (below graduate level in agriculture, engineering/technology, medicine, crafts, and other subjects); diploma or certificate (graduate and above level in agriculture, engineering/ technology, medicine, crafts, and other subjects).

tech employment in the region, thereby increasing the value of the high-tech employment variable defined above. However, infrastructure can have another effect of facilitating participation of workers in such industries. For example, good transport facilities can potentially enlarge the spatial scope of the labour market and good telecom facilities can facilitate participation of workers in the hinterland, especially in the area of IT services. The state infrastructure indices prepared by Mohanty (2004) are used to capture this effect. The infrastructure index 'reflects the degree to which a state is prepared in terms of its infrastructure to enable its population to take advantage of public services' and the associated industrial employment opportunities. The summary infrastructure index measures the overall levels of infrastructure development at the state level. The aggregate measure is based on variables that measure the supply as well as use of infrastructural facilities in three sectors: communication, power and transportation.[34] In order to capture the relative situation of states in terms of each of the underlying sectors, sector specific indices have also been used. Potentially, different segments of infrastructure can influence employment in high-tech industry differently. Thus, we have four indices for infrastructure for each state, viz.: an aggregate summary index of infrastructure, a power infrastructure index, a telecom infrastructure index and a transport infrastructure index. Both the supply and use of each category of infrastructure has been captured in these sub-indices.

5.4. Results

Table 6 shows that, on average, high-tech industries have a higher propensity to use workers with higher education. The share of workers in high-tech industries with graduate and post graduate qualification (both general and technical) is significantly higher than in other industries. Within high-tech sectors, high-tech services seem to be using workers with higher education more intensively than high-tech manufacturing, especially in urban areas.[35]

In order to explore the relationship between high-tech and higher education more systematically, we estimated the likelihood of being employed in high-tech industries, using a probit specification. These estimated relationships assess if the likelihood of participation in high-tech industries goes up with higher education, even after controlling for some other individual and region specific variables.

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[34] In constructing the overall index, the principal component method has been used to estimate the relative weights of the variables and the sectors. See Mohanty (2004) for details of each index

[35] It needs to be emphasized that 98.6% of rural workers and 92.6% of urban workers in all industries have no technical education.

The results presented in Table 7 show that higher education has a positive and significant effect on the likelihood of a worker's participation in high-tech industries. Interestingly, non-graduate technical education also has a positive and significant effect on participation in high-tech industries, although its impact is marginally lower than that of higher education.

Within high-tech industries there are some interesting differences. In high-tech manufacturing, though the impact of higher education is positive and significant, it is somewhat lower than the effect of non-graduate technical education. The situation is just the opposite in the case of high-tech services where higher education has a larger impact on the likelihood of being employed in the industry than non-graduate technical education.

As expected, while rural location affects the likelihood of working in high-tech industry adversely, *ceteris paribus*, male workers are more likely to be engaged in such industries. However, the negative effect of rural location seems to be outweighed by the education effect, thus suggesting that education may compensate for rural location. Local infrastructure does not seem to have any direct impact on a worker's participation in high-tech industries. The share of high-tech employment in the total state employment does have a positive impact but is somewhat significant only when one looks at all high-tech industries together.

Disaggregating higher education categories provides some interesting insights as seen in Table 8. The estimates suggest that the impact of technical higher education on the participation in high-tech industries is higher than that of non-technical higher education. Interestingly, when non-technical higher education is combined with non-graduate technical education, its impact is almost the same as that of technical higher education. The non-graduate technical education also has a positive impact but the magnitude is lower, close to that of non-technical higher education. The impact of other variables is similar.

Disaggregating the infrastructure index (Table 9) does not make any difference to the role of infrastructure in affecting high-tech employment. No sub-sector index approaches significance, with the possible exception of power's effect on services. It is possible that part of the impact gets captured by the share of high-tech employment in total state employment insofar as good infrastructure facilitates the growth of such industries. And the 'commutation-effect' through transport and 'local-outsourcing' effect through communication is not large, at least not as yet.

Apart from highlighting the strong effect of higher education on probability of high-tech employment, these results provide some interesting insights. In terms of their likelihood of getting high-tech employment, graduates with non-graduate technical education are similarly placed to technical graduates. This indicates that firms have some flexibility in combining technical and non-technical education. The links between higher education and high-tech employment are stronger in services than manufacturing across most categories. Non-graduate technical education helps to get manufacturing jobs more than services, while non-technical graduate education helps to get services jobs much more than manufacturing. This indicates, as expected, that manufacturing prefers technical education relatively more than services. Across gender, it does appear that services are relatively less biased, as compared to manufacturing.[36]

6. RESPONSE OF THE HIGHER EDUCATION SECTOR

The preceding analysis of the Indian labor market makes it clear that acquiring higher education, especially technical education does help to improve the chances of employment in the high-tech sector. Given the wage premium in this sector,[37] it is natural that there will be increasing demand for higher education as the pool of eligible population increases. How has the higher education sector responded to this development?

6.1. Growth in Institutions

Figure 2 shows the growth in the number of institutions over time. As can be seen, there has been substantial growth in recent years. The number of Universities shows a sharp trend in Figure 3a, and an even more rapid rise is seen in the number of deemed-to-be universities in the recent years, as shown in Figure 3b, with an increasing share of the private sector.[38]

6.1.1. Focused in Specific States

This stock of institutions is however concentrated in a few states, most of which are rich and relatively urban. Table 10 shows the state-wise number of institutions. Five southern states, viz. Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Maharashtra and two in the north, Haryana and Punjab have a Institutional Intensity Index (share of technical institutions divided by the share of population) of more than unity. Three of these states, viz. Maharashtra, Haryana and Punjab are the top three states in terms of per capita income while the other four occupy the sixth to ninth ranks. Five of these seven states are among the top six urbanized states in the

[36] Over 1999-2000 to 2004-05, the NSS data shows that the share of women in system analysts and programmers, which is the category of IT occupations showing the highest growth rate, has risen from 6.8% to 29.7%.
[37] For some estimates see Unni and Rani (2008); Bargain, Bhaumik, Chakravarty and Zhao (2007); Azam (2007); Kijima (2007); and Chamarbagwala (2006).

[38] There was a spurt in 2002, when twenty six such deemed to be universities came into being, of which nine were private institutions.

country (Andhra Pradesh is at the national average, while Kerala is below the national average). Though they comprise only 35.5% of the population and 36.4% of the universities, they account for 48.8% of all non-agricultural and non-household workers, and except for Andhra Pradesh, the ratio of such workers is higher than the national average.

These states have 53.4% of all deemed to be universities, 59.3% of all private deemed to be universities and 61.9% of the applications for deemed to be universities. They also have 74% of all engineering colleges and 69% of all medical colleges.

6.1.2. Rise in Private Participation

Moreover, most of these educational institutions are private. Table 11 shows that four of these states, Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka are in the top five by share of private engineering colleges and are the top seven states as measured by share of private medical colleges. [39]

This is consistent with an increasing trend of private higher education institutions and enrolment in recent years. In 2000-01, private unaided institutions constituted 42.6 per cent of the total number of higher education institutions, which increased to 63.21 per cent in 2005-06. The number of private unaided institutions (comprising of universities and colleges) almost doubled in a span of 4 years from 3223 in 2000-01 to 7720 in 2005-06. Similarly, the share of enrolment in private unaided higher education institutions has gone up from 32.89 per cent in 2000-01 (1.8 million) to 51.53 per cent in 2005-06 (3.2 million). The rise in government and private aided institutions was not as significant (UGC 2005-06) This is even more skewed for professional education, with 92% of engineering colleges, 64% of management (90% of hotel management) and 44% of medical colleges (Prakash, 2007; Agarwal 2006).

The surge in private engineering and technological education can be seen from the fact that the state of Andhra Pradesh had just one private engineering college in 1978, whereas the number rose to 174 in 2002, compared to 14 government colleges; and 53 medical colleges, compared to 20 government colleges. In Karnataka, their number rose from 17 in 1978 to 72 in 2002, in Maharashtra from 1 to 141, in Tamil Nadu from 0 to 137, in Haryana from 2 to 22, and in Uttar Pradesh from 1 to 58. The private sector also dominates degree and diploma courses in Ayurvedic, Unani, Homeopathy, and physiotherapy (Powar and Bhalla, 2004:178-82)

[39] If one ignores two states, Jharkhand and Uttarakhand, who top the list with just two private medical colleges and no public medical college.

6.2. Quality of Institutions

However, while the educational sector has certainly responded to the growth of the high tech sector, the quality of the response has not been as encouraging. We have previously pointed out the dissatisfaction of industry with the quality of the graduates and their efforts in remedial and supplementary education. Table 12 presents data on quality related aspects; the student teacher ratio; the quality of institutions (as assessed by NAAC) and the pass rate of graduates.

In terms of the student teacher ratio, three of the top five states are from the seven states that we have identified, but three of these, viz. Maharashtra, Punjab and Haryana, are also below the national average, while Andhra Pradesh is just at the national average. Similarly, in terms of proportion of below average institutions, while four of the seven states are among the lowest five states, three others, including Karnataka, Maharashtra and Haryana have a high proportion of institutions with a below average rating. When one looks at the pass rates, none of the seven states figure in the list of the top five.

Table 13 presents the pass rate for graduates for different disciplines. In none of the categories (except Nursing, where two of them are in the top five) does more than one of these seven states figure in the top five in terms of pass rates and often none are present. While it can be argued that this is because of the larger number of institutions and therefore a larger pool of intake, this is disturbing, especially when one considers the other data on quality and the employability of graduates in engineering disciplines, which is shown in Table 14.

6.3. Discussion

The institutional response is therefore one of significant growth in recent years, but in a few select states that are relatively richer and led by the private sector. Agarwal (2006) reaches similar conclusions about the role of the private sector (see Table 15). This is a natural progression from the situation where the universities have been largely public-sector, but a significant mode of undergraduate education has been affiliated colleges in the private sector.

The private sector is not just establishing professional colleges, it is also establishing universities. Given the low number of private universities established by state acts and the much larger number of “deemed to be universities”, the preferred entry mode of the private sector would appear to be this route, presumably because the regulatory constraints involved in establishing a university by state act is very large. With the approval of a large number of private “deemed to be universities”, the mix of universities is also changing. If all the 128 pending proposals of "deemed to be universities" were to be approved the number of universities and "deemed to be universities" would become almost equal.

However, this may not bring about greater variety in curriculum and course offerings since a number of the deemed to be universities are specialized institutions or engineering/technology institutions. Moreover, the UGC can be overbearing in its regulation, which extends to the nomenclature of degrees. For example, in 2001, it prohibited universities from offering a BIT and MIT or a BIS and MIS degree in Information Technology / Information Sciences, insisting instead that they award B.Sc. and M.Sc. degrees.[40]

The growth of deemed to be universities may have implications for the poor quality of the response. The regulation of higher education in India flows from the grant funding made available by UGC, but universities technically have complete autonomy in their decision making. The AICTE has more control over the institutes it regulates but the quality of the regulation has come in for criticism. However, even this regulation may not be effective.

Private deemed to be universities do not receive funding from UGC. As universities, they would arguably be outside the purview of the AICTE.[41] Besides, states are establishing affiliating universities, which could bypass the AICTE's regulation, given the concept of university autonomy. A number of technical institutions are now affiliated to a state university, which is really an affiliating organization rather than a teaching and research institution.[42] In the case of professional discipline, there is a single professional council which is the regulator and accreditation agency.

The system of regulation in India is therefore not geared to respond to the growing role of the private sector, which appears to be responding to a sharp spurt in demand for education. To add to this, there is now the emergence of smaller foreign educational institutions which are offering distance learning courses or off-site courses through Indian educational institutions.

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[40] See http://education.nic.in/technicaledu/ugc_bis.asp

[41] See Bharathidasan University vs. AICTE decided by the Supreme Court in 2001 which held that the "power to grant approval for starting new technical institutions and for introduction of new courses or programmes in consultation with the agencies concerned …would not cover a `University but only a `technical institution'. It is not entirely clear whether there is a distinction between universities established by State Acts, such as Bharathidasan University and deemed to be universities.

[42] For example, the West Bengal University of Technology has one hundred and twenty six affiliated colleges but no faculty of its own. All appointments to the University are through deputation, with a total of seven staff members, including four statutory officers and support staff.

Overall then, in response to the growing demand, India has seen significant growth in higher education. This growth is led by the private sector in select states that are relatively rich. The private sector has set up not just professional colleges, but also universities, with "deemed to be universities" (typically small) being the preferred private entry mode. The quality of this largely private sector response, however, is variable, due in part, to the nature of regulation, but also because of the inherent incentive structure in some of the private institutions.

7. HIGHER EDUCATION RESPONSE IN OTHER SOUTH ASIAN COUNTRIES

A number of the features described above are also common to other South Asian countries such as Bangladesh, Pakistan and Sri Lanka. The role of the government in these countries is still high, especially in Sri Lanka, but there is strong private sector growth wherever it is permitted or tolerated. Much of this growth is directed to meeting immediate labour supply needs of the high-tech industrial and service sectors, as in India. However, the limited size of such sectors in these countries means that we do not observe the kind of feedback loop that we are beginning to see in India.

7.1. Bangladesh

At present there are 80 universities in Bangladesh of which 53 are private and 27 are public. There are 1400 colleges providing tertiary level education, which are all affiliated to the National University[43]. Students in these affiliated colleges comprise 80 percent of all enrolment. After the enactment of the Private University Act in 1992, enrolment in private universities in Bangladesh grew rapidly, from 8718 students in 1998 to 35968 in 2001 and 91,648 in 2005, which is nearly half of the enrolment outside NU. In public universities, the comparable figures were 67531 students in 1998 to 92562 in 2001 and more than 115,929 in 2005, with. In 2005, there were and 6852 teachers, 5498 officers and 14643 employees in public universities compared to 3487 teachers, 1299 officers and 2356 employees in private universities.[44] The private universities

[43] National University serves as an affiliating university for degree and postgraduate degree levels education at different colleges and institutes. Three other public universities have no regular classroom instructions. These are Bangabandhu Sheikh Mujibur Rahman Agriculture University, the sole medical university, Bangabandhu Sheikh Mujib Medical University and Bangladesh Open University (BOU). BOU conducts 18 formal and 19 non-formal education courses. It has 12 regional centres for its 6 faculties and schools. Besides, there are 80 local centres and 1000 tutorials throughout Bangladesh. The data in this section is from BANBEIS (2006).

[44] Monem (2007) finds that regular faculty in public institutions work as part-time faculty in private institutions. This could be a device by private institutions to signal quality, by emphasizing the parent institutions of the faculty.

are small (see Figure 4) and of the 53, 46 are located in Dhaka metropolitan area. While over 80% of enrollment in general undergraduate degree courses is in private affiliated colleges, only 25% of the enrollment in honours courses and 17% of post-graduate courses is in such colleges. Similarly, in technical and vocational education, private offerings have been limited to the secondary and higher secondary school levels. This indicates that the private sector is currently serving the lower end of the market.

Aminuzzaman (2008) avers that quality evaluation processes in higher educational institutions, diagnostic review and evaluation of quality are generally absent, except for administrative reviews by the departmental chairman or deans of the faculties in the public universities. Private universities do however have to take mandatory approval from the UGC. He also states that industry and corporate support in research, which plays a very important role in research in areas of business, science and technology, is absent in Bangladesh. He contends that research activities in higher education is constrained by inadequate financial support, lack of a clear research programme, lack of facilities, such as laboratories, equipment, libraries, journals and lack of faculty incentives for research, e.g., time-bound promotion rules. In public universities, both revenue and expenditure per student are low[45], seventy percent of the budget is spent on salaries and research expenditure is less than 1%.

7.2. Pakistan

The small size of private universities is also seen in Pakistan; though not to as large an extent as Bangladesh. As shown in Figure 5, 36 of 111 universities in Pakistan have less than 1000 students and only 16 of the universities have more than 5000 students. However, their university status does enable them to, at least in principle, decide their curriculum, which is more than can be said for the many private affiliated colleges in Bangladesh and India.

Private participation is also more intensive at lower levels of education, as in Bangladesh. As compared to their share of undergraduate education, they have a minuscule share of PhDs (3% of men and 2% of women). In terms of enrolment, as shown in Table 16a, private institutions are concentrated by gender and in undergraduate education (18% of men and 9% of women) and postgraduate diplomas (21% of men and 9% of women). Private institutions have a large share of enrolment of post-graduate diplomas, usually professional courses. It is also regionally

[45] The revenue and expenditure per student in public universities is Taka 1,970 and 2.520 per annum respectively, while it is Taka 16,450 and 15,970 in private universities.

varied. However, in Sindh, where private institutions have the strongest presence, they account for 45% of men and 35% of women enrolled.

If one excludes the Islamabad Capital Territory (ICT), 37% of faculty in private institutions is part-time as compared to 20% of faculty in public institutions, as expected. In ICT, however, the position is remarkably reversed. In the private institutions, 90% of the faculty is full-time as compared to 11% in public institutions. For Pakistan as a whole, therefore, only 34% of the faculty in public institutions is full-time as compared to 68% in private institutions. The quality of this faculty, however, varies across public and private institutions. As seen in Tables 16b and 16c, even among full-time faculty in private institutions, only 21% have either an M.Phil or a Ph.D., as compared to 36% in public institutions.

7.3. Sri Lanka

In Sri Lanka, the National Policy on Education is rooted in the Ordinance No. 31 of 1939 and the Education Code with important amendments to the Ordinance made in 1945, 1946, 1947, 1951 and 1953. The University Grants Commission was established in 1979 to oversee the functioning of universities. The system has gradually expanded with the increase in student intake from 4950 in 1980 to 16,635 in 2006 with 15 universities comprising of 78 faculties, 425 departments and academic staff strength of 3818. The universities are almost entirely funded by the government. The control of by the national government limits the scope for experimentation and autonomy[46]. While the annual enrolment in universities is about 2.4% of their age cohort, there are many professional Institutes and cross border higher educational institutes operating in Sri Lanka offering diploma and degree level courses (see Gamage 2007). Considering all these students, the gross enrolment in Higher Education in Sri Lanka is more than 12% of the age cohort. Stephen (2007) finds nineteen private foreign education providers offering 74 courses in Sri Lanka. Of these courses, 28 are in Information technology, 10 each in Engineering and Business administration, 9 in Accounting, Finance, and Banking, and 5 in tourism and hospitality, i.e., 84% of course offerings are in these five sectors. There are 23 representatives of universities in 12 countries. Of these, the most numerous are Australia, United Kingdom, New Zealand, Malaysia and Singapore, in that order. Currently there is no formal system of Quality Assurance and Accreditation of diplomas and degrees awarded by cross border educational institutes.

[46] The government policy of Sri Lanka is not to charge any fees from the undergraduate and diploma level students. However the government has allowed them to share the cost of post graduate programs, short term training programs, contract research, consultancy and other services. About 95% of the University budgets still come from the treasury funds.

Given this environment, Esham (2008) finds that the common types of UIL in Sri Lanka are limited to consultancies and training programmes, student internships, and informal interactions at third party meetings, e.g., conferences. Among departments, Engineering had relatively more and Humanities relatively less interactions. Academics and industrialists both agree that the lack of established, mechanisms is a key obstacle. Heavy workload and lack of research facilities limit university capabilities, while industry continues to hold a dim view of the commercialization potential of university research and interest among academics. Whereas individual inventors claimed 72% of patents and private institutions 22% in 2000, just 6% went to public institutions, including universities.

7.4. Discussion

The review of experience in Bangladesh, Sri Lanka and Pakistan brings out a few common features. First, the extent of UIL in all these three countries is low, even in Pakistan, which has demonstrated high-tech capabilities as a nation, e.g., in the nuclear industry. This, however, does not fully apply in certain sections of the labour market, as discussed below. Second, there remains extensive government control of the sector, most so perhaps in Sri Lanka. Third, the private sector finds its niche in a variety of environments. It is reasonably quick to respond to labour market demands, as is evidenced by their behaviour in the three countries. However, they focus mostly on the low-hanging fruit, e.g., pass degrees and secondary professional education in Bangladesh, professional and cross-border higher education in Sri Lanka and undergraduate and post-graduate diplomas in Pakistan. Quality is an issue in all three countries, with faculty being a critical constraint.

We have argued that the growth of the private educational sector in India has been in response to the growth of the high-tech industry, especially the IT and ITES sectors. Arguably, the initial establishment of these industries was facilitated by the availability of high quality skills of sufficient numbers, produced for the most part by the public education system. Furthermore, one can also claim that, at the time that these industries were established, India was the most preferred business location for reasons other than education. However, the subsequent rapid increase in demand by these sectors has been met by the growth of private educational institutions of variable quality. The combination of first-mover advantages and agglomeration economies could imply that, as long as the Indian supply chain continues to produce reasonably and relatively (compared to the region) employable graduates, it would be difficult for other countries in the region to develop similar industries. A prospective investor, many of whom are now domestic Indian companies, would look at the thick labour markets in Indian cities such as

Bangalore, Chennai, Delhi, Hyderabad, Mumbai, Pune and now even Kolkata and would find it preferable to being among the initial investors in places like Dhaka, Karachi or Colombo. Given that none of these countries can, at least at the moment, offer the assurance that the supply of high-tech graduates can be maintained, as the industry scales up[47], nor offer the assurance that the quality of graduates would be substantially better than that of India, the strength of the labour market linkage between the high-tech industry and higher education sector in India almost acts as an entry barrier for other countries in the region.

8. POLICY IMPLICATIONS

We have explored the various linkages between the higher education sector and high-tech industry in India, with brief references to other countries in South Asia. We find that the links outside of the labor market are rather weak though they may be growing with the increased interest of high-tech industry in research, as for example, in the pharmaceutical and bio tech sector in India. However, such linkages are more with specialized research institutions rather than universities. While this is not a desirable state of affairs, it is only to be expected. We argue below that the reasons for this lie primarily in the regulatory features of the system.

8.1. Separation of Teaching and Research

Fundamentally, Indian universities are not involved in research, which is conducted by specialized science, technology and even social science institutions. This divorce of research from teaching is evident in our findings. Low supply of research-inclined faculty is also evident. According to some evidence ratio of PhDs to graduate engineers is less than 1% (Banerjee and Muley, 2008). Even within the public sector, the separation of teaching and research embodied in the establishment of specialized research institutions is "slowly depleting research-driven universities of their best faculty".[48]

8.2. Inappropriate Faculty Incentives

As noted earlier, universities in India have very limited autonomy with respect to faculty compensation, which is largely uniform across universities. Private universities and some specialized institutions can offer differential compensation, either in direct salary or in research

[47] In the case of Sri Lanka, such an assurance is also constrained by the limited size of its labour market. However, in Pakistan and Bangladesh, the number of technical graduates is also quite limited, though the overall size of the education sector is much larger.

[48] Padmanabhan Balaram, director of IISc, Bangalore, quoted in Yarnell (2006).

support. Research-inclined students self-select into public or private labs (industry) or go abroad essentially due to differences in compensation (Banerjee and Muley, 2008). In addition to the level of compensation, the lack of facilities and automatic promotion also diminish the research orientation in faculty. Automatic promotion also blunts incentives to move between universities so that a critical mass of good faculty cannot agglomerate leading to a sub-optimal dispersion of good faculty. This in turn adversely affects the next generation of faculty. Absence of research oriented, internationally visible faculty groups results in low level of interest among the researchers looking for post-doctoral opportunities, which in turn adversely affects building a research eco-system critical for productive research all over the world.[49] If faculty compensation and work environment is unattractive, quality erodes over time. This affects the very intellectual resource and capacity needed to generate new industry-relevant knowledge.

Box 3: Protection and Utilization of Public Funded Intellectual Property Bill 2008

Among the many shortcomings of the Indian faculty reward system, is the low weight being accorded to industry interfaces, except perhaps in management education. While it is still debatable whether the creation of new *commercial knowledge* and ventures should be an important objective of the academic institutions, the Indian government is taking some intermediate measures to change this situation. A correlate of the Bayh-Dole Act, the Protection and Utilization of Public Funded Intellectual Property (PUPFIP) Bill 2008 was introduced in the Indian Parliament on December 15, 2008. Universities and research institutions can patent the results of publicly funded research and inventors as well as institutions can get a share of royalties and licensing fees. The researcher (inventor) is to receive a minimum of 30 percent of the royalties from the public funded intellectual property (PFIP). However, she is restricted from publishing or disclosing the PFIP without prior notice of thirty days to the government. A violation will deprive the institution from future public funding and make it liable to repay the grant with interest. This is seen as a way to supplement the limited public budget for R&D.

There are however a number of issues with the effectiveness of this strategy. As Mowery et al (2001) show, it is not clear that Bayh-Dole had a significant effect on the content of research in American universities. Data on patenting, licensing and other types of commercialization show that the Act did not facilitate technology transfer and commercialization (So, et al, 2008). Furthermore, the ability of public funded research to address questions of limited commercial value but significant public good may be compromised by reducing the difference between private and public research. This is especially the case in developing countries where public benefits and commercial advantage may diverge significantly because of the low incomes of large sections of the population. As So, et al (2008) argue, "…*the focus on royalty returns at the expense of public goods may be misplaced*".

This limited effectiveness of Bayh-Dole may be because incentives may not always act in the manner anticipated. It is important to note that university faculty is self-selected such that they are not driven primarily by monetary incentives. As such, if increasing the commercial value of

[49] The authors are grateful to Pratap B Mehta for suggesting this implication. Salmi (2009) has a similar discussion and the negative effects of the separation of higher education into specialized *grande ecoles* and universities in France. See also Yarnell (2006).

research requires limiting its benefits, the incentives of the researcher may be adversely affected if her motivation comes from the public benefits of the research. Here, it is the design of the incentives under Bayh-Dole type legislation that is called into question. Perversely, however, such monetary incentives may be more effective in developing countries. If so, PUPFIP Bill may well be more successful in India than the Bayh-Dole was in the USA, but that success may not be in the social interest, which may be better served by an expansion of the public budget for competitively awarded research grants (see Aghion, et. al. 2009).

Thus, more than willingness, which could, in principle, be addressed by incentives (see Box 3); it is ability that is increasingly becoming rare in universities. Given the growing opportunities available elsewhere, this has meant that good faculty is in short supply especially in professional disciplines.[50] It is noteworthy in this context that many firms who have tried to build linkages with academia have been dissatisfied, due to quality related issues (Frew et al, 2007).[51] This has led to a downward spiral.

8.3. Limited Autonomy of Universities

We have already stated that the labour market linkages are the strongest and most widespread UIL in India. However, despite a vigorous response from the private sector to the growth in the high-tech industry, the quality of the average graduate remains poor. This is significantly driven by different problems of governance. A few of these key issues which relate to the autonomy of universities are discussed below.

8.3.1. Reluctance to treat professional education as a commercial activity

Even for professional education, there is extreme reluctance to recognize it as a commercial activity and as Mehta and Kapur (2007) note; this is a position that has been buttressed by a series of court judgments. The effort to preserve access to higher education has focused on keeping fees low, rather than raising access to educational finance and scholarships. This inability of universities to decide on their fees increases the dependence of the university on the UGC and the state government and consequentially constrains its autonomy, compromises its work environment and limits diversity within the system.

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[50] As noted in Agarwal (2006), the Report of the Board on Faculty Development of the AICTE (March, 2004) projects a serious shortage in faculty, given the growth in the number of institutions and increase in student intake. In fact, faculty shortage is cited as a reason for reduction of intake in 1346 approved engineering institutions and prohibition of intake in seven institutions.

[51] See also Maria et al (2003) for some cases where such partnerships were discontinued because what was promised was not delivered. Lack of mutual trust along with low quality infrastructure has been suggested as other constraints on such linkages (Bhattacharya and Arora, 2007).

8.3.2. Standardization of Curriculum and Affiliation of Colleges

An affiliating system wherein colleges prepare students for a university-administered examination based on a uniform curriculum at the university level leads to very large universities and reduces the colleges to teaching institutions and limits innovation in curriculum, except to the extent allowed in Autonomous Colleges. To add to this, the regulatory institutions such as UGC appear to be involved in exercises to standardize curriculum.[52] It is difficult to introduce innovations in curriculum as there are far too many colleges, whose faculty would have to be retooled. Consequently, many colleges continue with ossified content. This situation has a higher adverse impact where technology is changing faster. In such a scenario, it is impossible to think of innovative multi-disciplinary courses that can induce higher research orientation and leverage increasing convergence across various scientific and engineering disciplines.[53]

8.4. Poor Accreditation Capacity

The lack of a robust accreditation system adds to the problem. The incipient accreditation bodies are all in the government sector and have limited capacity to accredit the growing number of institutions. As Agarwal (2006) remarks the current system of "accreditation serves little purpose". The reputation of institutions is dependent more on its selectivity in intake of students than on its curriculum and pedagogy. This makes the role of industry in signaling quality of higher education ambiguous. Most of the professional courses in engineering, medicine, management etc. rely on entrance exams that are Independent from school-leaving exams. Companies can simply leverage the stringent selection process of technical higher education and de-emphasize the quality of instruction. This is especially true when the employees would have to be re-skilled after recruitment, e.g., in IT, where engineers from different streams enter the software sector. Such a perspective implies that the choice of

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[52] The UGC has however reiterated its belief in the freedom of universities in designing the curriculum, which it describes as "fundamental" to its policies. It has said that "impression… that the UGC has undertaken an exercise to design a nationally uniform curriculum… is not correct". It has however formed a committee to evolve a framework that would help in ensuring and enhancing the quality and relevance of curriculums. When this framework is available, it would be shared with universities, who would be free to adopt or adapt the curriculum framework. See The Tribune, January 8, 2008

[53] This argument has lesser relevance for AICTE and other Council Approved Institutions, deemed or state act universities. Efforts are on in a few institutions like National Center for Biological Sciences (NCBS), Indian Institute of Science (IISc), National Chemical Laboratories (NCL) to develop multi-disciplinary research programmes (Yarnell, 2006). Given the difficulties in developing inter-disciplinary courses and research programmes in existing institutions, the government is experimenting with new Indian Institutes of Science Education and Research which focus on multi-disciplinary curriculum at the undergraduate level but these will remain limited to a minuscule number of students.

employees is less quality and discipline dependent as these employees, thereby muting industry's response to indifferent quality.

8.5. Lack of a Credit and Qualification Framework

Credible accreditation would also allow transferable credits that would enable students to choose their pace of learning and choice of institution, is not yet available in India. The acquisition and especially upgradation of skills is affected by the absence of a system of transferable credits, [54] which retards the acquisition of qualifications by persons who are already employed, and who do not have the opportunity for full-time study or are continuously in one location, as would be required by the part-time courses that are currently on offer.

In summary, the ability of institutions to respond positively to industry and create a virtuous feedback loop depends on regulatory structure. Most of our findings relating to the poor state of UIL can be linked to some regulatory features or their second-order impact. Table 17 summarizes these arguments. As Mehta and Kapur (2007) note:

> *"The most acute weakness plaguing India's higher education system is a crisis of governance. Its most visible manifestation is a crisis of faculty. The generation that was inspired by a broad commitment to the public good has retired or will do so soon. There is little likelihood of sufficient replenishment, given entrenched mediocrity in institutions with lifetime appointments, few competitive pressures and abysmal governance. The result has been the academic equivalent of Gresham's law – the bad drives out the good. The prevailing political ideological climate in which elite institutions are seen as anti-democratic, finds its natural response in political control to influence admissions policies, internal organization, and the structure of courses and funding. As quality deteriorates, students are less and less willing to pay the very resources without which quality cannot be improved."*

The solutions to enhancing both labor market and non-labor market linkages thus appear to intersect at the core issue of faculty quality. While the indifferent quality of private response may indicate a bigger role for regulation, the current structure of regulation has resulted in the restricting private response at the high end, while neglecting its growth at the lower end. Addressing these regulatory failures in higher education is necessary to strengthen the links between higher education and high-tech industry.

[54] The Association of Indian Universities did hold a seminar on this issue in 2003, entitled "Threats and Opportunities in Higher Education in context of GATS and Networking among Indian Universities and Credit Transfer with Universities in India. CAB (2005) also mentions the need for credit system.

9. CONCLUDING OBSERVATIONS

In this paper, we have adopted an eclectic approach to linkages between High-Tech industries and the higher education sector. While it draws upon the NIS, triple helix and UIL frameworks, it does not situate itself solely within any one of the discourses. In the context of our initial discussion on NIS, and ignoring the financial aspects for the moment, it is useful to think of four entities, viz. the government, industry, specialized research institutions[55] and universities. Initially, industry, specialized institutions and universities were embedded within the state. With the gradual liberalization of industry, the first of these three to become relatively independent was industry. Since then, while specialized institutions have become somewhat more autonomous, universities have arguably become less autonomous. However, as we noted, a new class of relatively autonomous private institutions offering technical and professional education have also emerged. Even this limited degree of autonomy in research and educational institutions, coupled with a relatively high degree of agency in industry has led to many linkages between these two sectors, especially in externally oriented service and industrial sectors like IT and pharmaceuticals despite the difficult regulatory environment. The size of the high-tech private sector in India, particularly the IT industry, has permitted it to try and evolve a compensating response to the regulatory obstacle. Industry associations and individual firms are working with educational institutions to provide supplementary educational inputs that are customized to the needs of the industry or in the case of vocational training, of particular firms. In a research intensive sector like pharmaceuticals, we observe higher level linkages between select firms and elite institutions, which are supported by government funds, e.g., the NMITLI. However, the limitations of relying on such a response can be seen in the muted participation of sectors other than IT, ITES and pharmaceuticals, and also in other countries of the region where such a response is lacking given the absence of a large high-tech sector. Beyond this limited intersection it is difficult to find either the autonomy or the intellectual capability in the research and educational institutions or even the demand from the firms. In this sense, it can be seen as an intermediate stage between triple helix I to triple helix II, though some portions of the relationship have elements of triple helix III. It is this variegated nature of UIL that make it difficult to adopt a single analytical metric.

Other features of the NIS can affect the linkage decisions of different actors. For example, a significant constraint in India is the absence of early stage funding for startups. Most of the so-called venture capital (VC) activity in India is actually is “growth funding” and takes the form of

[55] These include the CSIR laboratories, the IITs and IIMs, IISc and such institutions.

private equity. As Dhingra (2007) notes, a limited amount of true VC funding has just started to happen but we have a long way to go, before it goes beyond well-established sectors such as IT. In such a situation, some firms may choose to link not to domestic educational and research institutions but to external institutions. This may be because external institutions come with their linkages into to the broader financial system that is necessary to commercialize innovations.

The success of such industry-led initiatives, were it to happen, should not detract from the underlying failure in the regulation of higher education that has led to the emergence of these initiatives in the first place[56]. Not only is it limiting, the response may also be deeply inequitable, as industry picks the few cherries in the educational system and concentrates its resources on them. It also runs the risk that the production of skills will become too tailored to the current industrial structure which would limit the flexibility that is necessary in any workforce in today's globalized environment.[57]

Measured against the metric of broadening and deepening UIL, this tendency of the higher education system to narrow its focus is disturbing and may be preventing the growth of many industries. Neither does the industry engagement, except for a few instances in biotech and pharmaceuticals, lead to the depth of knowledge that would be needed to assimilate more complex technologies. While liberalization has made industry much more nimble in effecting structural change, the same is not true for universities. The larger challenge is in designing appropriate work environments and compensation packages that will attract talented young people to academia. This will go a long way in alleviating the constraints on availability of 'research-inclined' faculty in academic institutions, which implies that the value addition from a more intensive exchange with industry remains limited. As a consequence of the lack of appropriate faculty, the industry initiative may remain restricted to the important but still shallow levels of enhancing the quality of entry level employees. The creation of a virtuous circle seems to have been arrested by an archaic regulatory structure, with constraints on establishing viable new institutions, hiring faculty and salaries that can be paid to them, and changes in curriculum. As noted above, many of these governance problems also permeate other South Asian countries such as Bangladesh, Sri Lanka and Pakistan.

[56] Such coping behavior as a response to a failure of public services is common in many other sectors in India, such as water, electricity, health, etc.

[57] Wolf (2002) suggests that that investment in basic skills such as mathematics or writing are may be much more relevant than investment in domain-specific skills

It is useful to benchmark the current situation to the three qualities of a world class university proposed by Salmi (2009), viz. **(A)** "*high concentration of talent",* composed of faculty and students, researchers from across the world **(B)** "*abundant resources*" from endowments, public resources, tuition and competitive research funding, which enhances the pedagogy and enables advanced research to be conducted, and **(C)** :"*favorable governance features*" that encourage innovation and academic freedom, foster strategic vision and enable flexibility to allow the university to make decisions autonomously and manage resources without bureaucratic interference, such as restrictions on faculty compensation. In a separate study of European and US universities, Aghion et. al. (2009) find that it is extremely important to avoid endogamy in faculty, i.e., recruitment of one's own graduates. Internationalization of faculty is therefore an important component. They also stress the significance of merit-based competitions for research funding. University autonomy and competition for research funding are positively linked to university research output. By giving more generous stakes for research competitions, governments can make research universities use their funding better, use their autonomy better, and response more productively to local competition. [58] These findings broadly support the analysis in Salmi (2009), who also relies on an earlier study by Aghion, et. al. (2008).

Each pair of these three attributes of Salmi (2009) can produce high quality graduates (A and B), significant research (A and C), transfer of technology (B and C), but in order to have all three outcomes, it is necessary that all the three attributes are present in the university. In our review, we describe a situation in India, where there are some elements of (A), primarily in the student quality, and some elements of (B) at some institutes of national importance like the IITs, IISc and IIMs but rarely any element of (C). Consequently, India manages to produce a certain number of outstanding graduates, but is unable to achieve either of the other two outcomes.

In conclusion, it is perhaps better to focus on how far UIL has traveled in India, rather than on where it is currently situated. Until recently, the lack of competitive pressure in a protected inward looking market with government licensing meant that private sector in India was not pro-active in seeking out linkages to advance their research capabilities. The bulk of research was done in public institutions, again with little regard for market demands. Two broad trends are merging to alter this picture. First, rising competition in recent years seems to be leading to a growing number of alliances among firms and among research institutions / universities and industry, especially in globally oriented, research – intensive industries like pharmaceuticals and

[58] Even external funding was found to be more efficacious if universities enjoyed autonomy and faced competition from other institutions.

bio-technology. Concomitantly, the rising fiscal reticence of government and the push to commercial orientation of education has meant that academic institutions are no longer financially protected. While this can have several deleterious consequences[59], especially if it is carried too far and married with a stifling governance environment, as is the case in India, it does push some of these institutions to be more orientated towards industry, alleviating a key mindset constraint that has restricted UIL in the past. As both these trends play out in the future, one can expect, in a positive scenario, more demand for UIL and consequently a derived demand for relieving of regulatory constraints that currently limit the capacity of universities to undertake cutting edge research, e.g., in faculty compensation and university autonomy. To some extent, the recent suggested increase in faculty compensation addresses this problem, but it still seem likely that faculty compensation will be individualized to any degree. On university autonomy, though, there appears to be little progress. On the other hand, in a negative scenario, industry, which is now relatively free of restrictions may choose to cope with the governance failures by exiting, perhaps to foreign academic and research institutions, which can have other collateral benefits such as venture funding, as alluded to earlier, or self-providing, which would usually be sub-optimal. In the final analysis, research in industry and university is complementary and mutually reinforcing and the success of industry-academia linkages likes in the intellectual exploitation of these complementarities.

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[59] Universities need to be autonomous not just from the government but also from the industry if a critical part of their research agenda is to be self-driven and cutting-edge. As such, they should not become too financially dependent on either of these two sources.

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Table 1: Different Types of University-Level Institutions in India

	Central	Private	State	State Act	Grand Total
University	20	7	209		236
Deemed to be University	36	59	8		103
Institute of National Importance	13				13
Established by State Act				5	5
Grand Total	56	66	217	5	357

Source: University Grants Commission website http://www.ugc.ac.in

Table 2: Distribution of Universities by the share of Fees in the Income of the Universities (late 1990s)

<10%	10 - 30%	30 - 50%	>50%
Hyderabad	Andhra	Guru Jambeswar	Mumbai
Kalyani	Bhavnagar	Punjab	Karnataka State Open
Maharshi Dayanand	Calcutta	S.N.D.T. Women's	Kuvempu
Rabindra Bharati	Dibrugarh	Bangalore	M.D. Saraswati
Tamil	Dr. Harsingh		Pune
Visva Bharati	Sri Venkateshwara		YCM Open
Anna	Calicut		
Delhi	Goa		
J.N.Vyas	Kannur		
Osmania	Karnataka		
	Kumaon		
	Mangalore		
	Mysore		
	Saurashtra		
	IGNOU		

Source: University Finances in India. New Delhi: National Institute of Educational Planning and Administration, 2000 (mimeo) reproduced from CABE (2005)

Table 3a: Number of Patents across Five-Year Periods

	Indian Assignee					Foreign Assignee		
	Individual	Private Firm	Public Sector	University/ Institution	NGO	Private Firm	State	University/ Institution
1976-80	16	11	3	3	0	50	0	5
1981-85	15	10	3	1	0	34	9	4
1986-90	27	10	16	1	0	36	16	15
1991-95	31	20	35	2	0	114	8	12
1996-2000	70	90	167	13	0	272	12	20
2001-2005	82	267	677	45	5	831	2	31
Total	241	408	901	65	5	1337	47	87

Table 3b: Share across Types of Assignees

	Indian Assignee					Foreign Assignee		
	Individual	Private Firm.	Public Sector	University/ Institution	NGO	Private Firm.	State	University/ Institution
1976-80	6.6%	2.7%	0.3%	4.6%	0.0%	3.7%	0.0%	5.7%
1981-85	6.2%	2.5%	0.3%	1.5%	0.0%	2.5%	19.1%	4.6%
1986-90	11.2%	2.5%	1.8%	1.5%	0.0%	2.7%	34.0%	17.2%
1991-95	12.9%	4.9%	3.9%	3.1%	0.0%	8.5%	17.0%	13.8%
1996-2000	29.0%	22.1%	18.5%	20.0%	0.0%	20.3%	25.5%	23.0%
2001-2005	34.0%	65.4%	75.1%	69.2%	100.0%	62.2%	4.3%	35.6%

Table 3c: Share across Types of Assignees

	Indian Assignee					Foreign Assignee		
	Individual	Private Firm.	Public Sector	University / Institution	NGO	Private Firm.	State	University/ Institution
1976-80	18.2%	12.5%	3.4%	3.4%	0.0%	56.8%	0.0%	5.7%
1981-85	19.7%	13.2%	3.9%	1.3%	0.0%	44.7%	11.8%	5.3%
1986-90	22.3%	8.3%	13.2%	0.8%	0.0%	29.8%	13.2%	12.4%
1991-95	14.0%	9.0%	15.8%	0.9%	0.0%	51.4%	3.6%	5.4%
1996-2000	10.9%	14.0%	25.9%	2.0%	0.0%	42.2%	1.9%	3.1%
2001-2005	4.2%	13.8%	34.9%	2.3%	0.3%	42.8%	0.1%	1.6%
Total	7.8%	13.2%	29.1%	2.1%	0.2%	43.3%	1.5%	2.8%

Source: Gupta (2008)

Table 4: Patent Characteristics by Sub-Classification

Patent Sub-Classification	Proportion of Indian Inventors	Average Backward Citation	Average Forward Citation	Share of Indian Entities
Agriculture, food chemistry	92.6%	1.4	3.7	86.7
Chemical engineering	86.8%	3.1	10.4	82.0
Metallurgy	86.4%	4.3	8.1	80.5
Organic Chemistry	87.4%	1.9	5.4	73.2
Chemical and petrol industry	87.6%	2.4	7.2	72.2
Biotechnology	82.8%	0.6	2.5	71.4
Pharmaceuticals, cosmetics	85.7%	1.9	7.4	70.6
Materials processing	79.0%	36.4	49.8	66.7
Macromolecular Chemistry, Polymers	71.2%	2.1	10.5	47.2
Control Technology	71.4%	7.2	15.2	36.9
Optics	58.9%	19.1	33.5	36.4
Medical Technology	69.2%	18.8	18.4	31.3
Surface Technology	63.8%	13.5	28.9	21.4
Semiconductor Devices	54.5%	8.0	9.9	12.2
Electrical machinery	67.0%	5.5	28.0	7.1
Information Technology	67.5%	3.3	12.8	6.3
Telecommunications	73.3%	4.4	11.0	4.5
Audio visual Technology	68.6%	4.4	21.1	3.9

Notes:

1. Share of Indian entities includes public sector institutions, private firms, universities and institutions and private individuals.
2. Share of Indian inventors is calculated as the number of Indian assignees in a patent to the total number of assignees.

Source: Athreye and Puranam (2008)

Table 5: Industries classified as High-Tech

3-Digit NIC Code	Description
241	Manufacture of basic chemicals
242	Manufacture of other chemical products
243	Manufacture of man-made fibers [This class includes manufacture of artificial or synthetic filament and non-filament fibers.]
291	Manufacture of general purpose machinery
292	Manufacture of special purpose machinery
293	Manufacture of domestic appliances, n.e.c.
300	Manufacture of office, accounting and computing machinery
311	Manufacture of electric motors, generators and transformers
312	Manufacture of electricity distribution and control apparatus [electrical apparatus for switching or protecting electrical circuits (e.g. switches, fuses, voltage limiters, surge suppressors, junction boxes etc.) for a voltage exceeding 1000 volts; similar apparatus (including relays, sockets etc.) for a voltage not exceeding 1000 volts; boards, panels, consoles, cabinets and other bases equipped with two or more of the above apparatus for electricity control or distribution of electricity including power capacitors.]
313	Manufacture of insulated wire and cable [insulated (including enameled or anodized) wire, cable (including coaxial cable) and other insulated conductors; insulated strip as is used in large capacity machines or control equipment; and optical fiber cables]
314	Manufacture of accumulators, primary cells and primary batteries
315	Manufacture of electric lamps and lighting equipment
319	Manufacture of other electrical equipment n.e.c.
321	Manufacture of electronic valves and tubes and other electronic components
322	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
323	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
331	Manufacture of medical appliances and instruments and appliances for measuring, checking, testing, navigating and other purposes except optical instruments
332	Manufacture of optical instruments and photographic equipment
333	Manufacture of watches and clocks
341	Manufacture of motor vehicles
342	Manufacture of bodies (coach work) for motor vehicles; manufacture of trailers and semi-trailers
343	Manufacture of parts and accessories for motor vehicles and their engines [brakes, gear boxes, axles, road wheels, suspension shock absorbers, radiators, silencers, exhaust pipes, clutches, steering wheels, steering columns and steering boxes and other parts and accessories n.e.c.]
352	Manufacture of railway and tramway locomotives and rolling stock
353	Manufacture of aircraft and spacecraft
359	Manufacture of transport equipment n.e.c.

Note: n.e.c is not elsewhere classified

Source: Mukhopadhyay, Narayanan and Bhardwaj, (2006)

Table 6: Percentage of Workers with Higher Education in High-Tech Industries

	All High-Tech Industries		High-Tech Manufacturing		High-Tech Services		All Industries	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Graduate and Post-Graduate Education	18.7	42.4	10.3	23.7	36.5	65.9	2.7	16.2
No Technical Education	87.1	76.8	86.6	79.2	88.3	73.9	98.6	92.6

Source: Authors' calculations based on individual level data National Sample Survey, Round 61

Table 7: Determinants of Participation in High-tech Industry (All Graduates)

	All high-tech industry		High-tech manufacturing		High-tech services	
Variable	Marginal effect	P>|z|	Marginal effects	P>|z|	Marginal effects	P>|z|
Age	-0.000124	0.00	-0.000106	0.00	-8.81E-06	0.24
Rural dummy	-0.024291	0.00	-0.015218	0.00	-0.006815	0.00
Male dummy	0.005572	0.00	0.003227	0.00	0.001745	0.00
Infrastructure index	4.89E-06	0.74	4.69E-06	0.68	7.44E-07	0.92
State Share of high-tech employment	0.000950	0.06	0.000412	0.24	0.000342	0.13
All graduates	0.045689	0.00	0.007687	0.00	0.034418	0.00
Non-graduate technical education	0.040615	0.00	0.026002	0.00	0.010265	0.00
Observed probability	0.019166		0.011349		0.007816	
Predicted probability	0.008276		0.005322		0.002101	
Number of observations	244849		244849		244849	
Wald $chi^2(29)$	3958.68		1897.17		2865.62	
Prob > chi^2	0.0000		0.0000		0.0000	
Pseudo R^2	0.1978		0.1448		0.2606	
Log pseudolikelihood	-18614.40		-13005.99		-8275.08	

Note: Estimates of state dummies have been suppressed

.

Table 8: Determinants of Participation in High-tech Industry (Disaggregated Education)

	All high-tech industries		High-tech manufacturing		High-tech services	
Variables	Marginal effects	P>|z|	Marginal effects	P>|z|	Marginal effects	P>|z|
Age	-0.000121	0.00	-0.000104	0.00	-7.92E-06	0.30
Rural dummy	-0.024286	0.00	-0.015194	0.00	-0.006846	0.00
Male dummy	0.005606	0.00	0.003201	0.00	0.001772	0.00
Infrastructure index	5.10E-06	0.73	5.11E-06	0.65	8.58E-07	0.91
State Share of high-tech employment	0.001037	0.038	0.000455	0.18	0.000369	0.11
Non-technical graduate	0.038146	0.00	0.003750	0.00	0.032824	0.00
Technical graduate	0.086855	0.00	0.025713	0.00	0.049432	0.00
Graduates with non-graduate technical education	0.080286	0.00	0.018771	0.02	0.055741	0.00
Non-graduate technical	0.041013	0.00	0.026084	0.00	0.010402	0.00
Observed probability	0.019166		0.011350		0.007816	
Predicted probability	0.008313		0.005296		0.002127	
Number of observations	244849		244849		244849	
Wald $chi^2(31)$	4033.68		1934.39		2904.67	
Prob > chi^2	0.0000		0.0000		0.0000	
Pseudo R^2	0.2002		0.1488		0.2608	
Log pseudolikelihood	-18560.63		-12945.36		-8271.93	

Note: Estimates of state dummies have been suppressed

Table 9: Determinants of Participation in High-tech Industry (Disaggregated Infrastructure)

	All high-tech industries		High-tech manufacturing		High-tech services	
Variables	Marginal effects	P>|z|	Marginal effects	P>|z|	Marginal effects	P>|z|
Age	-0.000121	0.00	-0.000104	0.00	-7.91E-06	0.30
Rural dummy	-0.024285	0.00	-0.015189	0.00	-0.006845	0.00
Male dummy	0.005607	0.00	0.003200	0.00	0.001772	0.00
Power index	0.000136	0.37	-0.000022	0.92	0.000072	0.13
Communication index	-0.000016	0.89	0.000106	0.52	-0.000033	0.39
Transport index	-0.000040	0.43	-0.000047	0.59	-8.79E-06	0.56
State Share of high-tech employment	0.001036	0.04	0.000456	0.18	0.000367	0.11
Technical graduate	0.086854	0.00	0.025705	0.00	0.049431	0.00
Non-technical graduate	0.038150	0.00	0.003749	0.00	0.032831	0.00
Graduates with non-graduate technical education	0.080280	0.00	0.018766	0.02	0.055738	0.00
Non-graduate technical education	0.041013	0.00	0.026078	0.00	0.010403	0.00
Observed probability	0.019166		0.011349		0.007816	
Predicted probability	0.008313		0.005294		0.002127	
Number of observations	244849		244849		244849	
Wald $chi^2(33)$	4041.89		1940.87		2907.61	
Prob > chi^2	0.0000		0.0000		0.0000	
Pseudo R^2	0.2002		0.1488		0.2609	
Log pseudolikelihood	-18560.52		-12945.30		-8271.77	

Note: Estimates of state dummies have been suppressed

Table 10: State-Wise Number of Institutions

State	Share of Population	General Colleges	Technical Colleges	Medical Colleges	Others	Tech Index[1]
Andhra Pradesh	7.37%	1,340	261	53	93	2.08
Haryana	2.05%	166	69	8	35	1.83
Karnataka	5.13%	930	120	172	214	2.77
Kerala	3.10%	186	66	40	82	1.67
Maharashtra	9.42%	1,208	177	116	128	1.52
Punjab	2.37%	212	27	49	51	1.56
Tamil Nadu	6.05%	445	222	97	184	2.57
Assam	2.59%	317	3	7	21	0.19
Bihar	8.07%	743	7	23	63	0.18
Chhattisgarh	2.02%	213	2	2	32	0.10
Gujarat	4.93%	507	44	57	177	1.00
Himachal Pradesh	0.59%	89	3	7	24	0.83
Jammu & Kashmir	0.98%	50	4	6	34	0.50
Jharkhand	2.62%	117	5	8	8	0.24
Madhya Pradesh	5.88%	760	60	28	209	0.73
Orissa	3.57%	700	37	30	102	0.91
Rajasthan	5.50%	611	39	24	113	0.56
Uttar Pradesh	16.17%	1,009	69	34	702	0.31
Uttarakhand	0.83%	86	2	1	28	0.18
West Bengal	7.81%	374	54	19	33	0.46
		10,063	1,271	781	2,333	

[1] The Tech Index is the State's share of professional colleges divided by its population share

Source: Selected Educational Statistics, Ministry of Human Resource Development, 2004-05

Table 11: State-wise Distribution of Technical Educational Institutions by Ownership

	Number of Government Medical Colleges	Number of Private Medical Colleges	Share of Private Sector	Number of Government Engineering Colleges	Number of Private Engineering Colleges	Share of Private Sector
Andhra Pradesh	14	14	50.0%	10	213	95.5%
Haryana	1	2	66.7%	7	29	80.6%
Karnataka	4	22	84.6%	13	99	88.4%
Kerala	7	8	53.3%	31	51	62.2%
Maharashtra	19	18	48.6%	16	133	89.3%
Punjab	3	3	50.0%	11	27	71.1%
Tamil Nadu	12	7	36.8%	16	234	93.6%
Assam	3	0	0.0%	3	0	0.0%
Bihar	6	2	25.0%	4	3	42.9%
Chhattisgarh	2	0	0.0%	2	9	81.8%
Gujarat	8	4	33.3%	9	16	64.0%
Himachal Pradesh	2	0	0.0%	2	3	60.0%
Jharkhand	0	2	100.0%	4	2	33.3%
Madhya Pradesh	5	1	16.7%	6	47	88.7%
Orissa	3	0	0.0%	6	38	86.4%
Uttar Pradesh	10	2	16.7%	25	58	69.9%
Uttarakhand	0	2	100.0%	5	4	44.4%
West Bengal	7	0	0.0%	15	37	71.2%
TOTAL	106	87	45%	185	1003	84%

Source: Kapur and Mehta (2007)

Table 12: State-wise Indicators of Quality

State	Student Teacher Ratio[1]	Proportion of Colleges Rated Below Average[2]	Proportion of Students Passing Final Exams[3]	Proportion Gainfully Employed within two years[4]
Andhra Pradesh	21	29%	48%	48.8%
Haryana	27	59%	71%	
Karnataka	14	47%	64%	64.0%
Kerala	16	11%	66%	94.3%
Maharashtra	26	55%	62%	75.5%
Punjab	25	17%	74%	54.5%
Tamil Nadu	16	21%	46%	33.5%
Assam	16	76%	60%	76.8%
Bihar	19	64%	73%	62.8%
Chhattisgarh	34	45%	76%	
Gujarat	41	34%	75%	62.0%
Himachal Pradesh	29	42%	69%	
Jammu & Kashmir	18	8%	79%	41.2%
Jharkhand	25	47%	71%	
Madhya Pradesh	35	55%	76%	52.8%
Orissa	18	74%	75%	39.5%
Rajasthan	30	61%	76%	74.5%
Uttar Pradesh	46	52%	63%	87.0%
Uttarakhand	40	43%	77%	
West Bengal	29	47%	71%	82.7%
INDIA	23	47%	63%	51.2%

Sources:

UGC Annual Report 2005-06; Selected Educational Statistics, MHRD, 2004-05

http://www.naacindia.org Quality categories used in this table are adapted from NAAC grading

University Development in India, Basic Facts and Figures, Examination Results - 2002, UGC

IAMR Manpower Profile 2005

Table 13: Percentages of Students Passing Final Exams by Subject

State	Computer Science / Applications	Engineering	Management	Medical and Dental	Nursing
Andhra Pradesh	79%	72%	74%	74%	92%
Haryana	85%	89%	71%	59%	
Karnataka	88%	85%	79%	78%	100%
Kerala	76%	71%	76%	88%	98%
Maharashtra	97%	73%	47%	70%	90%
Punjab	96%	90%	96%	73%	96%
Tamil Nadu	34%	77%	50%	70%	98%
Assam	98%	81%	85%	60%	66%
Bihar	92%	67%	74%	90%	100%
Chhattisgarh	100%	86%	100%	77%	99%
Gujarat	96%	92%	86%	77%	100%
Himachal Pradesh		83%	85%	78%	
Jammu and Kashmir		36%	89%	83%	
Jharkhand	100%	97%	100%	70%	
Madhya Pradesh	88%	91%	56%	87%	96%
Orissa	96%	86%	90%	87%	
Rajasthan	88%	88%	57%	82%	88%
Uttar Pradesh	62%	85%	87%	73%	
Uttarakhand	99%	98%	91%		
West Bengal	100%	94%	99%	95%	
INDIA	49%	79%	61%	75%	97%

Source: University Development in India, Basic Facts and Figures, Examination Results - 2002, UGC

Table 14: Percentage Gainfully Employed within two years for different disciplines

State	Chemical	Civil	Computer Science	Electronics / Communication	Electrical	Mechanical
Andhra Pradesh	31	56	54	57	59	36
Haryana						
Karnataka	66	67	68	60	61	62
Kerala	100	82	100	100	84	100
Maharashtra	83	68	83	60	80	79
Punjab	45	45	81	58	41	57
Tamil Nadu	23	38	35	33	43	29
Assam	95	65	93	94	51	63
Bihar	67	67		84	77	82
Chhattisgarh						
Gujarat	57	59	80	69	49	58
Himachal Pradesh						
Jammu & Kashmir	29	22	95	8	50	43
Jharkhand						
Madhya Pradesh	29	90	66	42	46	44
Orissa	47	40	33	36	40	41
Rajasthan	62	51	100	89	72	73
Uttar Pradesh	100	71	100	80	87	84
Uttarakhand						
West Bengal	85	87	84	79	79	82

Source: Institute of Applied Manpower Research Manpower Profile 2005

Table 15: Typology and growth trends of higher education institutions

Type	Ownership	Financing	Number of institutions*	Number of students*	Growth trends
Universities under the Government	Public	Public	240	1,000,000	Not growing
Private Universities	Private	Private	7	10,000	Emerging on the scene
Deemed Universities (Aided)	Private or Public	Public	38	40,000	Growing slowly
Deemed Universities (Unaided)	*Private*	*Private*	*63*	*60,000*	*Growing rapidly*
Colleges under the Government	Public	Public	4,225	2,750,000	Not growing
Private Colleges (Aided)	Private	Public	5,750	3,450,000	Not growing
Private Colleges (Unaided)	*Private*	*Private*	*7,650*	*3,150,000*	*Growing rapidly*
Foreign Institutions	Private	Private	150	8,000	Emerging on the scene

* These are approximate figures based on analysis of primary data for the year 2005/06 by Agarwal (2006)

Source: Reproduced from Table 1 in Agarwal (2006)

Table 16a: Share of Private Enrolment in Pakistan by level of degree (2006-07)

	Undergraduate	Postgraduate	Postgraduate (More than 16 years)	PhD	Postgraduate Diploma
Male	18% (239,274))	21% (83,264)	8% (16,433)	3% (6.659)	34% (4,560)
Female	9% (183,963)	9% (58,145)	3% (8,523)	2% (2,584)	14% (2,480)
Total	14% (423,237)	16% (141,409)	7% (24,956)	3% (9,243)	27% (7,040)

Note: The numbers in parenthesis denotes the total enrolment at each level of education.

Table 16b: Full Time Faculty Members by Highest Qualification in Pakistan (2003-04)

Sector	Bachelors	Masters	Master(16+)	M. Phil.	Ph.D.	Total
Distance Learning	9	110	0	22	41	182
Public	1059	4525	1319	1019	2549	10471
Private	1151	1480	508	284	540	3963
Total	**2219**	**6115**	**1827**	**1325**	**3130**	**14616**

Table 16c: Share of Full Time Faculty Members by Highest Qualification, Pakistan (2003-04)

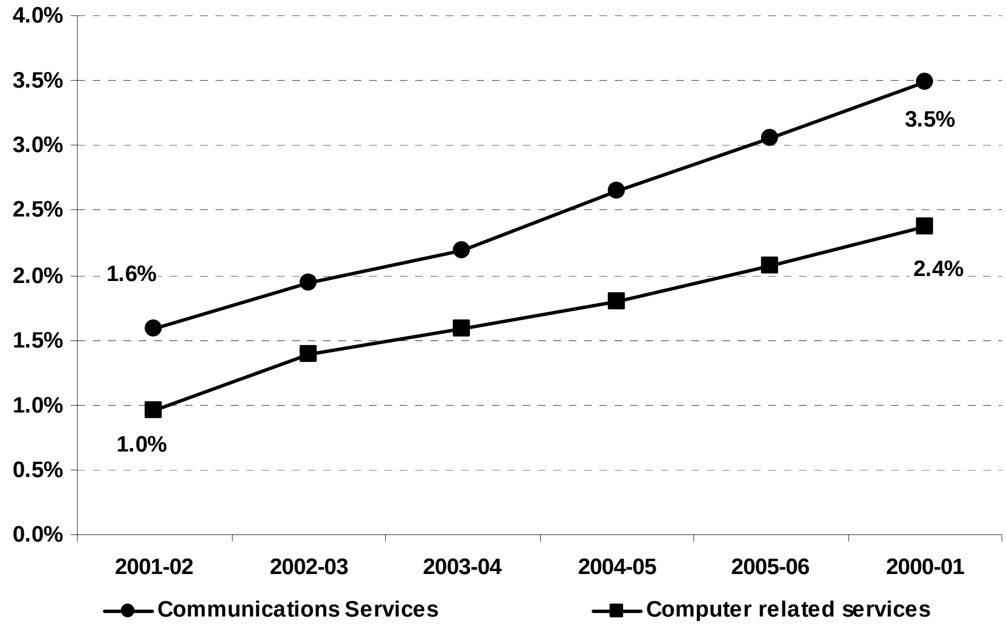
Sector	Bachelors	Masters	Master(16+)	M. Phil.	Ph.D.	Total
Distance Learning	4.9%	60.4%	0.0%	12.1%	22.5%	100.0%
Public	10.1%	43.2%	12.6%	9.7%	24.3%	100.0%
Private	29.0%	37.3%	12.8%	7.2%	13.6%	100.0%
Total	15.2%	41.8%	12.5%	9.1%	21.4%	100.0%

Source: Statistical Booklet on Higher Education, Higher Education Commission of Pakistan

Table 17: Summary of Key Arguments

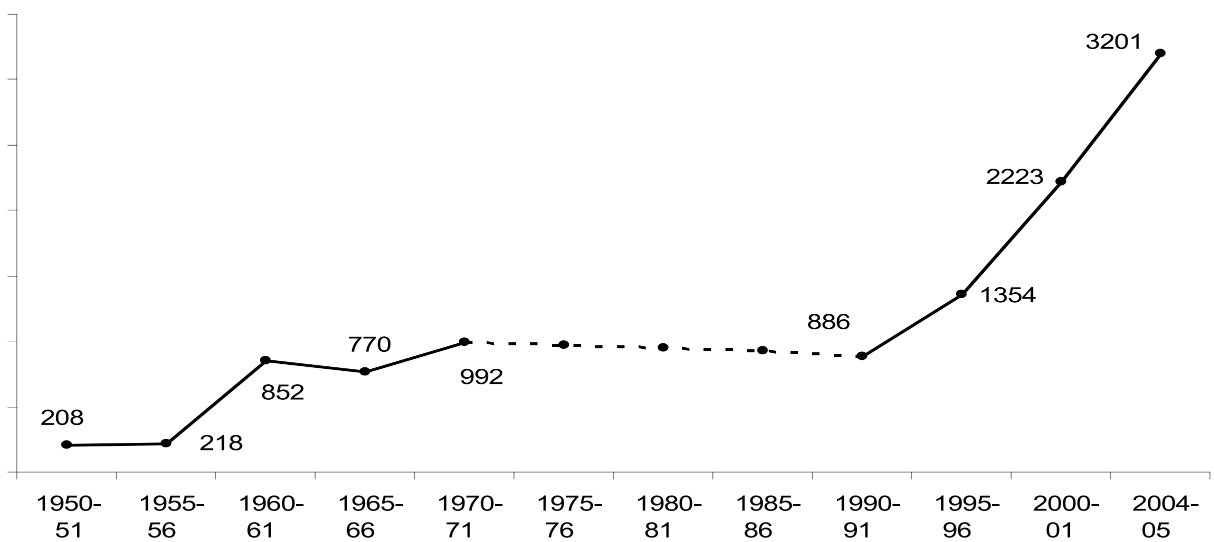
Finding	Feature Related to Regulation of Higher Education	Other Features
Low Knowledge Creation	Separation of teaching and research Inappropriate faculty incentives such as low compensation and automatic promotion leading to poor quality of faculty	Poor facilities
Low Enterprise Creation	Second order effect of low knowledge creation	Lack of venture financing
Concentration of Private Response in Few States	Differential entry regulation and state-level fee regulation across states	Agglomeration of industrial activity in a few states
Indifferent Quality of graduates	Second order effect of poor quality of faculty Affiliation of colleges restricts ability to change curriculum Poor accreditation system Lack of transferable credits limits lifelong learning	Highly selective entrance examination makes it easier for industry to tolerate poor instruction
Low Involvement of Industry	Second order response to Indifferent quality	Limited need in current competitive environment (this is becoming less relevant) Growing ability to link with foreign research

Figure 1 Growth in Share of High-tech GDP in India



Source: Authors' computation from data released by the Central Statistical Organisation, Govt. of India. .

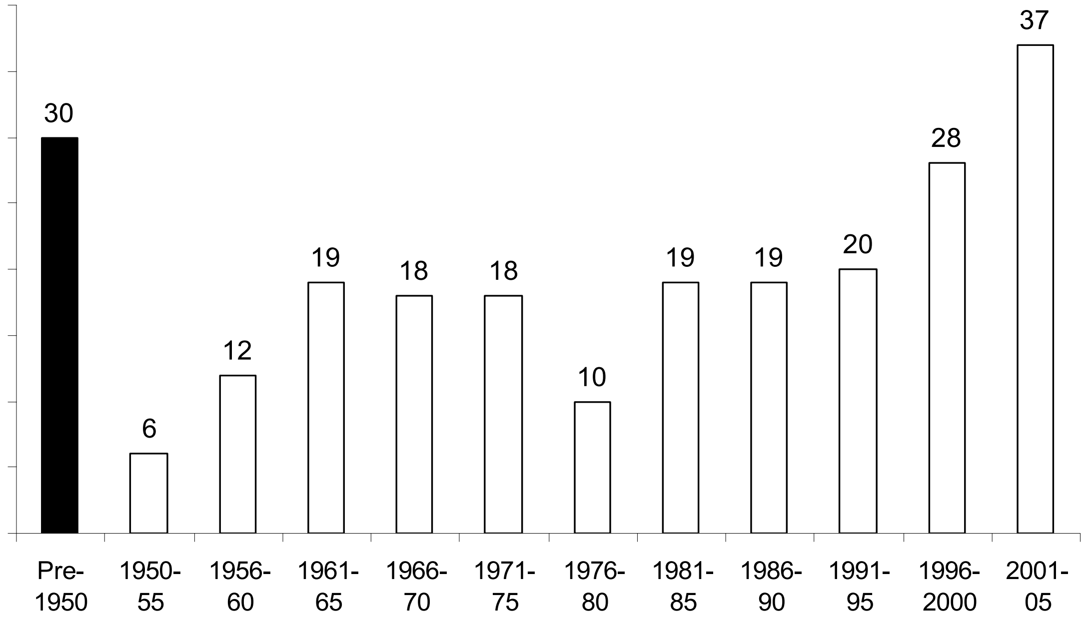
Figure 2 Growth of Colleges for Professional Education in India



Source: Selected Educational Statistics, Ministry of Human Resource Development, 2004-05

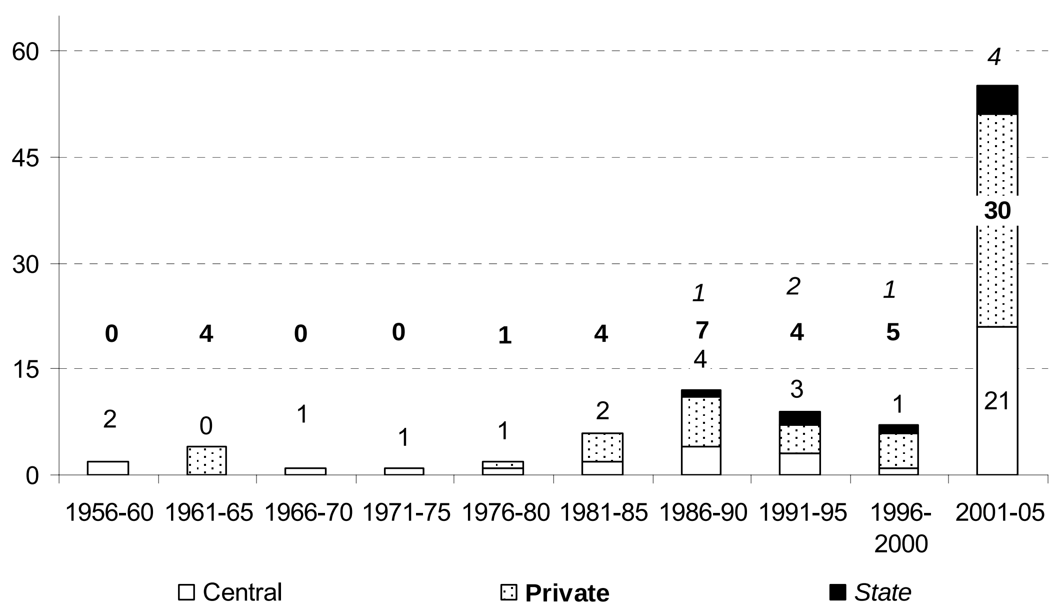
Note: Data for the years, 1975-76, 1980-81 and 1985-86 are non-comparable since they include institutions for post-matric courses

Figure 3a : New Universities Established in India by Five-Year Periods



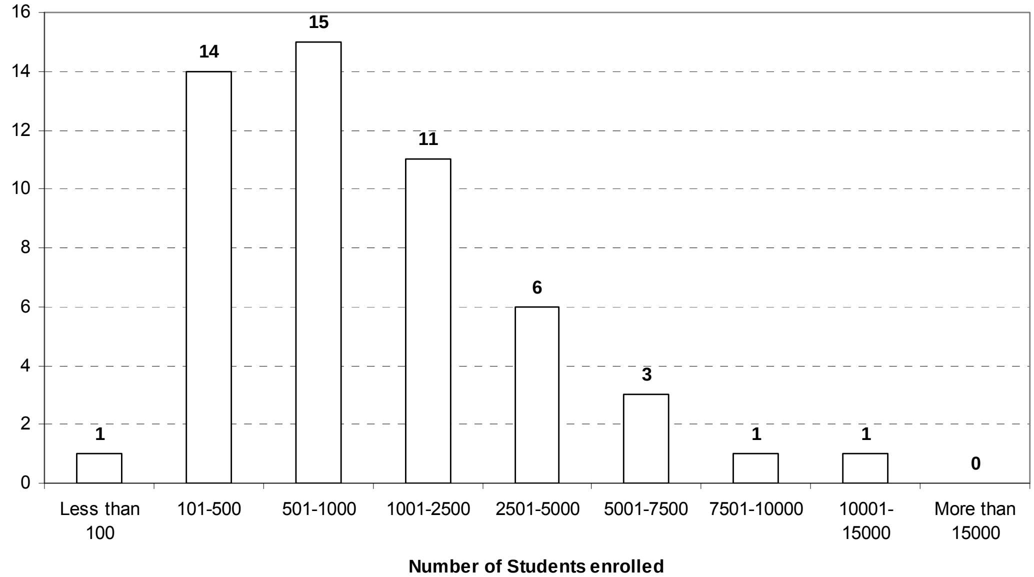
Source: Calculated from the dates of establishment provided in UGC Annual Report (2005-06)

Figure 3b : New Deemed-to-be Universities Established in India by Five-Year Periods



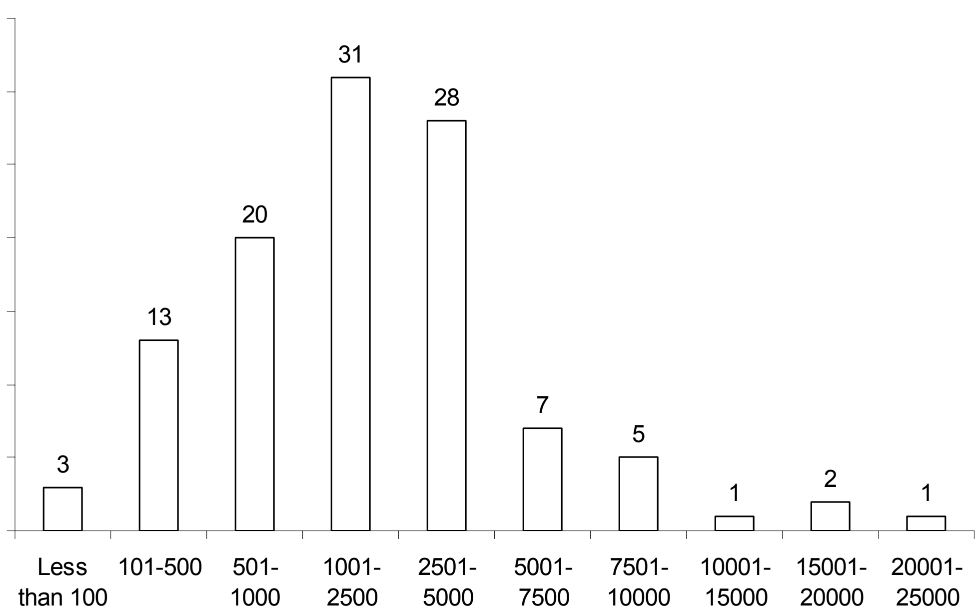
Source: Calculated from the dates of establishment provided in UGC Annual Report (2005-06) with authors' analysis as to ownership

Figure 4: Distribution of Universities in Bangladesh by Size-Class of Students



Source: Calculated from data available in National Education Survey (Post Primary) 2005, Bangladesh Bureau of Educational Information and Statistics (BANBEIS), Ministry of Education, August 2006

Figure 5:Distribution of Universities in Pakistan by Size-Class of Students



Source: Calculated from data available at Higher Education Commission of Pakistan

http://www.hec.gov.pk/QualityAssurance/download/1319_Enrollment-in-UniversitiesDAIs-2001-06-7-2-08-websie-7-07.xls

Appendix 1

Structural and Regulatory Aspects of Higher Education in India

The higher education sector in India is quite complex and is governed through a variety of intricate regulations that affect the structure of the sector, the admission and funding criteria and several other working conditions.

Structure

Different types of universities exist:

(a) Central Universities and Institutes of National Importance

A central university is one that is established by an Act of Parliament. The central Government has established twenty universities that are funded and controlled by it. The President of India is the ex-officio Visitor of the universities.

The institutes of national importance are autonomous bodies outside the control of the University Grants Commission that controls the governance of universities. These institutions have different funding structures, and their own curricula, academic calendar and compensation system for the faculty, which however varies only marginally from the UGC and is nowhere equivalent to the private sector. All the Indian Institutes of Technology (IITs) are in this group[60].

(b) State universities

State Universities are those that are charted under State Legislatures. In almost all the States, the Governor of the State is the ex-officio Chancellor of the universities in that particular State.

(c) Deemed to be Universities

Deemed universities are a novel feature in India. To obtain the status, institutions should generally be engaged in teaching programs and conducting research in chosen fields of specialization which were innovative and of very high standards. An institution will be considered a deemed to be Universities in pursuance of Section 3 of the UGC Act, which declares rules for Fitness of Certain Universities for Grants.

(d) Private Universities.

Private universities are usually established through a State Act by a sponsoring body for e.g. 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), i.e., the entity has to be a non-profit organization. Each private university is required meet the relevant provisions of the UGC Act, 1956.

Regulation of the Higher Education System in India

The regulatory system is composed of multiple bodies. The University Grants Commission (UGC), AICTE and the 13 professional councils regulate higher education in India in conjunction with central and state education departments.

[60] Postgraduate management courses were started in the early 1960's. The Indian Institutes of Management (IIM), which are Societies, award postgraduate diplomas as they do not have the authorization to award degrees.The doctoral programs at IIMs also do not award PhDs, but the graduates are called "Fellows".

(a) Central Advisory Board of Education (CABE)

The Central Advisory Board of Education is the highest advisory body to advise the Central and State Governments in the field of education. It was first established in 1920 and dissolved in 1923 as a measure of economy, but was revived in 1935 and has been in existence ever since. The functions of the CABE include reviewing the progress of education from time to time, to appraise the implementation of education policies of the Central and State Governments, to advise regarding co-ordination between the Centre and State Governments as well as the State Governments and NGOs for educational development.

(b) University Grants Commission (UGC)

The University Grants Commission was constituted in 1952. The UGC is the only grant-giving agency in the country which has been vested with two responsibilities: that of providing funds and that of coordination, determination and maintenance of standards in institutions of higher education. The UGC Act of 1956 lays down its powers and function, which are:

1. Monitoring developments in the field of collegiate and university education; disbursing grants to the universities and colleges
2. Promoting and coordinating university education
3. Determining and maintaining standards of teaching, examination and research in universities
4. Framing regulations on minimum standards of education
5. Serving as a vital link between the Union and state governments and institutions of higher learning
6. Advising the Central and State governments on the measures necessary for improvement of university education.

The UGC Act also lays the following provisions, emanating from its grant giving function, viz:

1. The UGC may, after consultation with the University, conduct an inspection of any department or departments for the purpose of ascertaining the financial needs of a University or its standards of teaching, examination and research.
2. The UGC can prescribe Minimum Standards of Instruction[61]. The right of conferring degrees can be exercised only by a University established or incorporated by or under a Central Act, a Provincial Act[62] or a State Act or an institution deemed to be a University or an institution specially empowered by an Act of Parliament to confer or grant degrees.

[61] The Act also lays down UGC Rules regarding Fitness of Universities for Grants, Rules for Recognition of College in Terms of Regulations, and UGC Regulations regarding the Minimum Standards of Instructions for the Grant of the First Degree, and UGC Regulations regarding Minimum Qualifications for Appointment of Teachers in Universities and Colleges

[62] Provincial Act is an Act made by the Governor in Council, Lieutenant Governor in Council or Chief Commissioner in Council of a Province under any of the Indian Councils Acts or the Government of India Act, 1915, or an Act made by the Local Legislature or the Governor of a Province under the Government of India Act, or an Act made by the Provincial Legislature or Governor of a Province or the Coorg Legislative Council under the Government of India Act, 1935.

(c) All India Council for Technical Education (AICTE)

All India Council for Technical Education (AICTE) was established in November 1945 as a national level Apex Advisory Body to promote development of Technical education in the country in a coordinated and integrated manner. It has since become a statutory body constituted under the All India Council for Technical Education Act, 1987. The Council is meant for planning, formulation and maintenance of norms and standards, quality assurance through accreditation, funding in priority areas, monitoring and evaluation, maintaining parity of certification and awards and ensuring coordinated and integrated development and management of technical education. “Technical Education”, under the Act means programs of education, research and training in: (i) Engineering/Technology; (ii) Architecture / Town Planning; (iii) Management; (iv) Hotel Management & Catering Technology; (v) Pharmacy; and (vi) Applied Arts & Crafts.

All technical programs must be approved by the AICTE[63], but not all programs are accredited by AICTE[64]. Approval of AICTE for new Institutions or for starting new programs is based on:

- Credibility of Institutional Management and the Program providers
- Assurance of Compliance to AICTE Norms and Standards
- Prior approval by the State Government and University or other competent authority
- Market sensitivity of program output, to avoid imbalance in supply of qualified manpower.

(d) Professional Councils

In addition to AICTE, there are other statutory professional councils that are responsible for recognition of courses, promotion of professional institutions and providing grants to undergraduate programmes and various awards. These are: (i) Medical Council of India (MCI); (ii) Pharmacy Council of India (PCI); (iii) Indian Nursing Council (INC); (iv) Dentist Council of India (DCI); (v) Central Council of Homeopathy (CCH); (vi) Central Council of Indian Medicine (CCIM); (vii) Rehabilitation Council of India (RCI); (viii) Bar Council of India (BCI); (ix) National Council for Teacher Education (NCTE); (x) Distance Education Council (DEC); and (xi) Indian Council for Agriculture Research (ICAR).

(e) State Councils

Some states have established State Councils for higher education. These are advisory bodies entrusted with the task of monitoring compliance with standards. Some of these Councils have significant operational functions, including conduct of “entrance examinations for admission to institutions of higher education” and rendering advice on admissions. For example, the Andhra Pradesh State Council of Higher Education performs the following additional functions:[65]

- Sanction of new Unaided Private Degree and Law Colleges

[63] Except with the approval of the Council, no new Technical Institution or University Technical Department shall be started; or no course or program shall be introduced by any Technical Institution, University or University Department or College; or no Technical Institution, University or Deemed University or University Department or College shall continue to admit students for Degree or Diploma courses or program; no approved intake capacity of seats shall be increased or varied. Approval is based on the fulfillment of certain pre-conditions

64 Accreditation is a process of quality assurance, whereby a program in an approved institution is critically appraised at intervals not exceeding six years to verify that the institution or the program meets the Norms and Standards prescribed by the AICTE from time to time.

[65] http://www.apsche.org/aboutus.asp.

- Sanction of BCA Course in the existing UG Colleges and sanction of P. G. and P.G. Diploma Courses in the existing P.G. Colleges
- Conduct of Vice-Chancellors' meetings
- Conduct of Training Programmes, Refresher Courses to the Degree College Teachers
- Conduct of Workshops on up-gradation of U.G. Syllabi and innovation of new Courses for the development of Higher Education
- Coordination activities with the Government

However, only a few other states, such as Tamil Nadu, West Bengal, Uttar Pradesh, Tripura, Himachal Pradesh and Arunachal Pradesh have established these Councils.

The powers with respect to higher education in other states are concentrated in the State Higher Education Departments. The roles and functions of these Departments range from formulation, implementation and monitoring of plan schemes; provide facilities for higher education; introduce new courses; sanctioning of salaries and grants; conducting examinations; imparting technical education at various levels; conduct teacher training programs.

(f) National Assessment and Accreditation Council (NAAC)

National Assessment and Accreditation Council (NAAC) is an autonomous institution established by the University Grants Commission in 1994. Its responsibility is to assess and accredit institutions of higher education that volunteer for the process, based on prescribed criteria. NAAC's process of assessment and accreditation involves the preparation of a self - study report by the institution, its validation by the peers and final decision by the Council.

The main purpose of assessment and accreditation is improvement and enhancement of quality, recognizing excellence, accountability, information providing and benchmarking. The assessment is mainly based on seven major criteria such as the following: (i) Infrastructure and Learning Resources; (ii) Curricular Aspects; (iii) Teaching – Learning and Evaluation; (iv) Research, Consultancy and Extension; (v) Student Support and Progression; (vi) Organization and Management; and (vii) Healthy and Innovative Practices.

(g) National Board of Accreditation

The National Board of Accreditation (NBA) was instituted by the AICTE in 1994 in order to assess the qualitative competence of educational institutions from the Diploma level to the Post-Graduate level in Engineering and Technology, Management, Pharmacy, Architecture, Town Planning and related disciplines. The NBA also assesses and assures the quality of the various constituent elements of these educational institutions, such as academic ambience, infrastructure, financial resources, physical resources, human resources, supporting systems like library resources, computational resources, and avenues to mould and develop the students' personality and learning characteristics**.**

(h) Association of Universities (AIU)

The AIU was established in 1925 to promote university activities, by sharing information and cooperation in the field of education, culture, sports and allied areas. Its membership includes traditional universities, open universities, professional universities, Institutes of National Importance and deemed-to-be universities. In addition, there is a provision of granting of Associate Membership to universities of neighboring countries.

The AIU performs a number of functions, such as - to act as a bureau of information and to facilitate communication, coordination and mutual consultation amongst universities; to act as a liaison between the universities and the Government (Central and State Governments) and to co-operate with other universities or bodies (national or international) in matters of common interest; to promote or to undertake such programs as would help to improve standards; to assist universities in obtaining recognition for their degrees, diplomas and examinations from other universities, Indian as well as foreign; etc

Courses of Study

India broadly follows the pattern of higher educational qualifications in the United Kingdom. There are three principal levels of qualification within the higher education system. These are: (i) Undergraduate level; (ii) Post-graduate level; and (iii) Doctoral level (an intermediate research degree of M.Phil. is also awarded[66]).

An undergraduate degree in arts, commerce and sciences is of three years duration, after twelve years of school education. Some universities offer a separate honors program that requires more intensive specialization in a given subject.

An undergraduate degree in a professional field of study such as agriculture, dentistry, engineering and technology, pharmacy, and veterinary medicine is of four-year duration, while architecture and medicine takes five and five and a half years respectively. Other professional degrees in education, journalism and librarian-ship are second degrees and an undergraduate degree in law can either be taken as an integrated degree lasting five years after twelve years of schooling or as a three-year course as a second degree.

A post graduate degree is normally of two-year duration. It could be coursework based without thesis or include a research component.

Diploma courses are also available at the undergraduate and postgraduate level. At the undergraduate level, it varies between one to three years in duration; postgraduate diplomas are normally awarded after one to years of study.

Admissions

For undergraduate education, the admission is usually on the basis of marks secured at the qualifying examination, though some institutions may hold an entrance examination. However, admission to undergraduate and postgraduate programs in professional disciplines is almost invariably done on the basis of nationwide or state-wide competitive examinations, followed by 'counseling' of students about their choice of discipline based on the rank achieved in an the examination and whether or not their qualifying high school examination is from within or outside the state. There are two nationwide examinations for engineering and a number of states hold their own "common entrance test". Different institutions can opt to use either the state test or the national test, but institutions that are affiliated to a state university usually choose to use the state test. Similarly, there are two major nationwide examinations for management education, one of which is used by institutions in different states. However, a number of other tests are also now being held.

Funding

Currently, the amount of fees that can be charged has to be justified by the institution before a quasi-judicial body in each state. Further, the central funding is directed largely to central institutions and little of it supports higher education at the state level. Student fees are increasingly becoming an important source of finance for educational institutions (also see main text and Table 2).

[66] A Master of Philosophy (M.Phil.) is taken after the completion of a postgraduate Degree. This can either be completely research based or can include course work as well.

Appendix 2:

Collaborations between Firms and Universities/Research Institutions in India in Pharmaceuticals and Biotechnology

Universities/Public Research Institutes	Company
IISc (Indian Institute of Science)	1. Bangalore Genei Ltd.; 2. Biological E.; 3. Genotypic; 4. Monsanto; 5. Bhat Biotech Bangalore; 6. Nicholas Piramal; 7.Rallis; 8.Strand Genomics; 9.Xcyton Bangalore; 10. Dr.Reddy's laboratories; 11. Syngene; 12. Shanta Biotechnics Hyderabad; 13. Indian Immunlogicals; 14. Cadila Pharma, Ahmedabad.
ICGEB (International Centre for Genetic Engineering and Biotechnology)	1. Bharat Biotech, International Bangalore; 2. Biological E.; 3. Rallis; 4. Shanta Biotechnics, Hyderabad; 5.Wockhardt; 6. Xcyton Bangalore
NII (National Institute of Immunology)	1. Panacea Biotech New Delhi; 2. Shantha Biotechnics Hyderabad; 3. Nicholas Piramal India; 4. Ranbaxy Laboratories; 5.Dabur India; 6. Reliance Life Sciences*
AIIMS (All Indian Institute of Medical Sciences)	1. Bharat Biotech International Bangalore; 2. Shanta Biotechnics Hyderabad; 3. Xcyton Bangalore; 4. LiferCare Innovations; 5.Bharat Biotech Ltd. Hyderabad
IICT (Indian Institute of Chemical Technology), Hyderabad	1. Shapoorji Pallonji Biotech Park, Hyderabad; 2. Dr.Reddy's Laboratories; 3. Bharat Biotech Ltd. Hyderabad; 4. Ingenovis; 5. Bharat Biotech International Bangalore
CCMB (Centre for Cellular and Molecular Biology)	1. Bangalore Genei Ltd.; 2. Biological E.; 3. Ingenovis; 4. Shanta Biotechnics Hyderabad; 5.Shapoorji Pallonji Biotech Park Hyderabad
CBT (Center for Biochemistry Technology)	1. Bharat Biotech Ltd. Hyderabad; 2. Nicholas Piramal; 3. Themis; 4. Genotypic
IIT (Indian Institute of Technology), Kanpur	1. TCS (Tata Consultancy Service); 2. LiferCare Innovations; 3. Themis
ICAR (Indian Council Agricultural Research)	1. Avesthagen; 2. Bangalore Genei Ltd.; 3. Cadila Pharma Ahmedabad
Madurai University Madurai (Tamil Nadu)	1. Genotypic; 2. Nicholas Piramal; 3. Rallis
CDRI (Central Drugs Research Institute), Luck now	1. Ranbaxy Laboratories New Delhi, 2. Stand Life Sciences, 3. Span Diagnostics, Surat
NCL (National Chemical Laboratories)	1. Hindustan Antibiotics Ltd, Pune; 2. Ranbaxy; 3. Dabur
Anna University Chennai	1. Shanta Biotechnics Hyderabad; 2. Nicholas Piramal; 3. Ranbaxy
IGIB (Institute of Genomics and Integrative Biology)	1. Nicholas Piramal India; 2. Bharat Biotech Ltd. Hyderabad; 3. Panacea Biotech New Delhi
BARC (Bhabha Atomic Research Centre)	1. Shantha Biotechnics Hyderabad; 2. Dr.Reddy's Laboratories
Delhi University	1. Dr Reddy's Lab; 2. Dabur India
Jawaharlal Nehru University Delhi	1. Panacea Biotech New Delhi; 2. Shantha Biotechnics Hyderabad
Osmania University Hyderabad	1. Shantha Biotechnics Hyderabad; 2. Shapoorji Pallonji Biotech Park Hyderabad

Collaborations between Firms and Universities/Research Institutions in India in Pharmaceuticals and Biotechnology	
Universities/Public Research Institutes	**Company**
Cancer Research of Technology Mumbai (CRT)	1. J Mitra and Co, New Delhi
IACS (Indian Association of Cultivation of Science), Kolkata	1. Syngene
IIT, Mumbai	1. Intas Pharma Ahmedabad
Tata Memorial Hospital	1. Shantha Biotechnics Hyderabad
NIMHANS (National Institute of Mental Health and Neuro Sciences)	1. Xcyton Bangalore
DBT (Department of Bio technological)	1. Bharat Biotech Ltd. Hyderabad
Biotechnology Consortium of India	1. Panacea Biotech New Delhi
National Institute of Pharmaceutical Education and Research	1. Ranbaxy
ICRISAT (International Crops Research Institute of the Semi Arid Tropics)	1. Avesthagen
TERI (The Energy and Resources Institute) Delhi	1. Monsanto, Bangalore
IICB (Indian Institute of Chemical Biology) Kolkata	1. Shantha Biotechnics Hyderabad
NCCS (National Centre for Cell Science Pune)	1. Shantha Biotechnics Hyderabad
IIT, Delhi	1. Dabur
PGIMER (Post Graduate Institute of Medical Education & Research) Chandigarh	1. LiferCare Innovations
SGS Medical College & KEM Hospital Mumbai	1. LiferCare Innovations
Indian Veterinary Research Institute	1. Panacea Biotech New Delhi
St.John's Hospital (St Johns College, Bangalore)	1. Strand Life Sciences
University of Agricultural Sciences, Bangalore	1. Avesthagen

Source: Compiled from Frew et al (2007), Yarnell (2006), Maria et al (2003) and internet sources.

Appendix 3

Details of Some Incubators in India

Name of the incubator (Date of Establishment)	Private Support	Public Support	Institution to which affiliated	Whether technology developed in institution?	Type of Incubatee	No.	No. from outside	No. of incubatees based on patented technology
TBI@ BITS (2004)	BITS Alumni	DST	BITS, Pilani	Yes	Students	4	2	NIL
Agri-Business Incubator at ICRISAT (2003)	-	DST	ICRISAT	Yes	Entrepreneurs	13	13	1
Nadathur S Raghavan Centre for Entrepreneurial Learning (2000)	-	-	IIM Bangalore	No	Entrepreneurs	7	7	Most work on patentable technologies.
MITCON Biotechnology Business Incubator (1982)		DST and APCTT		No	Entrepreneurs and Farmers	17	17	
Lemelson- Recognition and Mentoring Program (2004)	-	-	IIT Madras	No	Entrepreneurs	21	21	All
Technology Business Incubator (2004)	-	DST	NIT Khozikode	-	Entrepreneurs	11	-	2
NIT Karnataka Science & Technology Entrepreneurs Park (1998)		DST	NIT Karnataka.	No	Entrepreneurs	10	Most are from outside	None

Details of Some Incubators in India

Name of the incubator (Date of Establishment)	Private Support	Public Support	Institution to which affiliated	Whether technology developed in institution?	Type of Incubatee	No.	No. from outside	No. of incubatees based on patented technology
PSG –Science &Technology Entrepreneurial Park (PSG-STEP), Coimbatore (1998)	-	DST, IDBI and ICICI	PSG College of Technology Coimbatore	No	Entrepreneur s	33	33	
Science and Technology Entrepreneur's Park (2005)	-	NSTEDB and DST	Thapar University, Patiala	Yes	Entrepreneur s	15	14	NIL
TREC-STEP, Thiruchirapalli (1986)			NIT, Trichy	Yes, as per venture's requirement	Students and Entrepreneur s	12	12	Almost all are IP protected
Life Science Incubator at ICICI Technology Park (2006)	ICICI Knowledge Park	NSTEDB and DST		No	Scientists with work experience	6	6	

Source: Primary Survey of incubators, conducted by authors

Abbreviations:

APCTT: Asia Pacific Centre for Transfer of Technology
DST: Department of Science and Technology
ICRISAT: International Crops Research Institute for the Semi-Arid Tropics
IIM: Indian Institute of Management
IIT: Indian Institute of Technology
NIT: National Institute of Technology
NSTEDB: National Science and Technology Entrepreneurship Development Board