



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

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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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Introduction

This paper is divided into five broad sections. In the first section, we provide a brief but comprehensive overview of linkages between higher education and the high tech sector. We then review the structure of higher education in India and make reference to the experience in the other countries of the region. In the next section, we study the major linkages in India, focusing on the labor market channel in India for the information technology, financial services and high-end manufacturing sectors, using the National Sample Survey data. The following section reviews the response of the higher education sector to developments in the labour market with discussion the differences between states. It argues that this response has been restricted by the nature of regulation in India. The final section concludes.

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.

- (a) national innovation system (NIS),
- (b) triple helix paradigm and
- (c) 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 borders and encompass technical, commercial, legal, financial as well as social transactions.¹ 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

¹ See Metcalfe and Ramlogan (2008) for a succinct summary of the NIS literature.

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 and 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 model focuses more sharply 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 concentration 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 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 is to understand the factors that help 'traditional universities' to become 'entrepreneurial universities'.²

Broadly, all these three streams of literature encompass the linkages between higher education and high tech industries, with the studies on UILs focusing on them more sharply. However, these linkages remain largely under-explored in the context of developing countries and within them; the labor market linkages have not received adequate attention – neither in the local context nor in the context of the country as a whole. This is surprising because labor market linkage between industry and academia remains the most prominent linkage even in developed countries; where universities contribute relatively little to patenting, licensing and new enterprise creation, except probably in life sciences.³ In developing countries, such linkages are even more weak. Concomitantly, industries too have the potential to affect higher education institutions

² For some recent work in the area of UILs see Yusuf and Nabeshima (2007) and the special issue of World Development 35(6), 2007.

³ *ibid*

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.

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. 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 clientelist, both of which preclude productive dialogue. This is not a linkage we explore in this paper.⁴
- (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.⁵
- (c) The third link is through a ostensibly primary function of higher education, the *Creation of knowledge*, e.g., technology licensing, industry-institution R&D projects, etc. Given the

⁴ 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.

⁵ 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.

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 those from higher education institutions, e.g. 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. Despite the absence of deep linkages, Basant and Chandra (2007a) found that overall, academic institutions of Pune and Bangalore interact with the city clusters in a rich variety of ways.
- (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 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.

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. Given the low levels of government funding, such contributions can be more important in developing countries as compared to developed nations.
- (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.

Higher Education Sector in India

It is useful at this stage to briefly lay out the structure of the higher education system in India. The discussion below is grouped into various sub-sections, viz. structure, regulatory institutions, courses of study and admissions

Structure

There are several types of higher education institutions in India, viz. universities, deemed to be universities, colleges, institutions of national importance, post-graduate institutions. Universities can be set up by an act of the Parliament or by the State Legislature. Only the universities and deemed to be universities and the institutions of national importance are generally authorized to grant degrees. Other post-graduate institutions and polytechnics can grant post graduate diplomas and diplomas and should be recognized by the All India Council of Technical Education (AICTE).

Table 1 summarizes these different types of universities viz.:

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 group⁶.

b) State universities

State Universities are those that are chartered 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 university means 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 organisation. Each private university is required meet the relevant provisions of the UGC Act, 1956.

⁶ Post Graduate management courses were started in the early 1960's. The Indian Institutes of Management (IIM), which are Societies, do not have the authorization to award degrees but they award postgraduate diplomas. The doctoral programs at IIMs also do not award PhDs, but the graduates are called "Fellows".

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.

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.

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:

- a) Monitoring developments in the field of collegiate and university education; disbursing grants to the universities and colleges
- b) Promoting and coordinating university education
- c) Determining and maintaining standards of teaching, examination and research in universities
- d) Framing regulations on minimum standards of education
- e) Serving as a vital link between the Union and state governments and institutions of higher learning
- f) 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:

- a) 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.
- b) The UGC can prescribe Minimum Standards of Instruction⁷. The right of conferring degrees can be exercised only by a University established or incorporated by or under a Central Act, a Provincial Act⁸ 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.

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:

- a) Engineering/Technology,
- b) Architecture / Town Planning,
- c) Management,
- d) Hotel Management & Catering Technology
- e) Pharmacy, and
- f) Applied Arts & Crafts.

⁷ 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

⁸ 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.

All technical programs must be approved by the AICTE⁹, but not all programs are accredited by AICTE¹⁰. Approval of AICTE for new Institutions or for starting new programs is based on:

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

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:

- a) Medical Council of India (MCI),
- b) Pharmacy Council of India (PCI)
- c) Indian Nursing Council (INC)
- d) Dentist Council of India (DCI)
- e) Central Council of Homeopathy (CCH)
- f) Central Council of Indian Medicine (CCIM)
- g) Rehabilitation Council of India (RCI)
- h) Bar Council of India (BCI),
- i) National Council for Teacher Education (NCTE)
- j) Distance Education Council (DEC)
- k) Indian Council for Agriculture Research (ICAR),

⁹ 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

¹⁰ 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.

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. The Andhra Pradesh State Council of Higher Education performs the following additional functions:¹¹

- a) Sanction of new Unaided Private Degree and Law Colleges
- b) 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
- c) Conduct of Vice-Chancellors' meetings
- d) Conduct of Training Programmes, Refresher Courses to the Degree College Teachers
- e) Conduct of Workshops on upgradation of U.G. Syllabi and innovation of new Courses for the development of Higher Education
- f) 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.

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.

¹¹ <http://www.apsche.org/aboutus.asp>.

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:

- a) Infrastructure and Learning Resources
- b) Curricular Aspects
- c) Teaching – Learning and Evaluation
- d) Research, Consultancy and Extension
- e) Student Support and Progression
- f) Organization and Management
- g) Healthy and Innovative Practices

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.

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:

- (a) Undergraduate level
- (b) Post-graduate level
- (c) Doctoral level (an intermediate research degree of M.Phil. is also awarded¹²)

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

¹² 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.

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

While the popular perception is that 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 (page 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. 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.

Linkages in India

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. But the survey data revealed a hierarchy of institutions in terms of the strengths of their linkages. Three categories of institutions emerged: those that undertake only teaching (i.e., linkage through low-end labour market), those that do research and teaching (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). There exists, however, a hierarchy of institutions in each of these categories. Given the existence of this hierarchy, reflecting low institutional capabilities, academic institutions rarely come together to advance these linkages collectively. Only a few institutions have the relevant knowledge base to undertake high-end knowledge networking activities with industrial entities.

Despite the absence of deep linkages, Basant and Chandra (2007a) found that overall, academic institutions of Pune and Bangalore interact with the city clusters in a rich variety of

ways and many are gearing themselves up to participate in such linkages in a more systematic manner. The experience of these two cities also broadly supports the idea that institution and industry co-evolve to take advantage of emerging opportunities that arise.

Creation of Knowledge: Patenting

Consider, first, the creation of knowledge. Tables 3a, 3b and 3c present information about patents issued to Indian inventors in the US Patent database¹³. The data is grouped in six five year periods starting from 1976. A few broad trends are evident from this.

First, there has been an increase in patenting over time, with particular increase in recent period. 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.

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 academies¹⁴. Even in social sciences, where presumably infrastructural 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. 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.

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

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

¹³ See Gupta (2008)

¹⁴ See Agarwal (2006)

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

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)¹⁶ provide more detailed evidence for this (for example, see 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 on the higher education institutions, the indirect generation of knowledge too seems to be in areas where linkages to domestic industry appear low.

However, benefits of UIL become more pronounced when institutions start to compete with each other. So far, academic institutions in India have not competed in any significant manner. Further, till recently, the private sector in India have also not been pro-active in seeking out these linkages to advance their research capabilities due to lack of competitive pressures and the bulk of the research was done in public institutions. till very recently,. Rising competition in recent years seems to be leading to a large number of alliances, largely among firms, but also among academia and industry. As this competition intensifies one may see stronger linkages between academic and industry. Concomitant with the increased interest of the private sector in research, academic institutions have started to face financial difficulties which are partly being alleviated through 'sponsored' research thereby alleviating the lack of industry orientation among academic institutions and limited R&D orientation that constrained industry-academia linkages over the years. As both change, one would expect more academia-industry linkages.

¹⁶ 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).

Research in industry and university is complementary and the success of academia-industry linkages lies in the exploitation of these complementarities.

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. While most technology institutions with incubators support their own students and faculty members, increasingly some institutional incubators have started to incubate companies from outside.

Table 5 provides some basic details on eleven incubators. 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 set 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 creation¹⁷. While many of these incubatees have sought IP protection (especially in the incubator funded by a venture capital institution), many have not.

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

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

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 faculty¹⁸ this information is not collated. However, a quick survey of institution websites reveals that a number of the faculty are without PhD degrees and the size of the faculty is small. 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.

This phenomenon of part-time teachers is present in other countries of South Asia too, especially in the private sector. In Pakistan as seen in Table 6a and 6b, 36% of faculty in private institutions is part-time as compared to 22% of faculty in public institutions. Furthermore, even among full-time faculty, only 21% of faculty in private institutions has either an M.Phil. or a PhD as compared to 36% of faculty in public institutions. In Bangladesh, it appears that regular faculty in public institutions work as part-time faculty in private institutions¹⁹. Comparable information about faculty qualifications in Bangladesh was not available.

Changes or Additions 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

¹⁸ See the Proforma for Mandatory Disclosure of Information about Accredited Programmes by Institutions that is issued by AICTE. It has not been possible to collate this information in time for the conference

¹⁹ See Monem (2007) in Gamage ed. (2007)

NASSCOM²⁰, 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 therefore initiated a number of programs to improve the supply of labour. These can be grouped under three broad heads

(a) Improving and supplementing the curriculum:

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, Satyam Computer Services, 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 reinforce key basic engineering skills and in addition, acquire industry-specific knowledge, soft skills, and management and employment skills²².

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 1) is more than four years old. The extent of remediation efforts being undertaken by the IT industry provides evidence of the low quality of graduating engineers from higher education institutions.

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

²² See NASSCOM (2007)

Case Study: Infosys Campus Connect²³

Infosys is a large Indian IT services provider with over 90,000 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.²⁴ 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.

²³ The information in this box has been summarized from Campus Connect Program Overview. See Infosys (2007)

²⁴ 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 (see below) is the 3rd, 4th and 5th semester.

(b) Testing:

Another approach is testing. 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 sets²⁵ NASSCOM has also partnered with other organizations to develop customized certification programs for frontline managers in this sector such as CBQA (Certified BPO Quality Analyst) and CBTL-1 (Certified BPO Team Leader, Level-1). A test for the IT sector, NAC-Tech is in development.

(c) Verification

Besides upgrading the workforce through curriculum development and training, it is important to establish accurate verification of credentials. For this, it has established 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 fingerprints. 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).

Industry participation in curriculum is now spreading to other areas too, foremost of which is vocational training. India has a large number of Industrial Training Institutes (ITIs) that provide a variety of courses for industry, especially the manufacturing sector. Some of these courses are long-term, varying from two to three years. 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 instruction²⁶.

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

²⁵ 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/>

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 2.5 crore (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).

operations, retail employment, etc. These courses do not have a certification beyond the brand name of the institute²⁷. The onus of quality assurance therefore rests on the student. Again, this phenomenon is not confined to India. Sri Lanka has a similar situation where many of the service providers have foreign linkages, including with foreign educational institutions and Indian training firms²⁸.

While the system can be commended for allowing the growth of such institutions 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.

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 Siksha Kosh – whose use would be determined by the central Ministry of Education.

Higher Education and High-Tech Industry: Some Empirical Results

The Labour Market 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, the role of educational institutions can best be described as nurturing rather than creation, where existing entrepreneurs are facilitated to pursue their goals.

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

²⁷ 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.

²⁸ Gamage (2007)

industry in developing countries like India is likely to be through the labor market and it is this link that is of immediate concern to industry at this time.

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. In order to establish this linkage, we analyze the unit level data from the 61st round of the National Sample Survey data for the year 2004-05.²⁹

Defining High-tech Industries

Following the OECD classification of industries into Low, Medium, Medium-High or High Technology groups,³⁰ we have grouped sixty manufacturing industries into three categories (see Table 7 and Mukhopadhyay, Narayanan and Bharadwaj, 2006). 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 disaggregate as the OECD grouping, a comparison of the two showed that several groups categorized as medium-tech by OECD are part of high-tech in the other categorization. And 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.

In addition, we wanted to identify “high-tech equivalent” in the services sector. Financial and information technology related services have been identified for this purpose. 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

²⁹ The analysis covers usual status principal as well as subsidiary workers.

³⁰ 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.

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

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 education related information.³¹ Combining these two types of education, following higher education categories have been created:

- a) All types of higher education: Any graduate (or equivalent) qualification and above. This includes all those who either have 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
- d) Non-technical higher-education with technical non-graduate diplomas: Graduate (or above) in general education with below graduate level technical diplomas or certificates.

Other 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.

³¹ 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).

- 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-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.³² 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:

- a) Aggregate summary index of infrastructure;
- b) Power infrastructure index
- c) Telecom infrastructure index
- d) Transport infrastructure index

³² 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

As in the case of the aggregate index, both supply and use of each category of infrastructure has been captured in these sub-indices (see Mohanty (2004) for details of each index).

Table 8 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.

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 probits are exploratory in nature to 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.

Table 9 reports estimates of probits where all types of higher education are taken together. The results 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. Surprisingly, local infrastructure does not seem to have any 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 10. 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 11) 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.

Response of the Higher Education Sector

The 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, 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?

Growth in Institutions

Figure 1 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 2a, and an even more rapid rise is seen in the number of deemed-to-be universities in the recent years, as shown in Figure 2b, with an increasing share of the private sector.³³

This stock of institutions is however concentrated in a few states, most of which are rich and relatively urban. Table 12 shows the state-wise number of institutions. Five states south of the Vindhyas, 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 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

³³ There was a spurt in 2002, when twenty six such deemed to be universities came into being, of which nine were private institutions.

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.

They 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.

Moreover, most of these educational institutions are private. Table 13 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 colleges³⁴.

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 (1822 thousand) to 51.53 per cent in 2005-06 (3219 thousand). However 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 : (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)

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

³⁴ If one ignores two states, Jharkhand and Uttarakhand, who top the list with just two private medical colleges and no public medical college.

and supplementary education. Table 14 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 15 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 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 16.

This rise in private institutions is a feature in neighboring countries also, such as Sri Lanka, which also has a number of foreign collaborating institutions, Bangladesh, where the private sector is largely staffed by faculty who are from the public system, but work part-time in the private sector and Pakistan, which has seen the emergence of a large number of small universities. As shown in Figure 3, 95 of 111 universities have less than 5000 students. Ensuring that these service providers offer quality thus becomes a regulatory challenge.

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 17). 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.³⁵

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 AICTE³⁶. 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.³⁷ 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.

³⁵ See http://education.nic.in/technicaledu/ugc_bis.asp

³⁶ 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.

³⁷ For example, the West Bengal University of Technology has one hundred and twentysix 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.

Conclusion

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. While this is not a desirable state of affairs, it is only to be expected. A few of the reasons for this are listed below:

- a) 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.
- b) The Indian faculty reward system, such as it is, only looks at academic work without any weight being accorded to industry interfaces, except perhaps in management education. Should this be changed? Can and should the creation of new ventures be made an important objective of the academic institutions? This is a debatable issue that goes to the core of the purpose of a university. However, some intermediate steps are in progress. An equivalent of the Bayh Dole Act is awaiting cabinet approval, whereby scientists will now have more flexibility/freedom to participate in start-ups³⁸. However, even here, it is not clear whether universities are part of this initiative or whether it is limited to research institutions.

More to the point, faculty compensation and work environments is not attractive, which means that faculty quality is being eroded over time. This affects the quality of the very intellectual capital that is supposed to generate new knowledge. More than the incentives to produce industry-relevant knowledge, the basic capacity to do so is now in question.

- c) A concomitant problem 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 private equity. A limited amount of true VC has just started to happen but we have a long way to go, before it goes beyond well-established sectors such as IT.

In the final analysis, research in industry and university is complementary and the success of academia-industry linkages lies in the exploitation of these complementarities. While the liberalization of industry has made them much more nimble in effecting internal structural change, the larger challenge is in designing appropriate work environments and compensation

³⁸ See Ranjan (2008)

packages that will attract talented young people to take up careers in academia. This will go a long way in alleviating the constraints on availability of “research-inclined” faculty in academic institutions, a basic prerequisite for formation of research based linkages. This requires addressing governance problems in India’s higher education system, which is a difficult task. Furthermore, it appears that many of these governance problems also permeate other South Asian countries such as Bangladesh, Sri Lanka and Pakistan.

Let us now turn to the labor market where we found that, despite a vigorous response from the private sector to the growth in the high-tech industry, the quality of the response left much to be desired. In substantial part, this too is driven by problems of governance, viz.

- a) First, 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 increases the dependence of the university on the UGC and the state government and limits its autonomy and compromises its work environment and limits diversity within the system.
- b) There is also a national uniformity in compensation to faculty, at levels that do not differ across disciplines and there is little financial incentive in securing promotions. Given the growing opportunities available elsewhere, this has meant that good faculty is in short supply especially in professional disciplines.³⁹ This has led to a vicious downward spiral, 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

³⁹ 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.

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.”

Thus, the solutions to enhancing labor market and non-labor market linkages appear to intersect at this core issue.

- c) An affiliating system wherein colleges prepare students for a university-administered examination based on a uniform curriculum at the university level 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.⁴⁰
- d) The lack of a robust accreditation system. 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. As Kapur and Mehta (2007) note, the “fact that the system nonetheless produces a noticeable number of high-quality students is due to the sheer number of students and the Darwinian struggle at the high school level to gain admission into the few good institutions.”
- e) The absence of a system of transferable credits, 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 on offer. This would be follow-through step from accreditation, which is to allow transferable credits that would enable students to choose their pace of learning and choice of institution, is not yet available in India⁴¹, though Sri Lanka has moved ahead with this.

⁴⁰ 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

⁴¹ 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.

Nevertheless, even in this 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. The limitations of relying on such a response can be seen in the muted participation of other sectors of India, other than IT and ITES, and also in other countries of the region where such a response is lacking given the absence of a large high-tech sector.

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 place⁴². 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 environment⁴³.

Measured against the metric of broadening and deepening, 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 lead to depth of knowledge that would be needed to assimilate more complex technologies. The lack of quality faculty in educational institutions implies that the value addition from a more intensive exchange with industry can only go so far and that the industry initiative may be limited 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.

Finally, there is a broader debate on how education should be viewed. 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.

⁴² 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.

⁴³ 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

References

- Agarwal, Pawan (2006) Higher Education in India: The Need for Change, ICRIER Working Paper No. 180, June 2006
- Athreye, Suma and Martha Prevezer (2008) "R&D offshoring and the domestic science base in India and China" mimeo, May 2008
- Athreye, Suma and Phanish Puranam (2007) "India and China: their role in the global R&D Economy" Paper presented at the MEIDE conference at Renmin University Beijing held on the 21-22 April, 2007
- Basant, Rakesh and Pankaj Chandra (2007a), "Role of Educational and R&D institutions in City Clusters: An Exploratory Study of Bangalore and Pune regions in India", World Development, 35 (6) June, 2007, 1037-1055.
- Basant, Rakesh and Pankaj Chandra (2007b), "University-Industry Link and enterprise Creation in India – Some Strategic and Policy Issues" in Yusuf and Nabeshima (eds.) (2007), pp209-226
- Central Advisory Board of Education (CABE) Report of the CABE Committee on Financing of Higher and Technical Education, National Institute of Educational Planning and Administration, New Delhi, June 2005,
- Chatterjee, Partha et. al. (2002). Social Science Research Capacity in South Asia, SSRIC, New York, 2002
- CII (2007) "Public Private Partnership for ITI Upgradation" CII Communique, July 2007, p. 34
- Etzkowitz, Henry (2002), "The Triple Helix of University-Industry-Government – Implications for Policy and Evaluation" Working Paper No 11, Science Policy Institute, Stockholm.
- Gamage, Sujata (2007) ed. Linking Knowledge to Innovation in the Economy and Society: The Role of Universities in Asia, Report to IDRC, Canada
- Gupta, Anil (2008) "Do Patents Matter: IP in Indian R & D Institutions and Universities" paper for IPR Management Development Program, Indian Institute of Management, Ahmedabad, mimeo
- Infosys (2007) Campus Connect Program Overview accessed on May 3, 2008 from <http://campusconnect.infosys.com>
- Kapur. Devesh and Pratap B. Mehta (2007) Indian Higher Education Reform: From Half-Baked Socialism to Half-Baked Capitalism Paper presented at the Brookings-NCAER India Policy Forum 2007, New Delhi
- Kodama, Fumio, Shingo Kano and Jun Suzuki (2007) "Beyond Absorptive Capacity: The Management of Technology for a Proactive Corporate Strategy towards University-Industry Links" in Yusuf and Nabeshima (eds) (2007), pp 241-254.
- Metcalfe, Stan and Ronald Ramlogan (2008), "Innovation Systems and the Competitive Process in Developing Economies", The Quarterly Review of Economics and Finance 48, 433-446.
- Mohanty, Nirmal (2004) Study on State Infrastructure," Report to the Twelfth Finance Commission
- Monem, Mobasser (2007). Higher Education in Bangladesh: Status, Issues and Prospects. Seminar on "Knowledge for Development (K4D): The role of universities" Colombo, Sri Lanka, 25th of January
- Mukhopadhyay, Partha (2008) A PPP Model for Vocational Education: Upgrading the ITIs in India Infrastructure Report 2008: Business Models of the Future, Oxford University Press, Delhi
- Mukhopadhyay, Partha, K Narayanan, and Parul Bhardwaj (2006) "Unified in Diversity? Spatial Patterns in Indian Manufacturing" mimeo

NASSCOM (2007) Finishing School for Engineering Students – Nasscom Education Initiative (mimeo)

NASSCOM-McKinsey Report 2005 Extending India's leadership in the global IT and BPO industries

Nichenametla, Prasad (2007) "ITI upgrade plan a non-starter", Business Standard, New Delhi December 8, 2007 [http:// www.rediff.com/money/2007/dec/08iti.htm](http://www.rediff.com/money/2007/dec/08iti.htm)

Powar, K.B. and V.Bhalla (2004), 'Private Professional Higher Education in India', New Frontiers in Education, 34(2): 126-127.

Prakash: Ved (2007) Trends in Growth and Financing of Higher Education in India, Economic and Political Weekly August 4,

Ranjan, Amitav (2008) "Working in Govt labs, scientists can now set up their own firms, get equity" Indian Express, May 20, 2008 <http://www.indianexpress.com/story/311934.html>

Stehrer, Robert and Julia Wörz (2003) 'Industrial Diversity, Trade Patterns, and Productivity Convergence' WIIW *Working Papers*, No. 23, Vienna, July 2003

The Tribune News Service (2008) UGC not for uniform curriculum, The Tribune, January 8, 2008 [http:// www.tribuneindia.com/2008/20080109/delhi.htm](http://www.tribuneindia.com/2008/20080109/delhi.htm)

Wolf, Alison. 2002. *Does Education Matter?* London: Penguin.

World Development 35 (6), Special Issue on University-Industry Linkages and the Development of Knowledge-Intensive Clusters in Asian Cities

Yusuf, Shahid and Kaoru Nabeshima (eds) (2007), How Universities Promote Economic Growth, The World Bank, 2007

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
Maharshi Dayanand	Calcutta	S.N.D.T. Women's	Open
Rabindra Bharati	Dibrugarh	Bangalore	Kuvempu
Tamil	Dr. Harsingh		M.D. Saraswati
Visva Bharati	Sri Venkateshwara		Pune
Anna	Calicut		YCM Open
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 CAFE (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 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	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: Details of Selected 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
1. TBI@ BITS (2004)	BITS Alumni	DST	BITS, Pilani	Yes	Students	4	2	NIL
2. Agri-Business Incubator at ICRISAT (2003)	-	DST	ICRISAT	Yes	Entrepreneurs	13	13	1
3. Nadathur S Raghavan Centre for Entrepreneurial Learning (2000)	-	-	IIM Bangalore	No	Entrepreneurs	7	7	Most work on patentable technologies.
4. MITCON Biotechnology Business Incubator (1982)	-	DST and APCTT		No	Entrepreneurs and Farmers	17	17	
5. Lemelson- Recognition and Mentoring Program (2004)	-	-	IIT Madras	No	Entrepreneurs	21	21	All
6. Technology Business Incubator (2004)	-	DST	NIT Khozicode	-	Entrepreneurs	11	-	2
7. NIT Karnataka Science & Technology Entrepreneurs Park (1998)	-	DST	NIT Karnataka.	No	Entrepreneurs	10	Most are from outside	None
8. PSG –Science &Technology Entrepreneurial Park (PSG-STEP), Coimbatore (1998)	-	DST, IDBI and ICICI	PSG College of Technology Coimbatore	No	Entrepreneurs	33	33	

Table 5: Details of Selected 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
9. Science and Technology Entrepreneur's Park (2005)	-	NSTEDB and DST	Thapar University, Patiala	Yes	Entrepreneurs	15	14	NIL
10. TREC-STEP, Thiruchirapalli (1986)			NIT, Trichy	Yes, as per venture's requirement	Students and Entrepreneurs	12	12	Almost all are IP protected
11. 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

Table 6a: Number of Full and Part Time Faculty by Education Sector (2003-04)

Sector	Full Time	Part Time	Total
Distance Learning	182	17620	17802
Public	10471 (72.5%) [77.9%]	2975 (57.3%) [22.1%]	13446
Private	3963 (27.5%) [64.1%]	2217 (42.7%) [35.9%]	6180
Total	14616	22812	37428

Note:

The numbers in parenthesis denotes the share of the public and private sectors as a percentage of total full-time and part-time faculty (excluding distance learning).

The numbers in square parenthesis denote the share of full-time and part-time faculty in the public and private sectors as a percentage of total faculty in the sector.

Table 6b: Full Time Faculty Members by Highest Qualification (2003-04)

Sector	Bachelors	Masters	Master(H)	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 6c: Share of Full Time Faculty Members by Highest Qualification (2003-04)

Sector	Bachelors	Masters	Master(H)	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 7: 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

Table 7: Industries classified as High-Tech

3-Digit NIC Code	Description
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 8: 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 9: Determinants of Participation in High-tech Industry (All Graduates)

Variable	All high-tech industry		High-tech manufacturing		High-tech services	
	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 10: Determinants of Participation in High-tech Industry (Disaggregated Education)

Variables	All high-tech industries		High-tech manufacturing		High-tech services	
	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 11: Determinants of Participation in High-tech Industry (Disaggregated Infrastructure)

Variables	All high-tech industries		High-tech manufacturing		High-tech services	
	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 12: 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 13: 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%
Chattisgarh	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 14 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%
Chattisgarh	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:

1. UGC Annual Report 2005-06; Selected Educational Statistics, MHRD, 2004-05
2. <http://www.naacindia.org> Quality categories used in this table are adapted from NAAC grading
3. University Development in India, Basic Facts and Figures, Examination Results - 2002, UGC
4. IAMR Manpower Profile 2005

Table 15: 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%
Chattisgarh	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 16: 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
Chattisgarh						
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

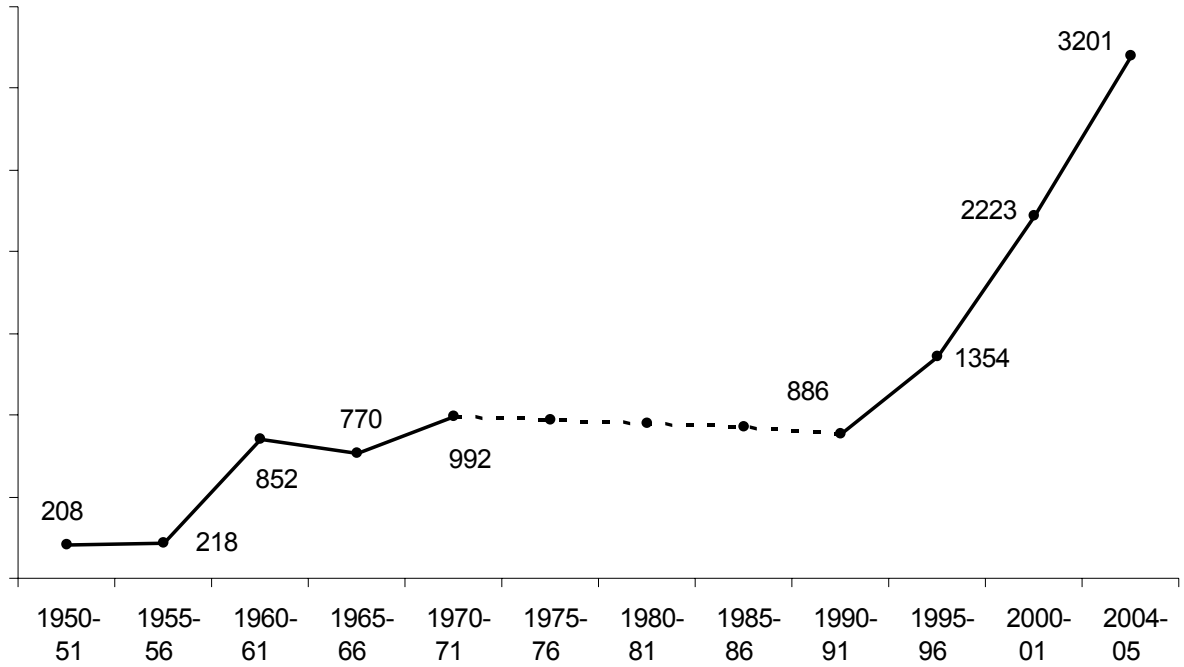
Table 17: Typology and growth trends of higher education institutions

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
<i>Deemed Universities (Unaided)</i>	<i>Private</i>	<i>Private</i>	63	60,000	<i>Growing rapidly</i>
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
<i>Private Colleges (Unaided)</i>	<i>Private</i>	<i>Private</i>	7,650	3,150,000	<i>Growing rapidly</i>
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)

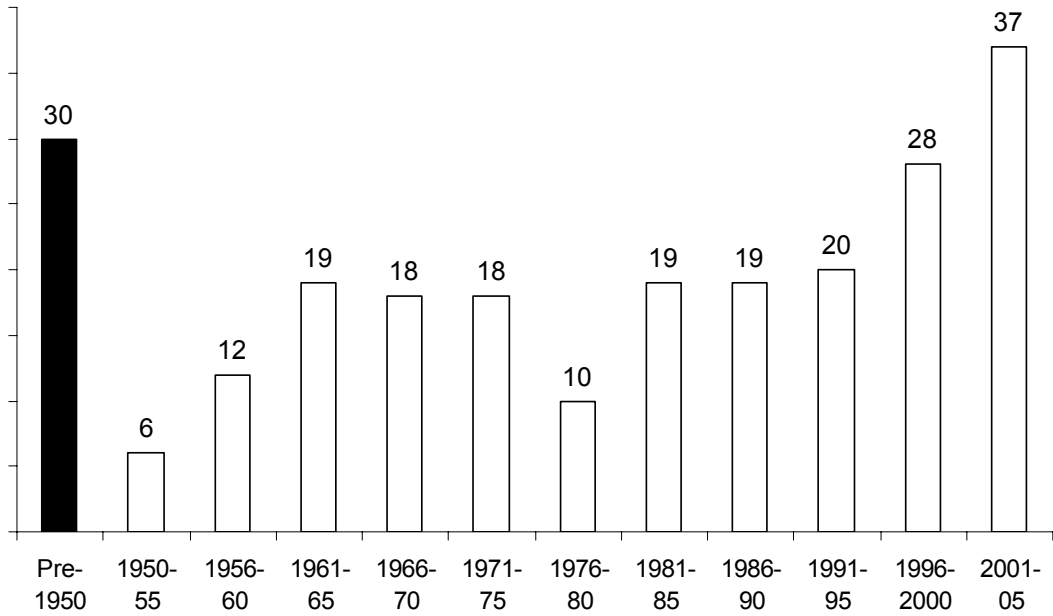
Figure 1 Growth of Colleges for Professional Education



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

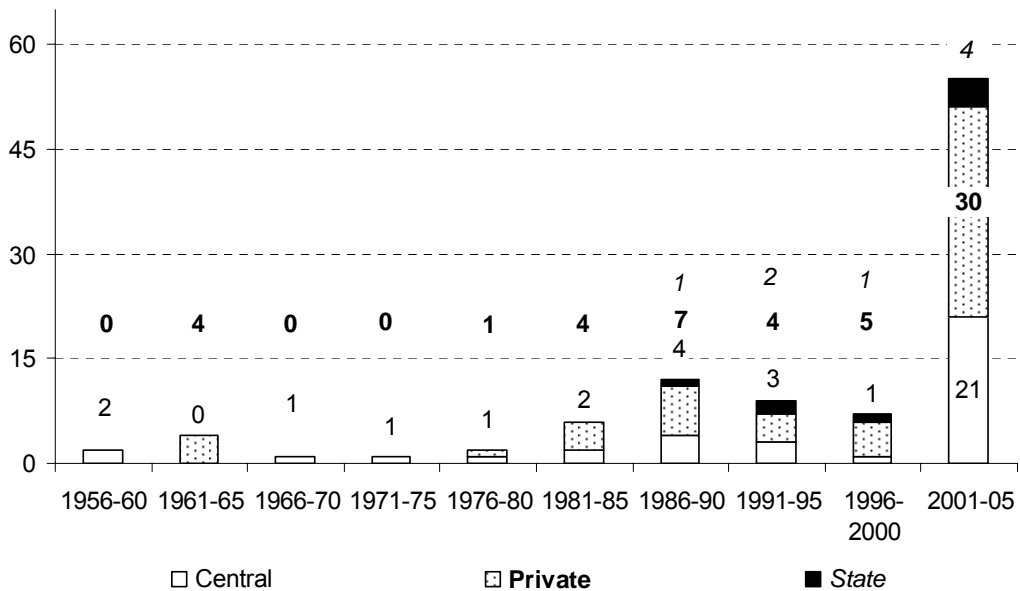
Note: Data for the years, 1975-76, 1980-81 and 1985-86 are non-comparable since they include institutions for post-matric courses

Figure 2a : New Universities Established by Five-Year Periods



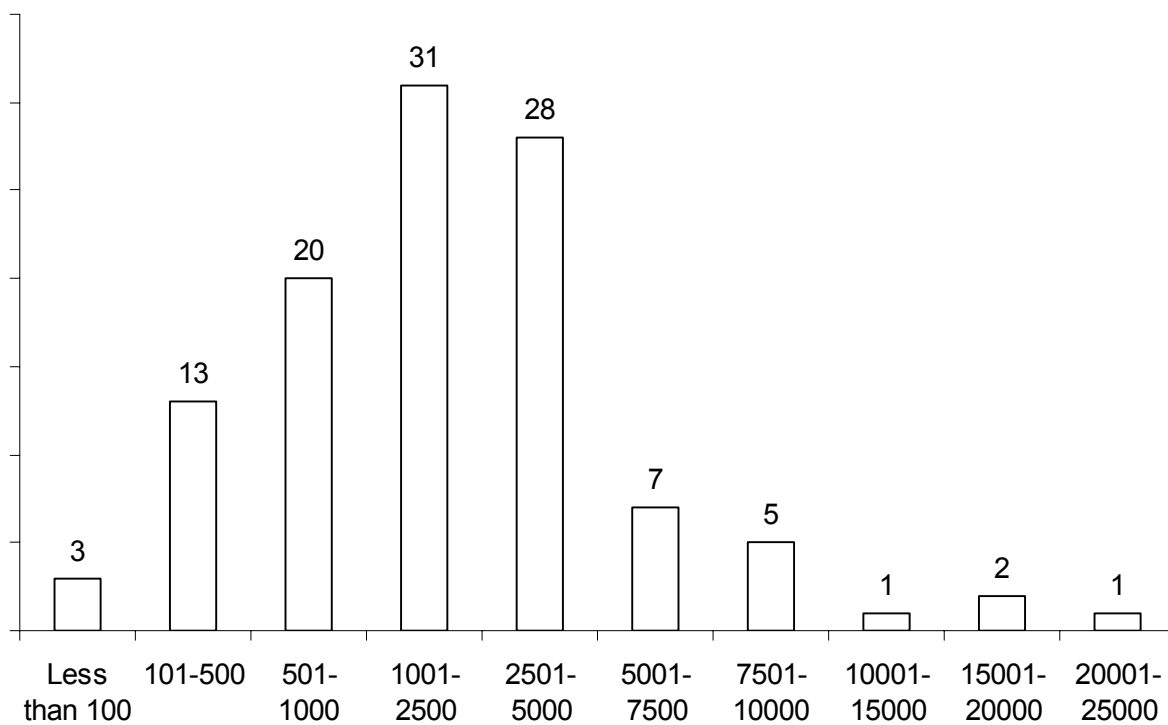
Source: Calculated from the dates of establishment provided in UGC Annual Report (2005-06)

Figure 2b : New Deemed-to-be Universities Established 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 3: 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-website-7-07.xls