REPORT

ON

Quality of manpower in knowledge intensive sectors: cases from drugs and chemicals sector

By

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Parthasarathi Banerjee
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Volume - I

Chapter 1 :

Introduction

Introduction:

Human resources occupy the center stage of the National Innovation System (NIS) of a country. Recent studies indicate the importance of the quality of such resources for developing the NIS and also for building up the capacity of such an NIS. Contrarily, capacity of an NIS gets reflected through its capabilities manifested in generating quality manpower.

Such quality manpower must address, as is the goal of an NIS, the business domain and the domain of economic growth of a country. In order that the country manpower can achieve that the manpower must be well equipped with the wherewithal of property rights over its knowledge output.

This present investigation has attempted to study drugs and pharmaceuticals, and the related chemical sectors of India in terms of the above three aspects, namely:

- Quality manpower, and how to compare quality say based on indicators
- Capacity building aspect of domestic institutions in generating quality manpower
- Intellectual property rights (IPR) aspect of protecting knowledge output

Quantity and quality of manpower reflected as these are in the scientific output of the nation, however, remain determined or at least conditioned by the local availability of infrastructure captured otherwise as the capacity, which includes among others domestic organizations with capability to undertake quality research.

This study has highlighted the quantity dimension of quality or how quality remain constrained owing to sub-critical levels of quantity of manpower. Secondly, it has attempted to design several quality indicators based on numerous dimensions of quality of the organizations producing the manpower. Therefore, quality of manpower remains determined by the capacity of domestic institutions. Thirdly, it has concluded that both capacity and the quality aspects are crucially dependent on how capacity is distributed over domestic geography. Fourthly, it has observed that multiple modes of institutions, such as R&D laboratories, universities, or medical hospitals produce quality manpower. Often such manpower is beyond the scope of formal degree-endowment activities. Fifthly, strategic dimension of protecting IPR especially in the US is weak.

Objectives of the study:

The main objectives of the study are:

- To indicate quality-indicators and to measure quality manpower in the knowledge-intensive area of drugs and pharmaceuticals
- To provide a profile of the capacity-building aspect in the above area
- To compare attractiveness and strategic responses of this area based upon IPR.

Scope of the study:

- The study aimed to generate data from survey of researchers and academicians from most organizations, however, only 564 persons responded out of 4000. These persons are mostly from Delhi, Varanasi, Kolkata and Hyderabad, and from other cities and towns such as Kanpur. In addition, data was collected from all available websites on personal profiles.
- Data was generated from all available websites of domestic universities, public research organizations and special public forums.
- Data was generated on all the relevant types of teaching courses, research possibilities and the levels as well as intakes/outputs for all areas relevant to drugs and pharmaceuticals and related areas of chemical – from all universities, IITs, IISc., and similar others.
- Data was generated from several databases on multi-country for drugs-related areas and on Indian output in several areas of biology, and chemistry. These databases include Medline, ScienceDirec, and Scirus.
- Output data as well as data on citation of survey-respondents were generated from both the SCI for some and from ScienceDirec for others.
- A few micro areas were selectively studied and these include: Microbiology, molecular biology, protein, and such others
- The period covered varied because of availability and comparability; however, most often data covered a period of 8 to 10 years.
- Special attention has been paid to the capacity building through social capital in a single geographic location – Hyderabad as a special city in the map of drugs and pharmaceuticals has been studied from several aspects.

Methodology of the study:

Following methodology was adopted:

- A brain-storming workshop participated by subject experts was organized to hone questions and issues. Subsequently, fellows of national scientific bodies such as the INSA were sent a preliminary questionnaire. Based on 46 responses the final questionnaire was designed and tested on professionals from 3 organizations.
- The final questionnaire was then put into circulation through multiple modes in parallel, and these modes were sending electronic and hard copies of questionnaire, eliciting responses through field-collectors who happened to be students of local universities always, and through personal interviews filling-in by the PI.
- In parallel, a database was generated on all universities and other research-teaching organizations such as the IITs on all the courses on offer and all venues for research including when available intake/output quantities for all areas related to drugs and pharmaceuticals, such as biotechnology, molecular biology, and such others.
- Output data on multiple countries in the areas of was generated from Medline.
- Output data on chemistry and biology related areas were generated from Scirus.
- Output and citation data was generated on subject areas and on India from ScienceDirec.

Limitations of the study:

During the course of conducting this study, following limitations were observed:

- Objective of the study was not to compare and rate individual or an organization. In view of this, the status has been analyzed concealing individual names or most often the names of the organizations.
- The study was limited to a few select areas related to drugs and pharmaceuticals such as biotechnology, biology, chemistry and such other interdisciplinary areas. Further, detailed probes were made on a small set of sub-areas such as microbiology.
- A large number of researchers and academicians from several geographic areas such as Western India and several important universities such as Mumbai University did not respond to survey questionnaire. Analyses on Survey data are not representative. These are exemplary.
- Most organizations do not maintain websites, and even when these are maintained do not contain data on individual profiles. As a result website database is poor.
- Data validation could not be undertaken because respondents were extremely reluctant to spend time.
- Databases such as Medline, Scirus, ScienceDirec cover fragments of generated output; hence, data generated from these databases cannot claim to be exhaustive. Our analysis shows facets of output and not total output.
- Repeated crosschecks and cleaning of data were undertaken to improve quality of data. However, errors often owing to incomplete addresses or in punctuations created difficulties and possible errors in the output of data-analyzed through programs. There still are possible errors of other kinds, for which NISTADS would expect to be excused.

Executive summary:

- Quality of manpower can be raised by a policy that recognizes the role of research institutions in generating high-level manpower.
- Quality of manpower can be raised only if policies on both university system and the research system are brought together on the same platform.
- Quality is directly dependent on quantity of manpower; hence raising large quantity of manpower should be first policy objective.
- Quantity of research output is the next indicator of quality and such output from India is far below the benchmark set by the focal country, the USA or below even the neighboring country China in most areas.
- There is no single and dependable source of data on output quantity. This report accessed data from several public and proprietary databases such as Medline, Scirus, Science Direct, MathSci, SCI, Chemical Abstracts, etc.
- There is no commonly agreed upon indicator of quality of research. Some professionals and some organizations use an indicator of journal, called Impact Factor (IF), to represent quality of output. A few others use another measure based on citations received.
- This report found several occasions to doubt the efficacy of IF as a measure of quality. IF appears more to be an indicator of market gained by a journal. Hence, IF is an indicator of business success.
- Citation is also dependent upon domestic research network.
- Citation network in India is extremely weak.
- Another important aspect is the size of the critical mass of researchers who are employed in the same organization or in organizations geographically very close. Both quantity and quality of research output appear to depend upon the size of this critical mass, which almost always is much below the critical level in most of the Indian research organizations.
- Active addresses can be indicated by quantity of output and numbers of researchers/academicians in an organization, and abundance and distribution of such addresses indicate both quality and institutional capacity.

- Active addresses in India both in terms of continuous output and in terms of size of active researchers/academicians are very few and quantity produced by these addresses too is low.
- This points out to the absences of - an active research milieu, an active body of large number of students, mid-career trainees along with researchers and academicians. Currently they appear to be in isolation.
- Institutional capacity and quality are directly interlinked. Capacity can be sustained and enhanced through this milieu, active addresses, and large quantity of quality manpower.
- Drugs and pharmaceuticals demand raising capacities of the institutions of universities, research systems and medical systems together.
- From each of these three and as the first objective, quantity of manpower must be raised immensely. Another corresponding issue is training mid-career personnel.
- Another related aspect of capacity is the systemic strength in IPR.
- Strategic positioning of Indian IPR, especially in the USA, is very weak. Patenting by public research bodies, medical system and the university system is extremely weak.
- Domestic patenting appears not to be having any strategic thrust.
- Incentives internal to organizations as well as those operative within the peer-system of Indian science do not seem to favor manpower-raised as an objective. Regenerative processes of research, teaching and clinical practices have been disfavored. Such disincentives should be replaced by incentives.
- Inter-personal as well as inter-organizational competition since based upon the accumulation of non-manpower related aspects, have further degenerated the system. Domestic public space and research milieu have shrunk to its core.
- Finally, absence of critical mass inside organizations and dependence upon global infrastructure together have resulted into production of minimal quantity of both manpower and research output.

Summary of the report:

This report is about the capacity of institutions and the quality of its regenerative practices. It therefore directly refers to the resources and infrastructure of a national innovation system (NIS).

Fundamental assumption at the back of our argument is that manpower constitutes the most important resource in a NIS. Firstly, we argue that two aspects of this resource appear supreme, and these are the quantity and the quality. Secondly, improvement of the quality of these manpower resources becomes possible when a country NIS reproduces as well as generates knowledge through increasing in very large quantum the quantity-aspect of the capacity, that is by simply raising very largely the quantum of manpower. Thirdly, capacity refers to relations between national infrastructures. We identify this relation between infrastructures as a common set of policies directed to university, public research system and medical system. Our final and fourth argument refers to the desirability of collaborations between several NIS on cooperative infrastructure solutions.

Infrastructure can be defined as the set of backbone-institutions[1] capable of developing and sustaining the reproduction and generation of the above two aspects of national manpower. An infrastructure thus can be evaluated in terms of its degree of achievement of quantity and quality of national manpower.

Elaboration:

Generation of moderately good quality manpower in very-large quantity as a policy thrust can be compared with policies on (1) generating high quality but meager-quantity; and (2) generating low quality but very-large quantity manpower. Policies (1) and (2) are constrained by the believed folklore that constraints on resources force a country such as India with either/or option between these two.

We argue for an intermediate regime. Folklore makes us believe that hard budget constraints have caused paucity of manpower resources; we argue however and on the contrary, that waning resources can be remedied through institutional innovations. Limitations imposed by hard budget constraints can largely be remedied thus. Such innovations open up possibilities for developing moderately good quality manpower in extremely large quantity. Very large quantity of a population when faced with constraints of resources might resort to (a) opportunistic migrations to foreign destinations; and since

only a small fraction can move out the large remainder must (b) compete fiercely to grab resources. This regenerative aspect of competition ensures maintenance of moderately good quality of manpower even without any institutional innovation. We offer a supply side dominance perspective.

Increasing manpower would generate more information for its own survival. Such information on quality in turn generates demand for quality-indicators. What institutional aspects can purvey this information? It appears logically and also from a reading of the institutions in developed countries that competence in generating knowledge and participation in the generation of knowledge carry forward quality-information.

Typically, information on research undertaken and research output generated in the public domain carry information on generative competence. Further, information on reviewer ship and peerage transmit information on quality of participation. These two aspects are interrelated. A research undertaken passes through competitive grant procedure generating demands for information on quality. However, this information is accessed by the peers and not by students or the potential undertakers of research.

This entire process therefore rejuvenates reproduction and generation of knowledge in the public domain (which in turn stands upon prior existence of such generative and reproductive facilities in the country NIS).

Policy intervention at these stages is thus crucial. Interventions must remove current dis-incentives; design positive incentives towards raising manpower. Policies can be shaped through:

- Firstly, recognizing manpower generated as desired output;
- Secondly, designing coherent and common policies for manpower generation in the entire system, that is with university, public research body and in medical system.
- Thirdly, increasing quality of manpower generated as indicator of increasing quality of knowledge/research;
- Fourthly, recognizing importance of supporting and sustaining domestic discourse.

Competition for resources and search for reputation can then be channeled through infrastructure of knowledge as described above. Information cues required for

selection mechanism are provided by this infrastructure. The physical mechanism of publishing research output when present in an NIS generates the other systemic aspects of infrastructure (in the form of quality signals).

Information signal on quality of research or on what constitutes the most contemporary manifold of research as well as information on who are most active remain tied to the presence of a public domain sustained singularly by the infrastructure of journals-reviewers-writers communities among others. Therefore potential knowledge-community, namely students and research-students have the privileges of reduced search spaces, increased dependability of information signal and increased density of information signal in a geography endowed with infrastructure of the kind mentioned above. Other elements of this infrastructure refer to the mobility of academicians, nature of auctions or competitions in research-grants, degree of dependence on research grant, relevance of and encashability of reputation or in other words on the nature of property rights institutions in place.

However, in an NIS that does not have similar infrastructure signals would appear irrelevant or pervert. Situations in India simulate such states of affairs. Allocations of the primary resources, namely the competitive and competent manpower in such a country fails to follow any rational outcome. Often outcomes in such a country are feat-based and are very deeply implicated by history (path-dependence). Perpetuations of enclaves of competencies to fixed locales or rigid names are indicative of a lost dynamism and a lost diffusion of pedagogical experimental practices.

Our argument is that institutional rigidities of the above kind can be largely erased through infusion of large quantity of manpower. Demands from this large quantity sets in demands for quality-indicators, activity-indicators and such likes.

Major policy thrust we look for remains first in generation of moderately good quality but very large in quantity of manpower. This refers to institutional capacity. At this stage we emphasize that public research bodies, universities and medical systems must have similar and common policies on raising quantity and quality of manpower.

Next, second in sequence in policy is to encourage enhanced role of limited and regulated market-based competition for quality. At this stage regulatory oversight in the form of supports appears crucial. Market applies mechanisms of selection of

infrastructure. Final and third in sequence in policy is to support the selected infrastructure; and inter-NIS cooperation is sought at both sequences second and third.

These three together constitute an intermediate strategy for Indian and possibly other NIS from Asia; and the intermediate period remains there till national infrastructures and institutions that can sustain as well as develop high quality large quantity manpower is reached.

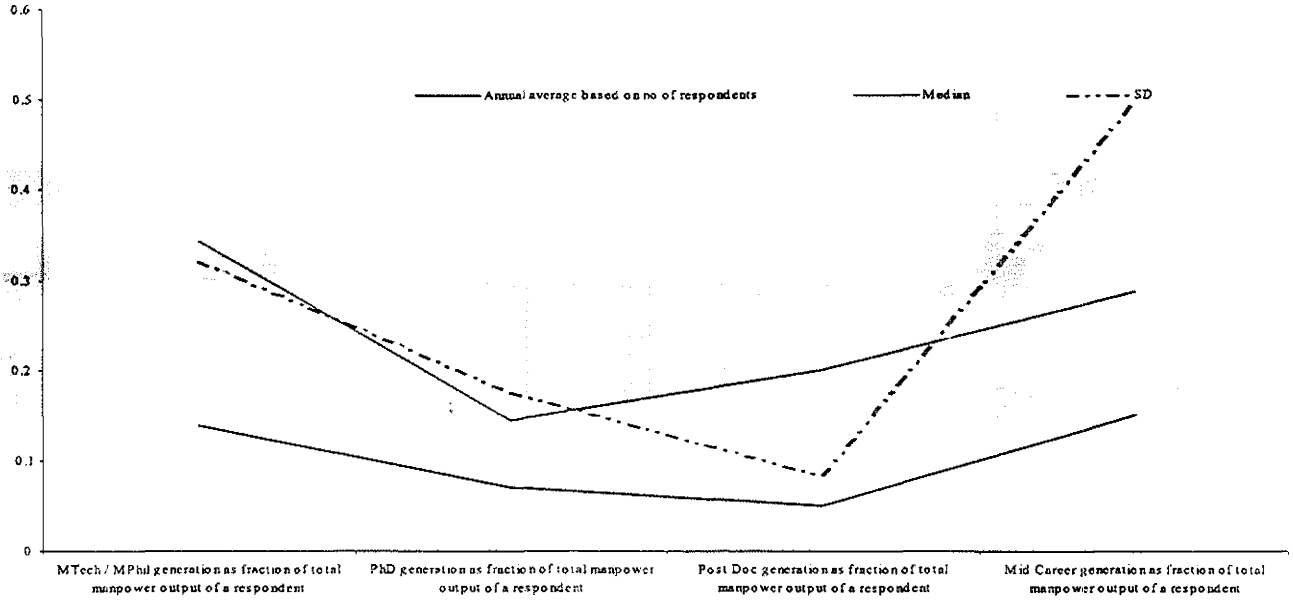
Our argument is supported by data. Our conclusion leads to suggesting possible policy initiatives.

Summary of data:

Drawing upon the results of a survey of Indian organizations engaged in manpower generation, such as universities and research institutes, we can observe two significant features. First: quantity of manpower generated per person at various grades/levels is low. Second: there is an absence of right kind of incentives inside Indian organizations affecting generation of larger manpower of good quality. The quality enhancing and quality assuring aspects of the institution of incentives are missing. In fact and on the contrary, quality assurance is performed by default mechanisms, such as by piggy riding peer-review processes in the focal country, namely the USA.

In the following Figure-1, we present survey result on how professionals from biochemistry spend their time-resources on generation of manpower across four categories of MTech students, PhD students, Post-doctoral students and mid-career trainees.

Figure-1: Expenditure of time-resources by biochemists on manpower generation



The following Table-1, presents data on the extent of manpower generated in seven categories by these biochemists.

Table-1: Manpower generation by biochemists of India

Manpower generated by professionals/academicians: Data from 564 professionals from Survey of professionals in Univs/res orgns, 2003/4 ONLY BIOCHEM Group

	M tech /M Phil students	PhD earned	Post-doctoral	Summer/Winter training	Attendance to research colloq	Trg to mid-career professionals	Juniors in ogn received trg	Total manpower generated
Annual average based on no of respondents	2.93	1.13	0.8	3.86	4.27	1.56	1	7.33
Median	3.5	2	1	10	10	2	3	10.5
SD	11.12	3.53	2.19	11.24	10.57	4.62	1.41	23.92
Manpower generation as percentage of total manpower output of a respondent	0.14	0.07	0.05			0.15		

The following Figure-2 and Table-2 presents similar data as above on professionals from genetics.

Figure-2: Expenditure of time-resources by biochemists on manpower generation

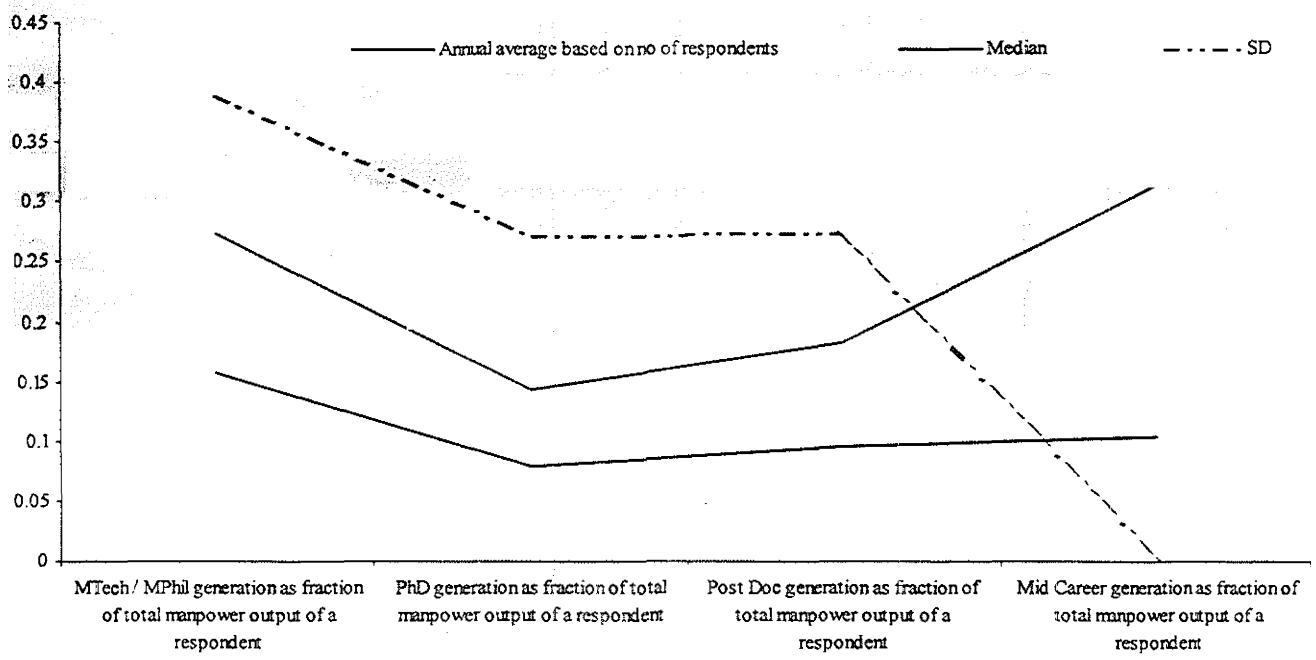


Table-2: Manpower generation by biochemists of India

Data from 564 professionals from Survey of professionals in Univs/res orgns, 2003/4 ONLY GENETICS Group

	MTech/ MPhil students	PhD earned	Post-doctoral	Summer/Winter training	Attendance to research colloquia	Trg to mid-career professionals	Juniors in ogn received trg	Total manpower generated
Annual average based on no of respondents	3.9	1.34	1.38	1.52	6.44	3.33	7.22	8.24
Median	6	2	2.5	3	6	10	7.5	13.5
Std. Dev.	12.67	3.46	4.51	3.35	26.63	0	38.52	28.03
Manpower generation as percentage of total manpower output of a respondent	0.15	0.07	0.09			0.1		

No less important is the existence of negative-list of incentives, or the absence of incentives. This applies to policies regarding publication in domestic journals, or policies on generating large number of good quality students. Survey respondents expressed their opinions on how their respective organizations valued respective classes of activities. Remarkably, international publication always attracts high pay off. Figures-3 & 4 explain this.

Figure-3: Perceptions regarding current incentive-system inside organization in Kolkata city

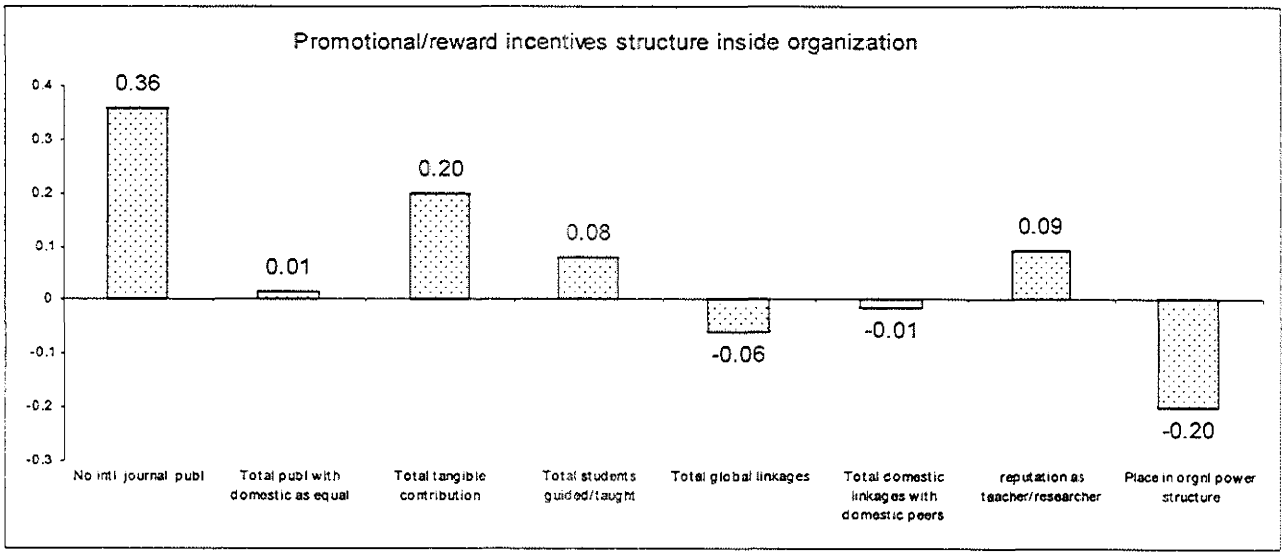
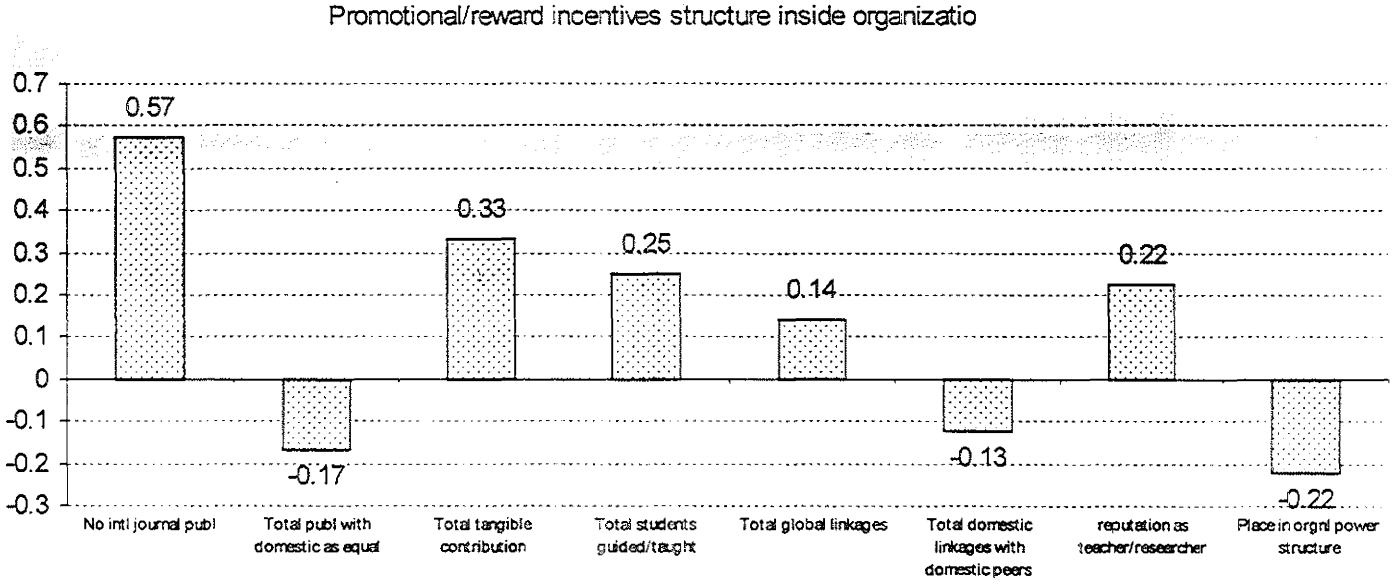


Figure-4: Immunologists' Perceptions regarding current incentive-system inside organization



Quality of the manpower has been attested by the nature of publication. Data drawn from public databases have been analyzed. This shows that nearly all the research publications are brought out in journals published by agencies in the focal country(ies).

Low volume of manpower generation, low volume of quality-faculty, low volume of research publications and finally negative-incentives on publishing locally (contrary to publishing internationally) – all act synergistically to put a severe restraining curb on the primary resource, the manpower.

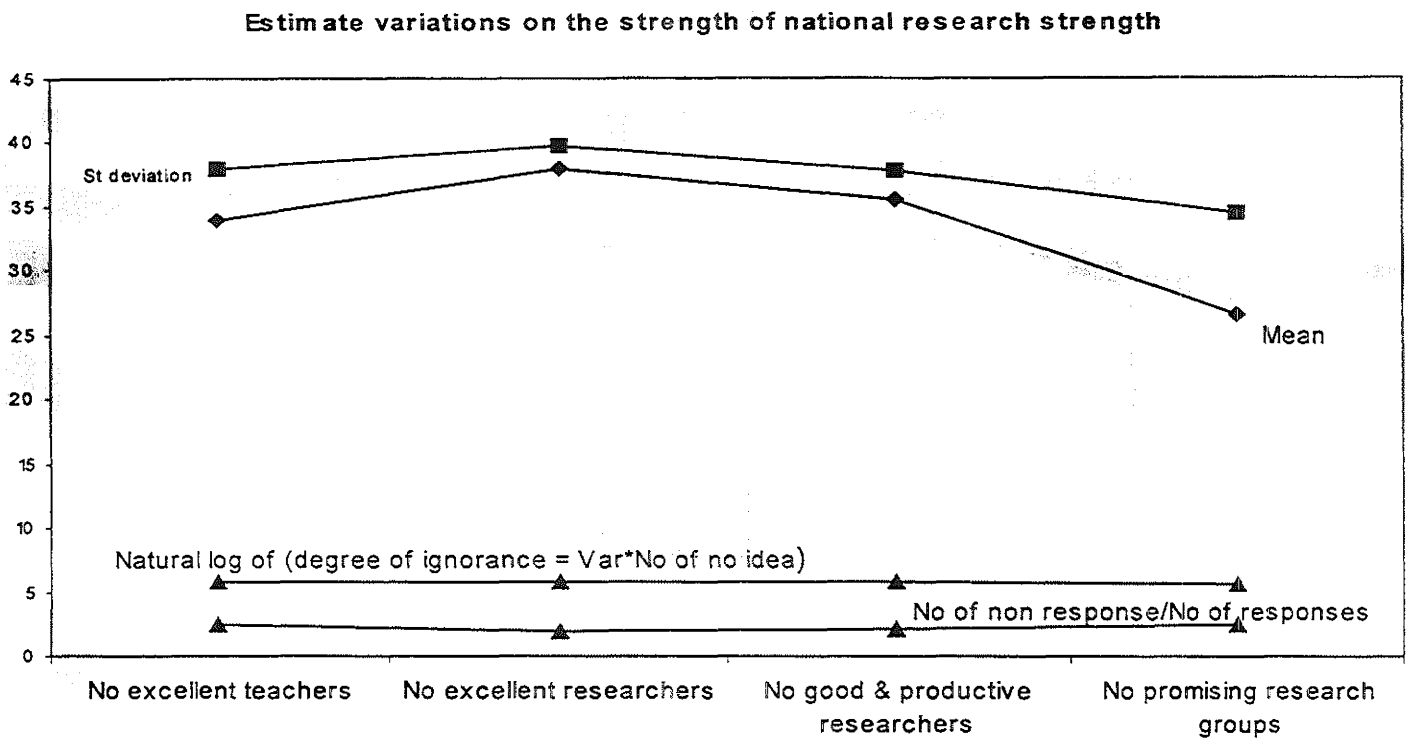
Low quantity in particular conditions the nature of research groups. Research networks are formed primarily through bi- or tri-lateral research groups. Following descriptions capture how such research groups remain limited to one-organization alone – thereby limiting dynamism in research networks. Figure-5 shows strengths of bioinformatics research groups.

Indian data on strength of such research group's show how limited is continuation of joint research over time. Figure-5 shows this.

Figure-5: Strength of Indian research groups

Weaknesses in research groups are revealing. However, more revealing is the degree or the level of ignorance of a professional regarding the domestic profession. Respondents in the survey indicated (or said they did not know) the strength of the domestic professional community in terms of several parameters – a very wide divergence in the values of those parameters express the degree of ignorance or the degree of absence of communication of the respondent professional with his/her own professional community. Inter alias, this is an indicator of weakness of public domain. Figure-6 represents the weakness in domestic public domain.

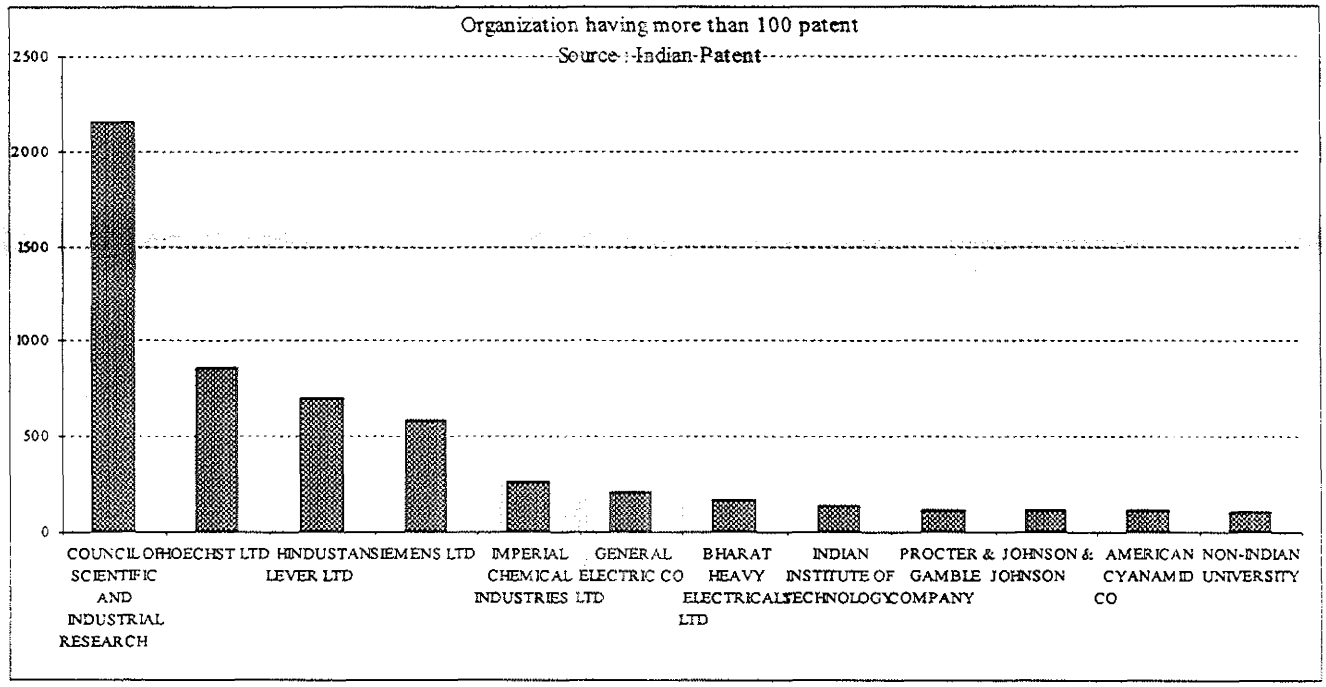
Figure-6: Weakness in domestic professional public domain



Capacity building is intrinsically related to the distributive aspects of manpower, both in terms of quantity and quality, over several cities and geographies as well as over several modes and systems of institutions. This report has drawn attention to this aspect rather often.

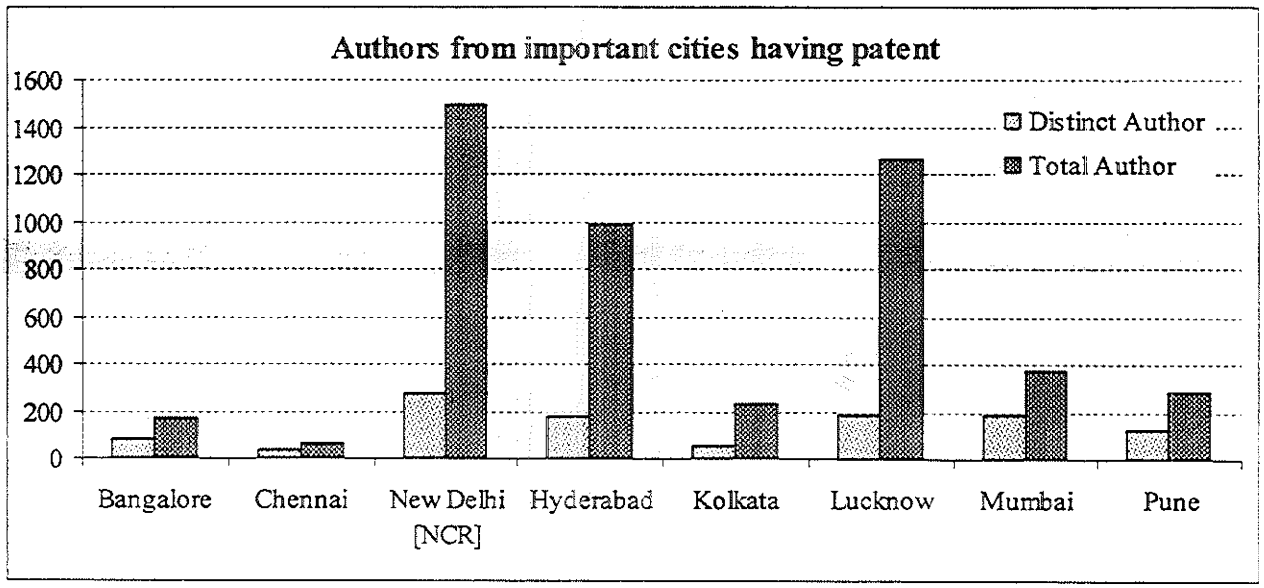
IPR related aspects have been looked at from two sources of data, first the Indian patents and second from US patents. Figure-7 brings out organizations who have been granted more than 100 patents by Indian Patents office.

Figure-7: Organizations granted more than 100 patents in India



Strategic aspects of patenting are reflected in the US patents granted to Indian organizations in several areas of drugs and pharmaceuticals. Figure-8 exhibits such US patents when distributed over several cities of India. Distribution reflects the capacity and quality aspects of the patenting activity. Differences between distinct and all authors indicate the degrees to which there are some authors who could be described as super-achievers.

Figure-8: US patents granted to Indian authors from various cities



Policy Perspectives:

- To recognize quality manpower as the most crucial resource for S&T and innovation; (Policy recognition of manpower as the strategic driver)
- Quality can be bootstrapped through increasing moderately-good quality but of immense quantity of manpower; (Quantity-driven policy)
- Facilitating competition within this very large quantity of manpower; (Policy on capacity-building through market facilitation)
- (through) Designing incentives and infrastructures for quality in manpower, such that competitive pressures fall in line with incentives of initially fragile infrastructure; (Policy recognition of infrastructures and incentives-systems)
- Such infrastructures must take shape of social institutions – it must design common manpower policies for universities, public research bodies and medical institutes and activate the public domain in knowledge discourse; (Policy on knowledge/innovation competition and on sustainability)
- Strategic initiatives in the area of drugs and pharmaceuticals must make strategies on IPR. Current IPR strategies are weak as reflected through IPR in both USPTO and in India.

Chapter-2:

States of affairs

Field level data in India on quality of the knowledge manpower and on the organizations involved are not available. There is no reliable source of data. Websites of organizations are often not complete, sometimes offering no data. Annual reports too are sporadic and often such reports present data on items, which are unique and hence incomparable across multiple organizations.

In the absence of data making an estimate based on studies of sampled organizations and sampled individuals would be very unstable. Moreover existing statistical methods would imply undertaking sample surveys involving larger resources beyond the permissible limits of the current project.

Most importantly the response rate of respondents is extremely poor. Our experience is disastrous. Often the responses to mailed questionnaires have been less than one in thousand. Given the absence of national-level data we could begin our survey based only on our pre-disposition and on our prior beliefs.

In order to avoid such trappings we designed a questionnaire, tested by seeking a few responses, and sent the same in three electronic modes (Word, pdf and Linux) to almost all researchers and academicians listed in organizational websites, in the three scientific academies (Delhi, Bangalore, and Allahabad) and known otherwise. Subsequently we sent reminders to these individuals. Further, upon non-receipt of filled-in questionnaires we sent more than 1000 questionnaires in hard copies and by post to these individuals. Sadly, through all this we could barely cross fifty filled-in responses.

Next stage was to scout around for volunteer-academicians in universities/research organizations to whom we requested for student data-collectors. These students were expected to get filling-in from their teachers in the same university or from academic/research organizations in respective hometowns. Our limited ability permitted us to collect data from scattered centers. Unfortunately our colleagues in South, Central, and West India largely neglected our requests. As a result we could gather data from spots in East and North India.

Figures 1 and 2 present the distribution of respondents in two modes. Figure-1 presents this distribution across cities. Our objective was to map out as far as possible the variations in quality aspects of manpower across cities of varying resources endowments. Quality is believed to result from great infusions of social capital embedded often in knowledge infrastructures. Even amongst metropolitan cities of India there are great variations in resources and infrastructure endowments, such that Bangalore possibly tops the list in such bountiful infrastructures as most others envy. In the next group falls non-metro cities including serene townships who share a very scanty scientific infrastructure. Finally, there are regional disparities. However, as mentioned in the previous page, we could not receive answers from all this groups in large quantities. As a result, Delhi, Kolkata, Varanasi tops the list, followed by a few small cities/towns. Despite this limitation, the number of respondents is not very small and their spread is fairly representative.

We tried to look into differences in quality aspects across organizations from those heavily funded to those least, from those under autonomous bodies to those more restrictive, from non-teaching to those almost entirely devoted to teaching in the following Figure-2. This Figure-2 presents distribution across metropolitan cities, and across cities large and small, academically well known to least known for such excellences, from those with plethora of research/academic bodies to those with singularities.

Figure-1: Distribution of respondents over major cities

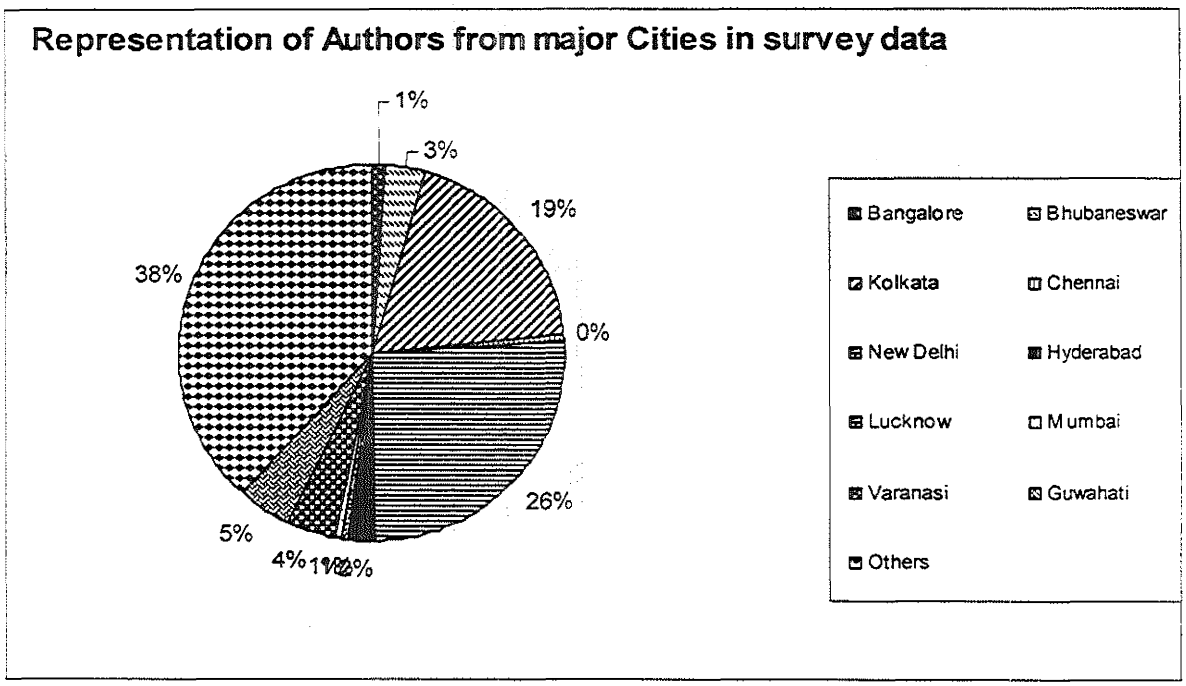
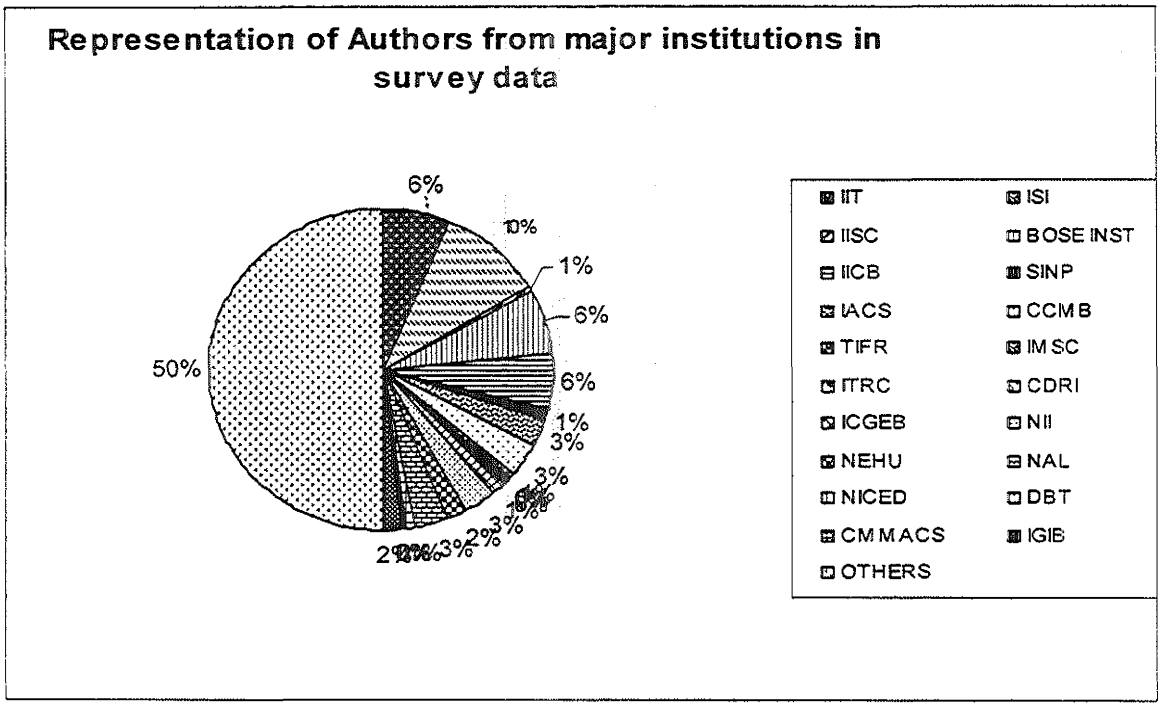


Figure-2: Distribution of respondents over major institutions



Quality of manpower indisputably depends on the quality of instructions received during major phases of specializations.
Following three Figures-3, 4 & 5 exhibit how and from which types of organizations as well as cities, that is from which types of social capitals our respondents received their post-graduate trainings, doctoral instructions and research trainings, and post doctoral semi-independent detour through research.
Ordinarily believed position is that a training received from focal countries, especially from the USA is much superior to trainings received in domestic institutions. In order to categorize quality based on the geography of training we classified trainings into two broad groups – domestic and abroad, the latter almost always refer to organizations in the USA or the UK.

Figure-3: Geography of postgraduate study of respondents

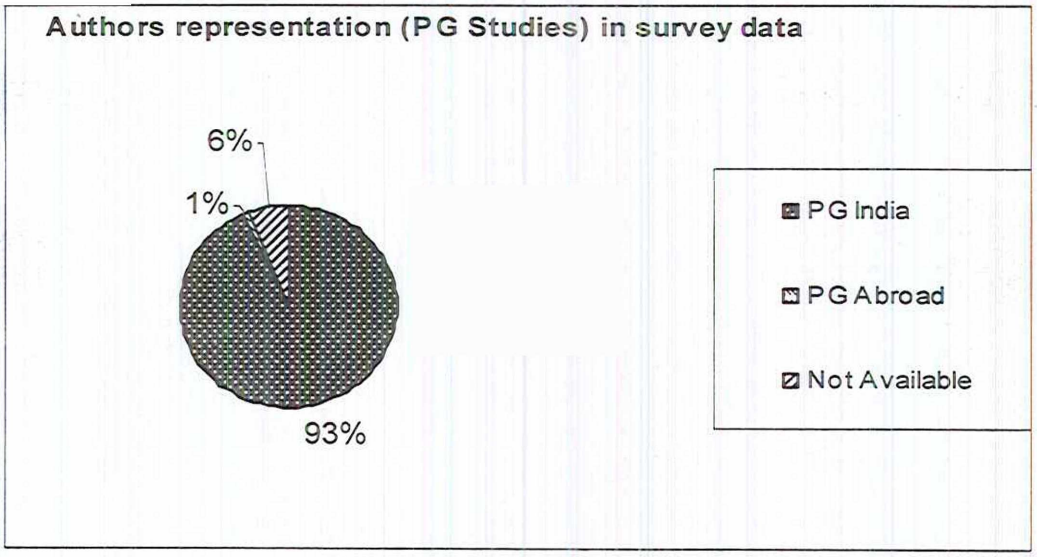


Figure-4: Geography of doctoral research-study of respondents

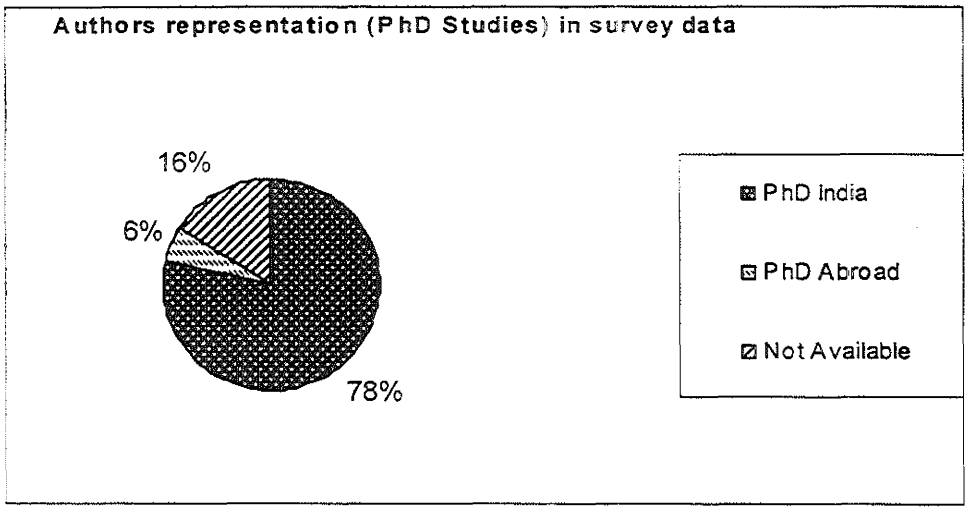
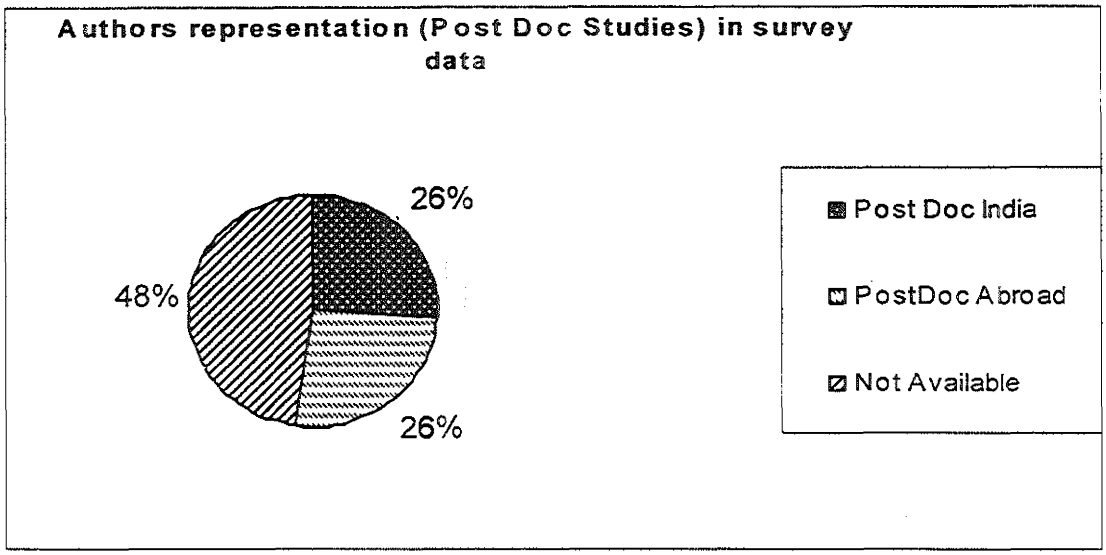


Figure-5: Geography of postdoctoral research-study of respondents



Quality depends, some argue, on exposures to interdisciplinary research or instructions; or on a dynamically shifting profile of expertise of respondents when respondents responded to changes in research focus or in global fashions of research by aligning oneself to the new research thrust.
Quality of manpower, in this case, refers to dynamically shifting frontiers of expertise. The value of a National Innovation System (NIS) would greatly vary over variations in the expertise pools and over the dynamics in such expertise pools.
Our research was not directed to mapping out of such pools. Neither was it meant to capture temporal shifts in both quantity and quality of such pools.
We therefore attempted the locating of the existence of dynamics in expertise domains. Following two Figures-6 and 7 exhibit these trends. Figure-6 captures shifts in expertise and hence the dynamics.
Figure-7 captures this same aspect though mobility across organizations, assuming that most organizations specialize in distinct areas. Hence job mobility indicates shift in expertise. Moreover, such mobility indicates dynamics of careers and the attractiveness or reputation of organizations.

Figure-6: Dynamics in expertise of respondents

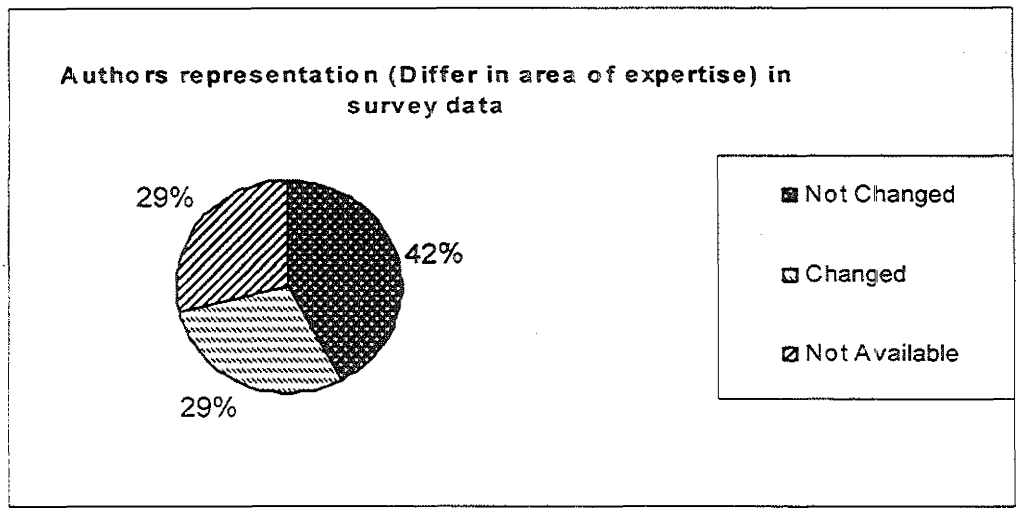
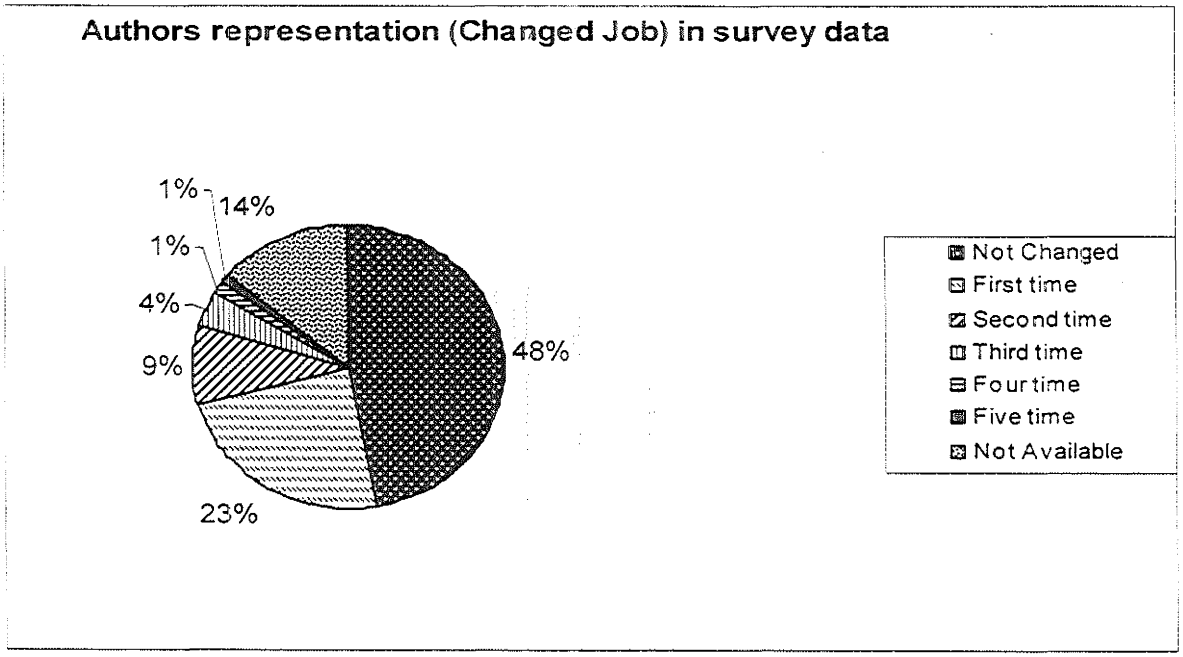


Figure-7: Career and expertise mobility of respondents



Perceptions on what determines quality of an individual vary widely. Often professionals look at the organization where the incumbent received training or under whom the person received instructions. Many others, however, prefer to look at other qualities which they believe are either intrinsic to the individual or are dependent upon such aspects as business orientation drives.

Our respondents ranked six such parameters that could define the quality of an incumbent young job seeker on a seven-point scale, providing us with data on what degree of importance might get attached to respective parameters. Following Figures-8, 9, 10, 11, 12 and 13 exhibit the distribution of ranked weights to each parameter shown separately.

As is evident, deep understanding and originality scored maximum number of weights followed by number of research outputs. Other parameters appear to have received very similar weights. Hence these other factors might not over a large population be able to discriminate quality. The scorecard is distinctly in favor of individual quality in contrast to measuring quality based on such factors as the reputation of alma mater. The market for organizational reputation might prove then weak, while market for individual quality indicators could prove strong.

Figure-8: Importance of reputation of alma mater in deciding manpower quality

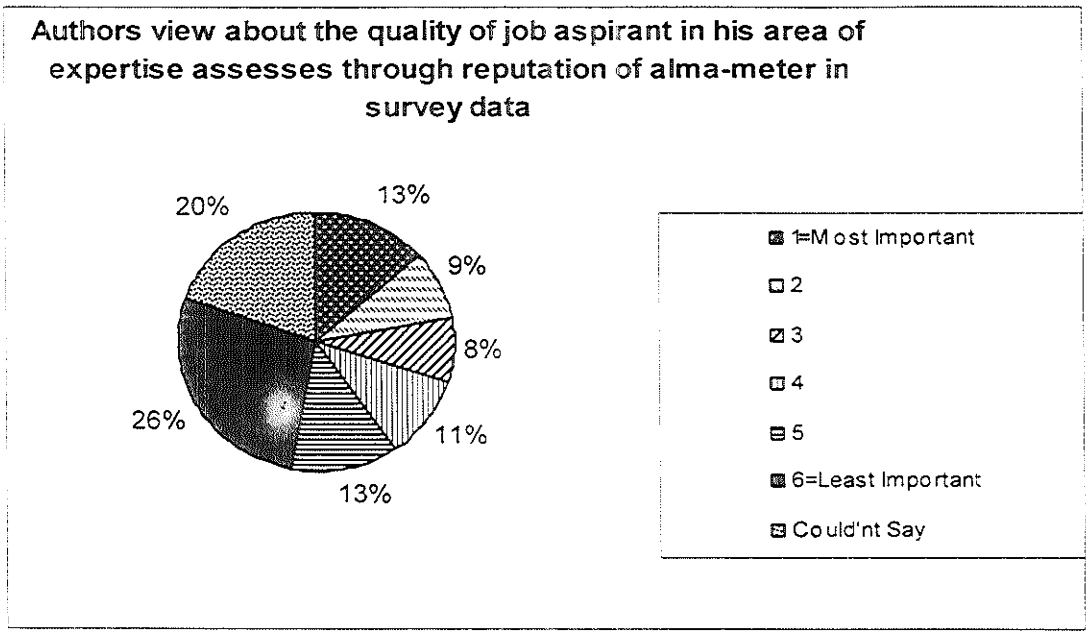


Figure-9: **Importance of reputation of guide/teacher in deciding manpower quality**

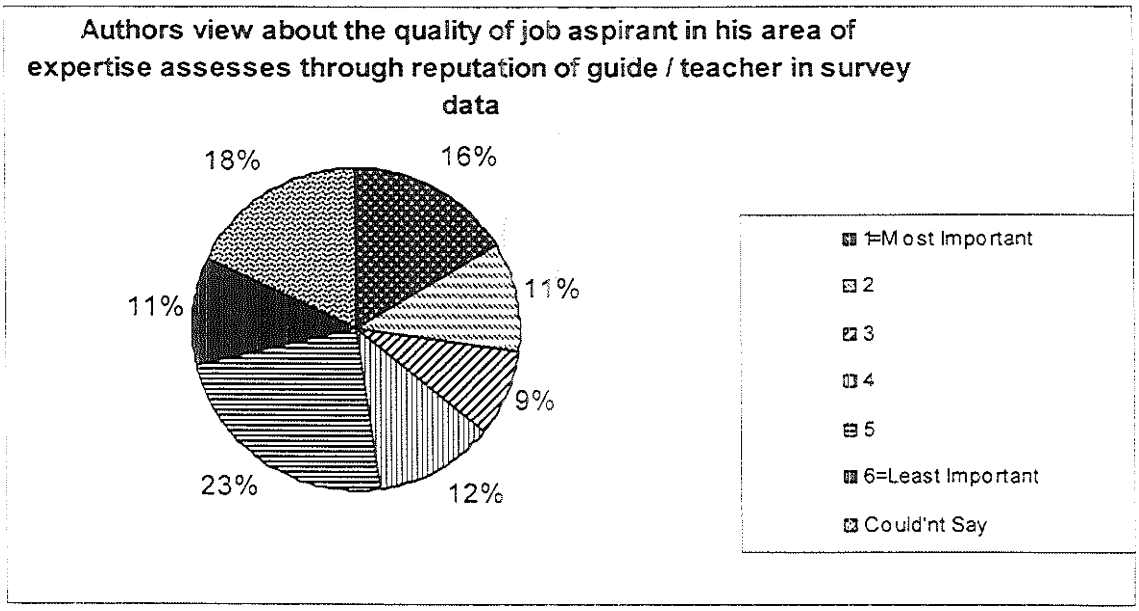


Figure-10: Importance of research publication/output in deciding manpower quality

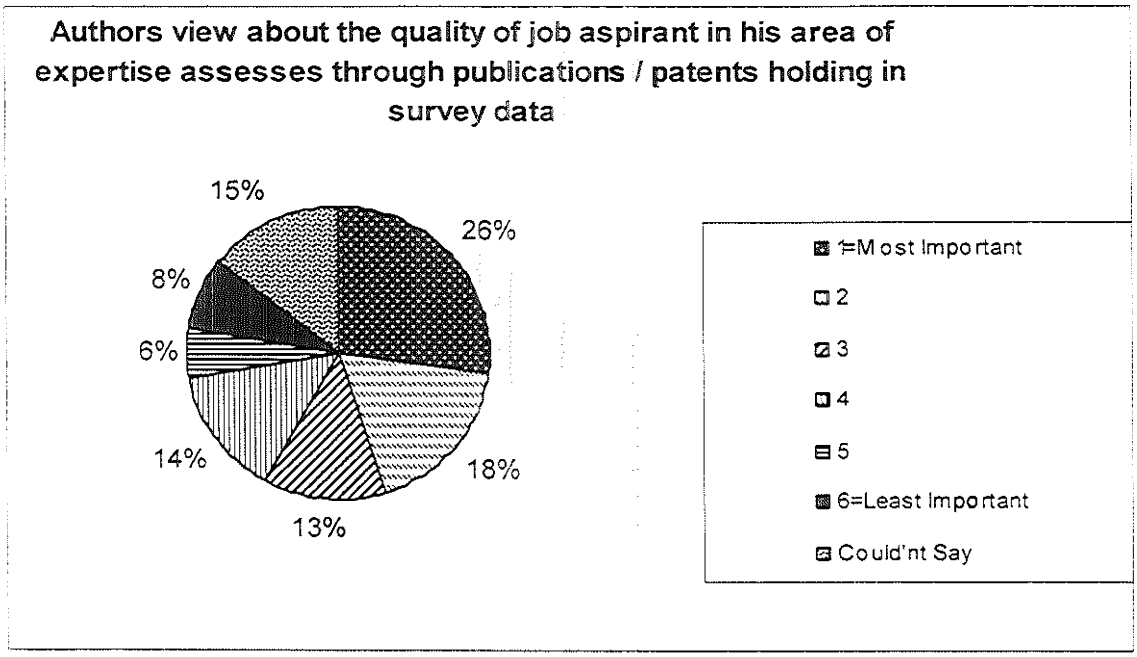


Figure-11: Importance of originality and understanding in deciding manpower quality

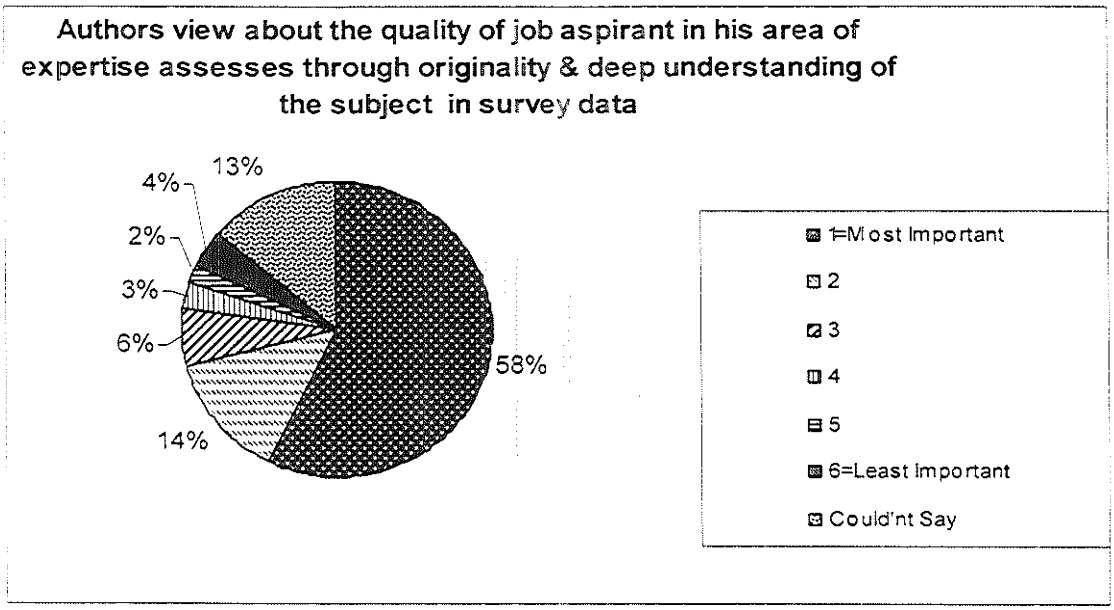


Figure-12: Importance of problem-solving skill & business orientation in deciding manpower quality

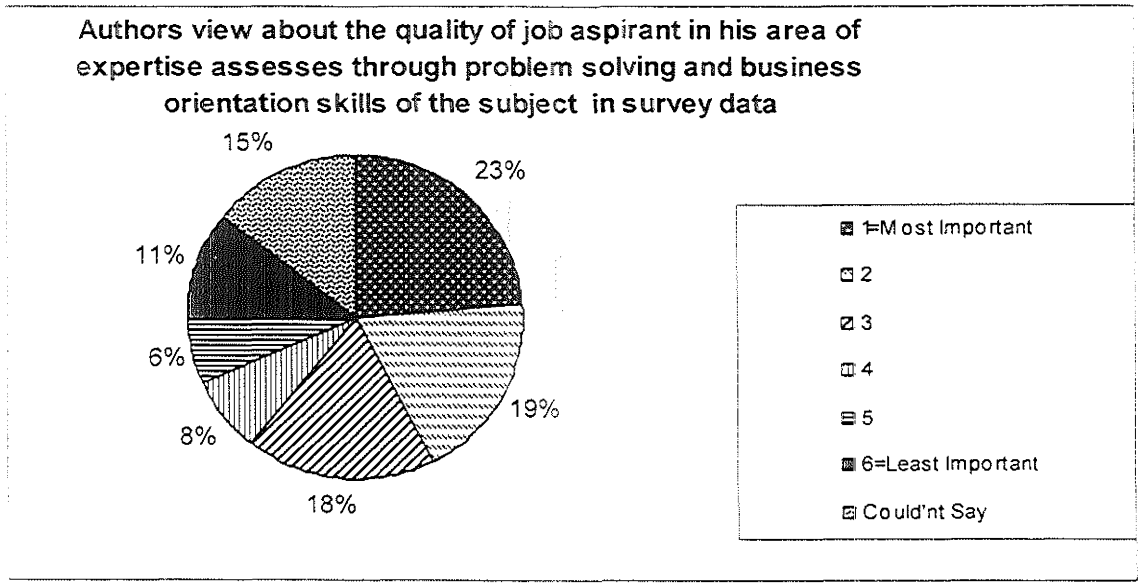
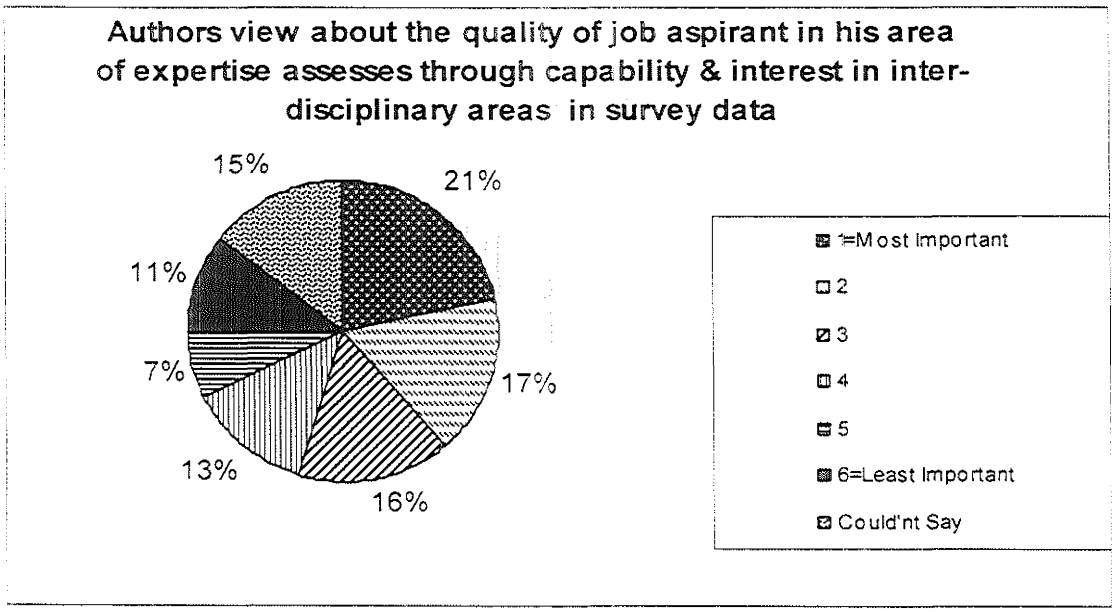


Figure-13: Importance of capability in interdisciplinary research/teaching in deciding manpower quality



Quantity of quality manpower is very important. Quality often depends upon the push provided by and in particular the competitive environment that an incumbent is forced to enter into.

Following Figures-14, 15, 16 and 17 exhibit both the quantity of manpower trained in sufficiently high skill sets pertaining to M.Tech or M.Phil levels; as well as these Figures bring out facets of the dynamics of such trained manpower in three directions – firstly, into further higher education in domestic organizations; secondly, for further higher education in organizations abroad; and thirdly, for jobs markets.

Inter-alias, these Figures (as some of the exhibits already presented) present the capacity building aspects of domestic organizations. Capacity of domestic organizations are captured through the levels of instructions imparted, through the quantity trained, through the retaining features of domestic organizations vis-à-vis organizations abroad, and finally, through building up of the manufacturing capability in domestic job markets.

Moreover, each of these avenues, namely higher studies in domestic organizations or that in organizations abroad and the job markets are competing for quality manpower. The degree to which manpower gets apportioned across each such markets therefore indicates the attractiveness and the built-in capacity of respective segments.

Finally, there is no other avenue to collect data on such aspects of manpower quality, quantity, mobility and organizational as well as institutional capacity – excepting through collecting data from the researchers/academicians who trained the incumbents. Our data is poor always because respondents seemed to have been reluctant to fill-in lengthy questionnaire.

Figure-14: Number of students trained at M.Tech/M.Phil levels

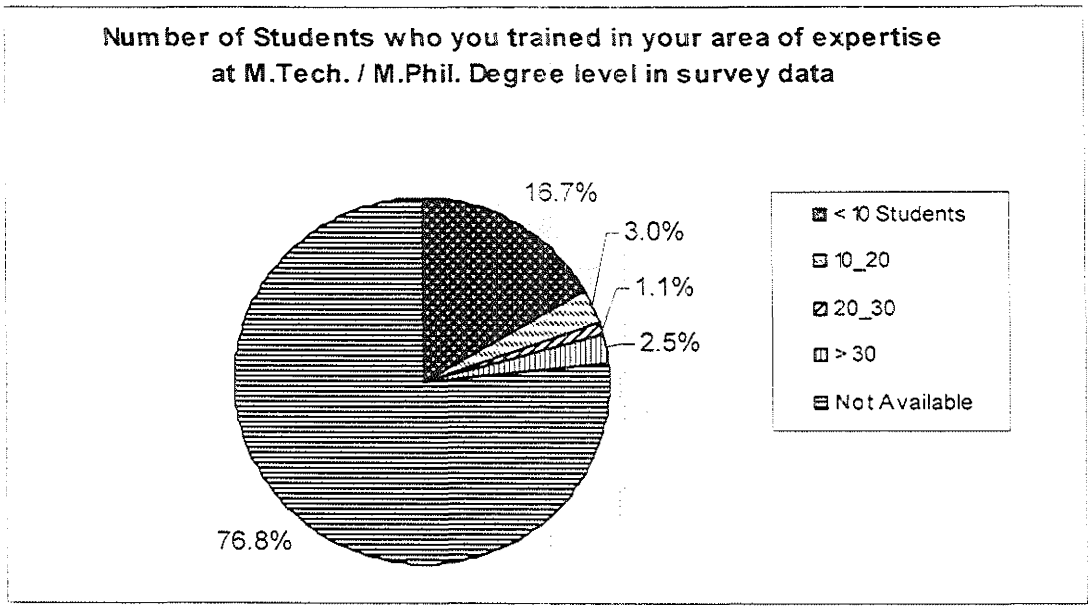


Figure-15: Number of students continuing higher studies following M.Tech/M.Phil

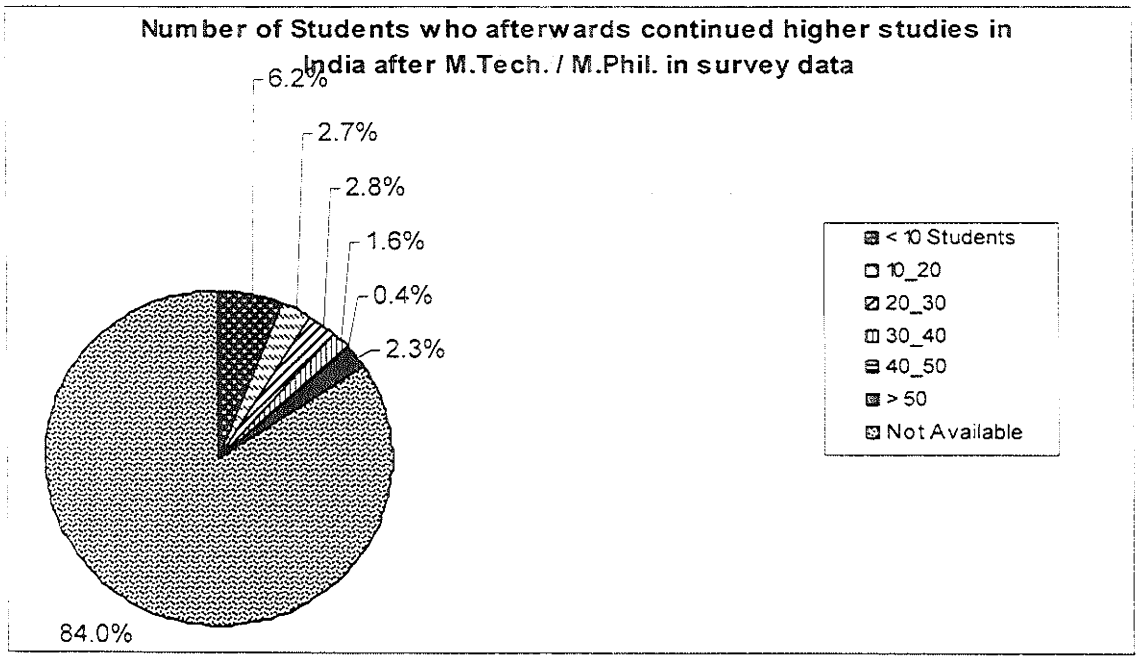


Figure-16: Number of students that went abroad for doctoral and other higher studies

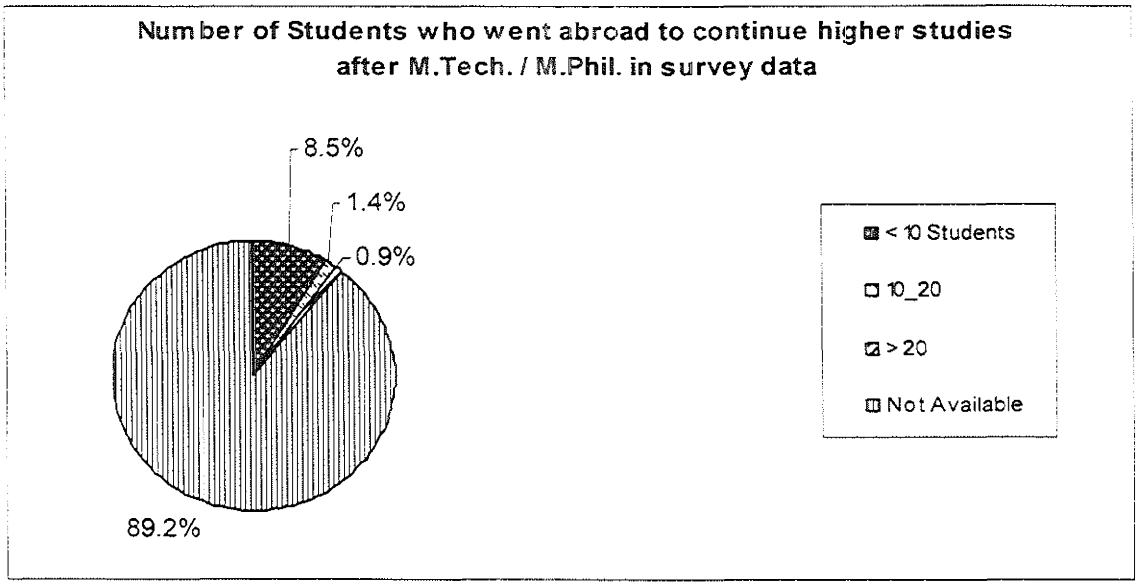
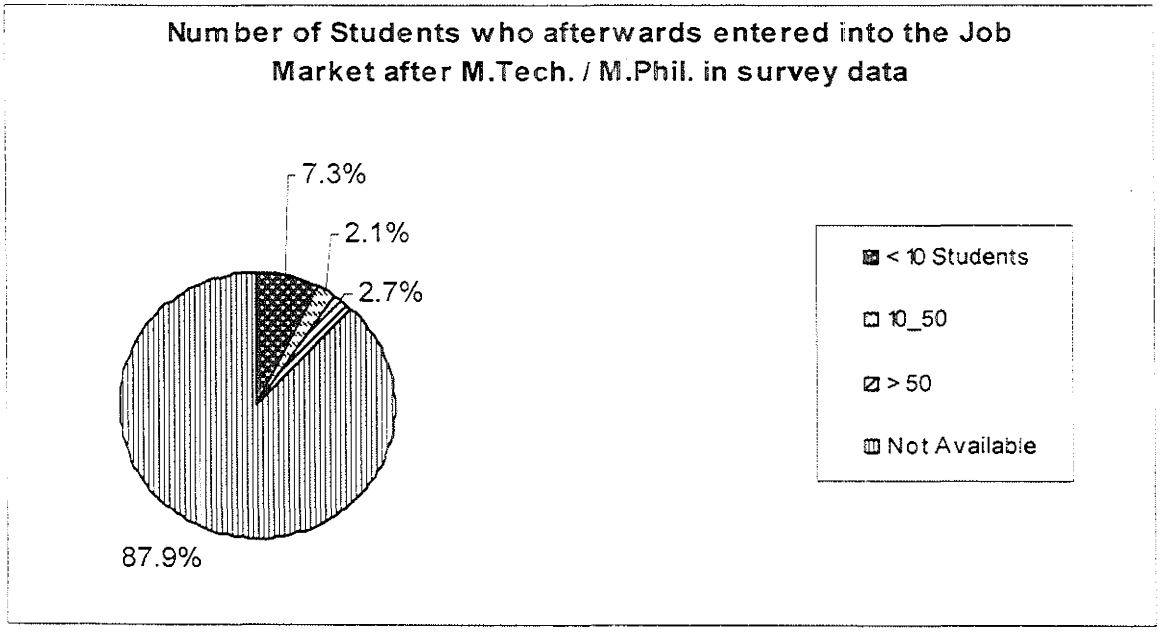


Figure-17: Number of students entering job market following M.Tech/M.Phil levels



Quality of manpower cannot be considered as an outcome or output of the processes of teaching and research. Instead quality reproduces and in turn is (re) produced by the processes of research and teaching. Together these processes constitute a system.

In another language, this system is the public space and the space of discourse that scientists, researchers, academicians, students, et al, together keep alive and in turn this discourse space keeps the qualities of the knowledge-based interactions alive. In a system devoid of such public space or where such public spaces are extremely fragmented and are weak, indisputably quality of research/teaching and the quality of manpower necessarily remain poor, trapped and encapsulated within small worlds of incomparability's.

In our survey, we looked for the degree to which respondents as professionals and as members of societies of knowledge's, keep interacting with each other on issues of joint research, joint teaching, benchmarking, competition on quality, and similar other issues. Obviously, in a states of affairs where respondents have fairly high knowledge of others and about what research/teaching others have undertaken, there would be a lively public space of discourse on the directions of and quantities as well as qualities of research in the country. If on the other hand, respondents prove to be ignorant we might conclude that the public space is weak or dead. A weak discourse space implies that there cannot be any agreed upon benchmark of quality or there cannot be any agreed upon rules of competition as well as directions of research.

Following Figures-18, 19, 20, 21, 22, 23 and 24 exhibit certain facets of the degree of this public space that our respondents share or keep regenerating.

Respondents were asked questions on what one thought to be number of excellent teachers, or excellent researchers, or good and productive researchers, or numbers of doctorates earned or numbers of promising research groups or numbers of interesting and challenging research projects - in the country and exclusively in one's own area of specialization or expertise.

As these Figures exhibit, respondents had either begged the questions affirming their ignorance, or else when they had answered, their answers for each sub-group of expertise varied very widely (that is with very high standards of deviations). All this indicates that on these very important issues related to research or teaching, our respondents had little common knowledge. The public space in India is either dead or very weak.

Respondents cannot therefore agree on what research projects could be taken up or how many doctoral candidates needed to be guided or what minimum critical mass of researchers and other resources would be needed for the country to produce quality research in an area of choice, etc.

These Figures exhibit that the degrees of ignorance are very high and respondents dwell in make-believe worlds.

Figure-18: Public space: Knowledge about excellent teachers in the country for own area

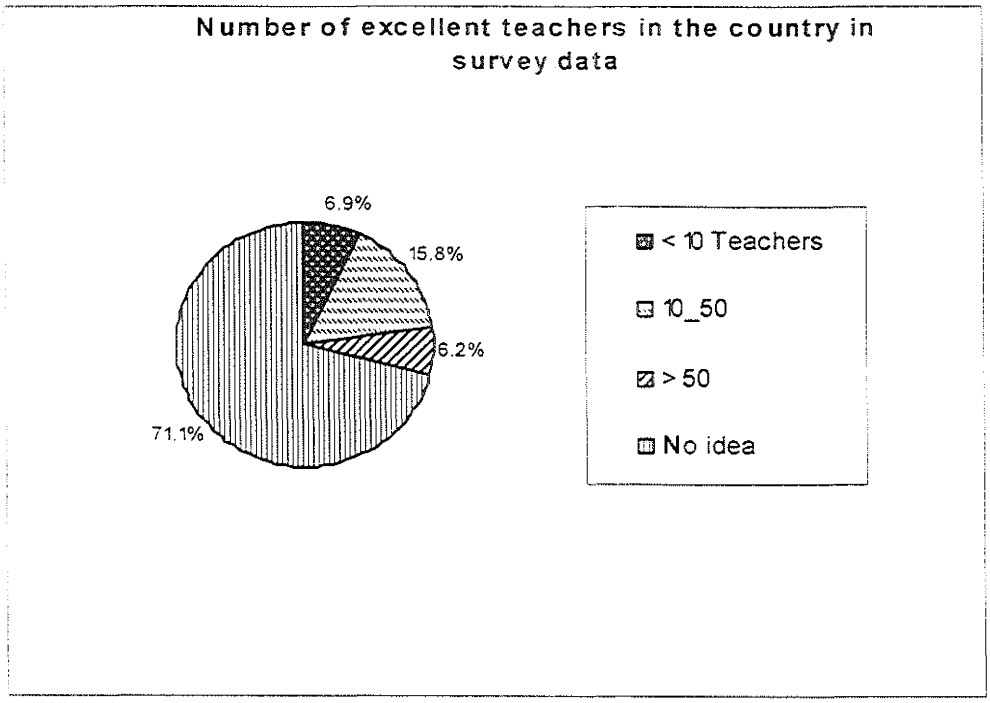


Figure-19: Public space: Knowledge about excellent researchers in the country for own area

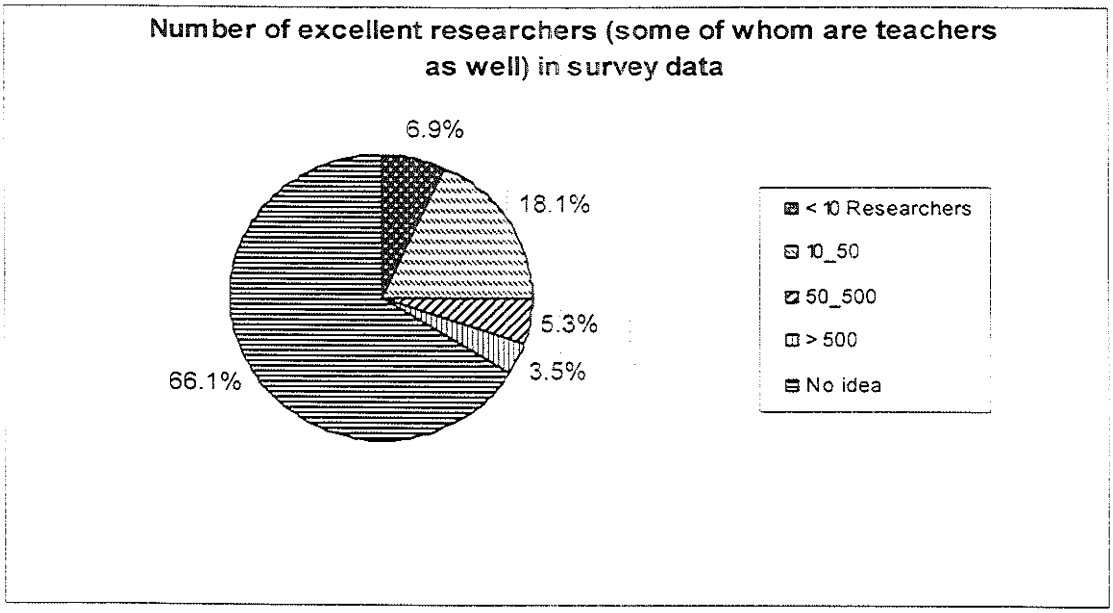


Figure-20: Public space: Knowledge about good & productive researchers in the country for own area

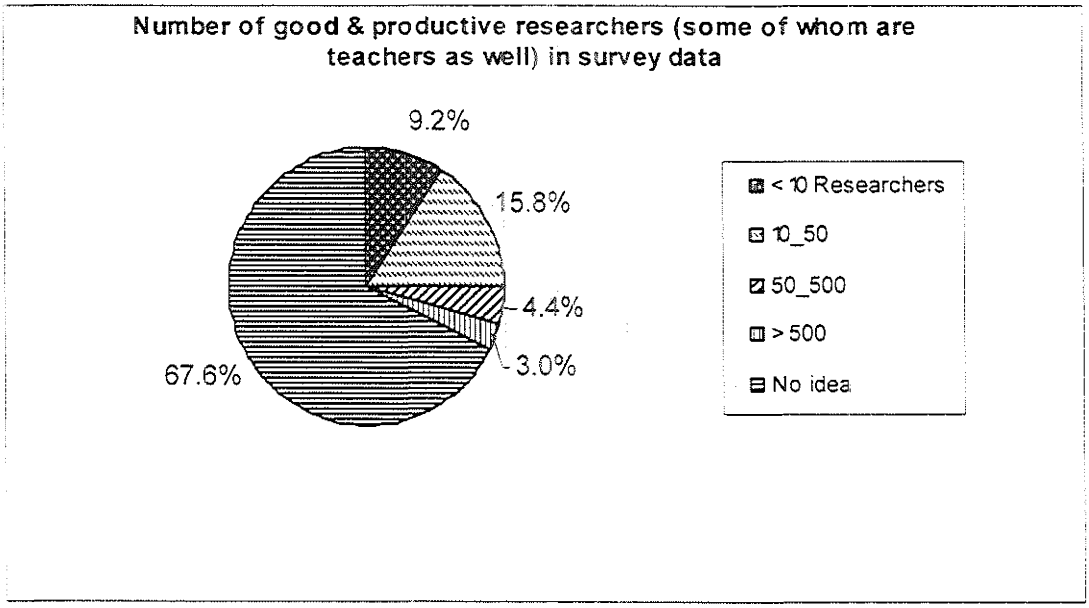


Figure-21: Public space: Knowledge about doctorates earned in the country for own area

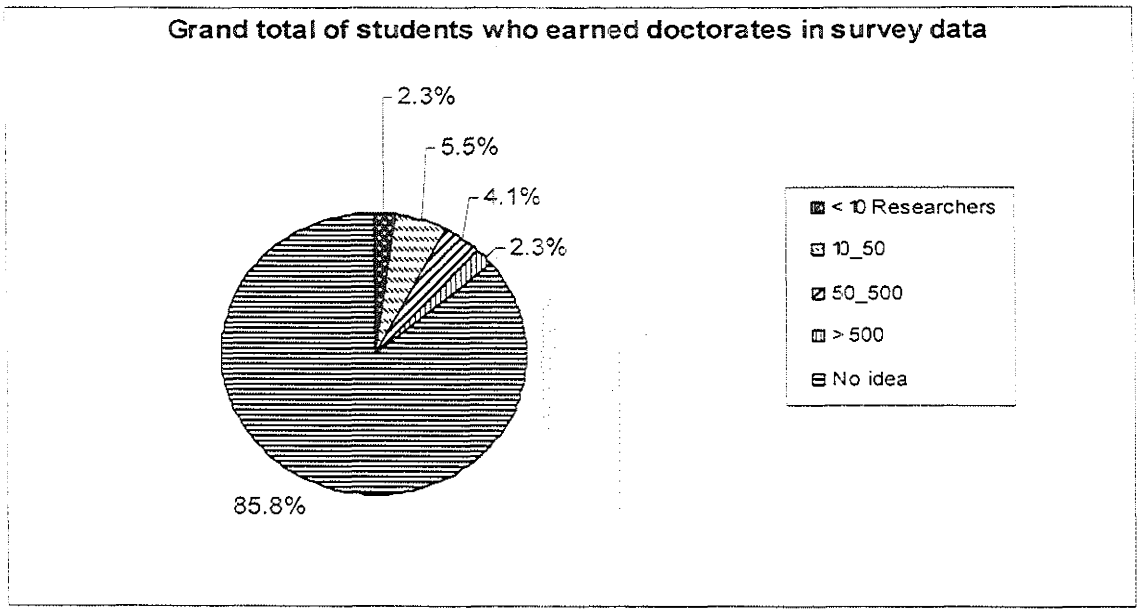


Figure-22: Public space: Knowledge about excellent research papers from the country for own area

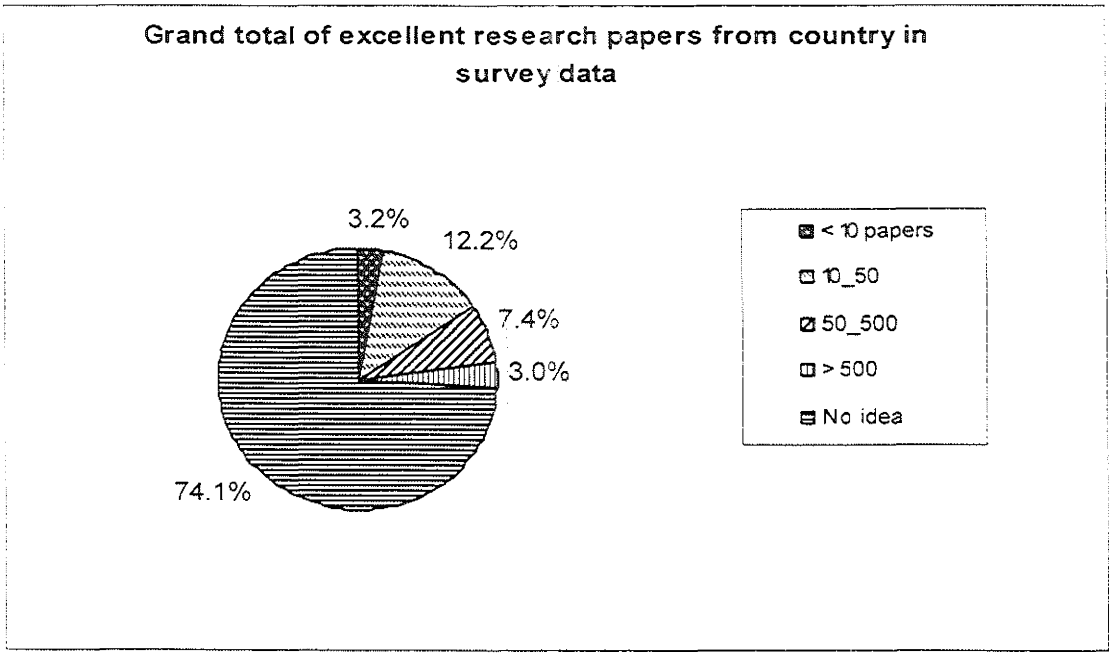


Figure-23: Public space: Knowledge about promising research groups in the country for own area

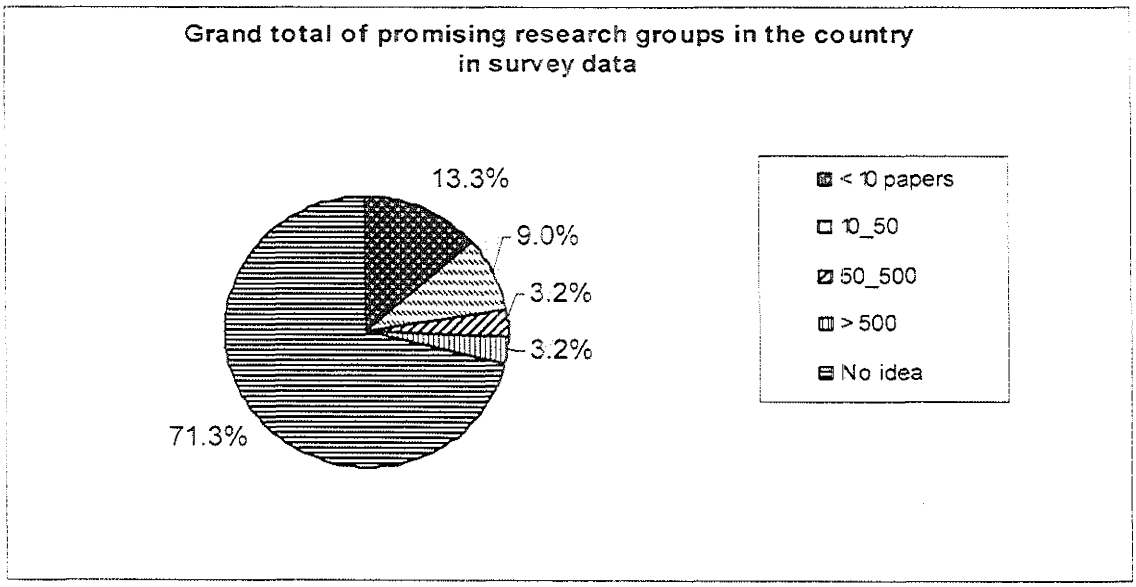
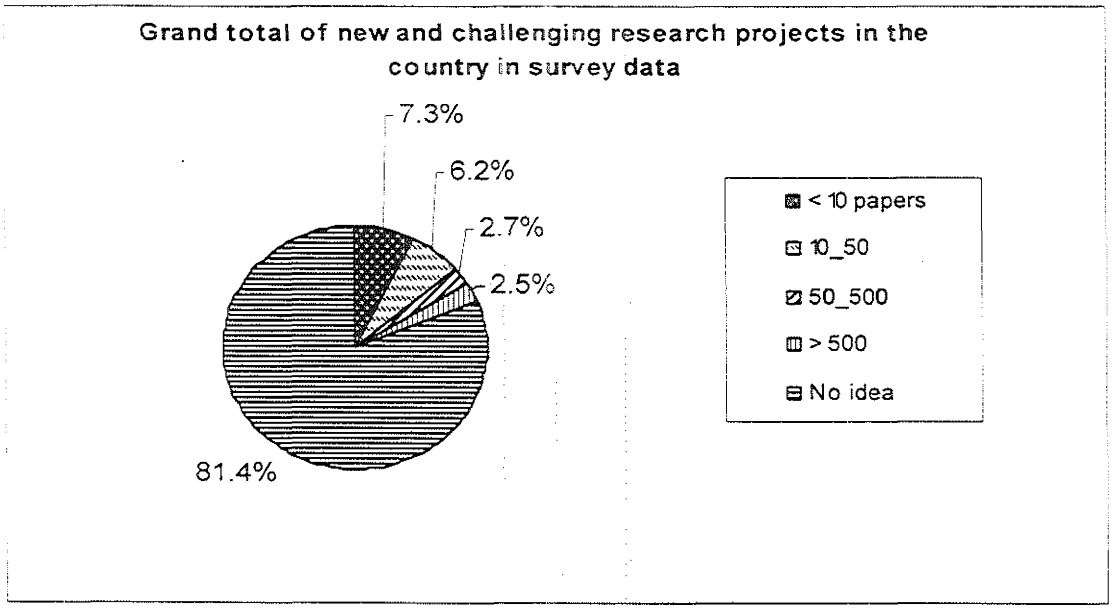


Figure-24: Public space: Knowledge about New & challenging research projects in the country for own area



The two aspects of competitive grant of research funding and formation of national inter-organizational research team critically influence the quality of research and consequently the quality of manpower.

Following three Figures-25, 26 and 27 exhibit how our respondents fare in both undertaking of sponsored research and in forming nationally wide research teams.

Assuming that national funding of sponsored research projects are undertaken on competitive basis, we must appreciate that such competitions can be sustained only if the public space amongst researchers is active. Such a public space alone compares with a market that can disseminate signals. No competition can be arranged in the absence of passages of signals. As derived from the previous group of exhibits, public space in India on matters scientific and technological is very weak and fragmented – consequently, undertaking of sponsored research projects even while procedurally competitive would fail to be described as competitively earned.

Figures 25 and 26 represent two modes of sponsorships, the first from national resources and the second from private industry sources. The first might refer to public good and of national concern on long duration, while the latter could be for private and short-term ends.

Our respondents as these two Figures exhibit are weakly positioned in undertaking of both these types of sponsored research projects.

Figure-27 exhibits dimensions on the formation of nationally wide research teams. Such teams are few and far between. There are very few such projects. Sometimes, researchers and academicians cooperate on informal basis.

Figure-25: Undertaking research sponsored by national agencies

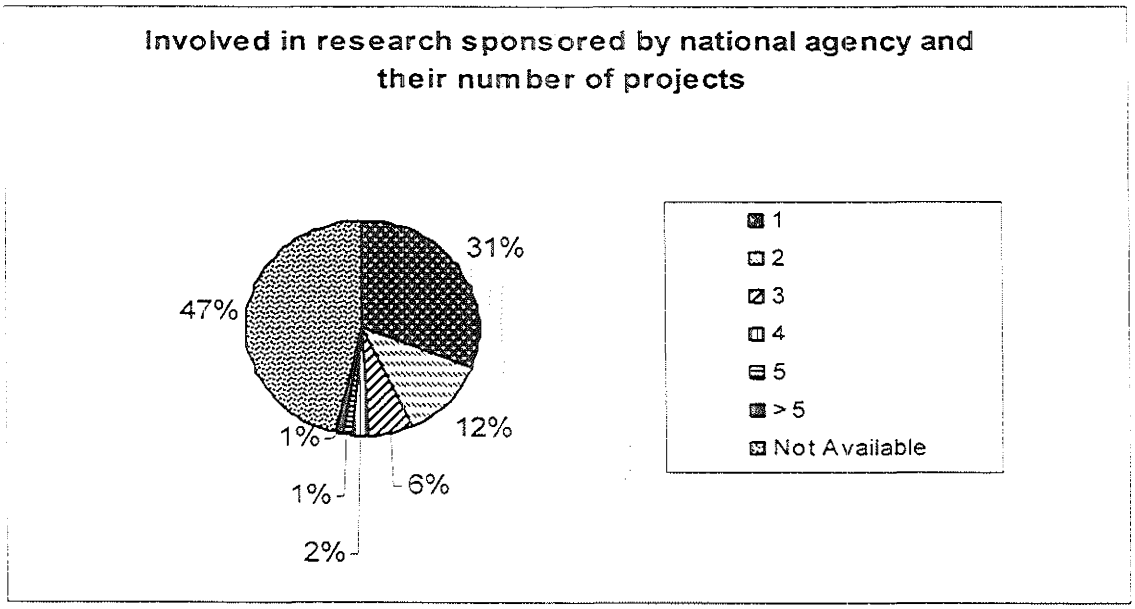


Figure-26: Undertaking research sponsored by industry

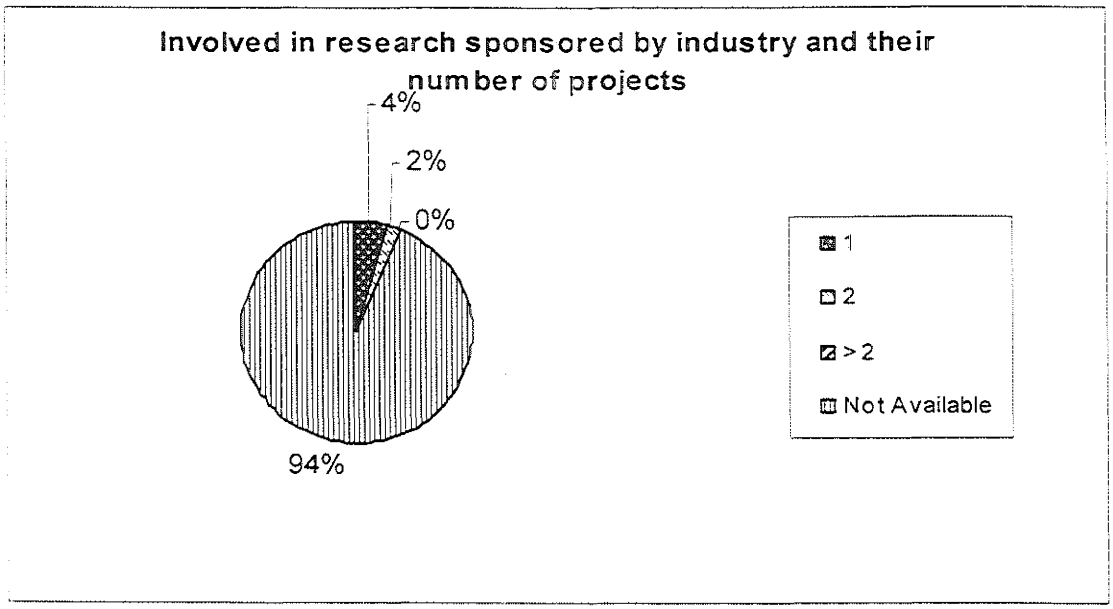
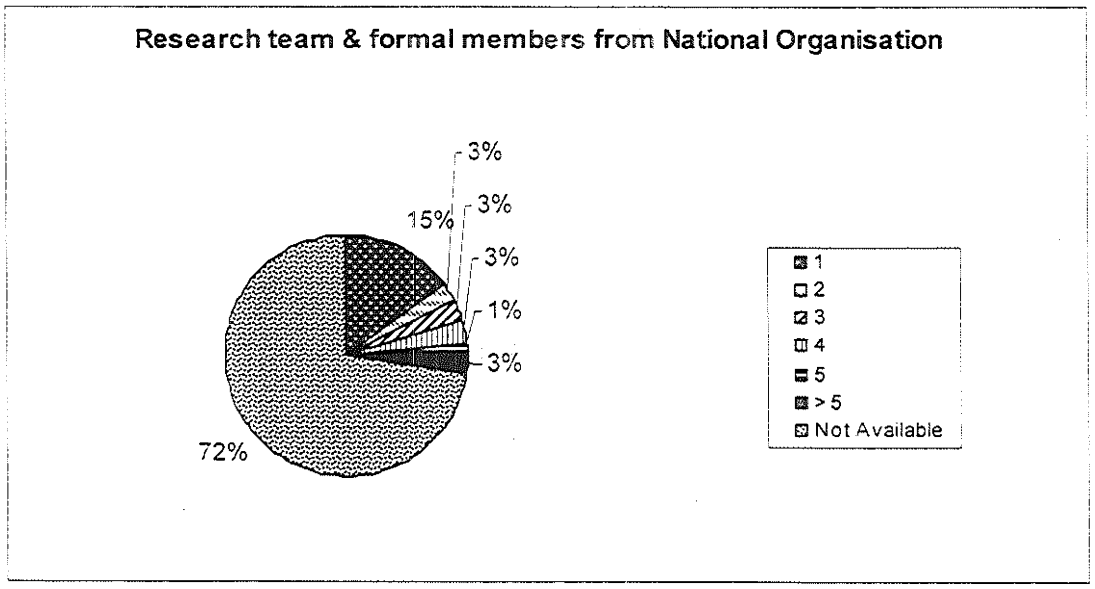


Figure-27: Undertaking team-based research with members from national organizations



Some professionals believe continuing with lone-research is critically essential, and some professionals love doing that. There are others, however, who go for collaborative or sponsored research work.

A lone research can be potentially very innovative or can be equally likely to be very poor. Lone research can go beyond fashion. However, sponsored research would in all likelihood be for immediate utility or in line with fashion, and when supported through competitive-funding mechanism, such research necessarily satisfies minimum benchmark condition. A benchmark must refer to fashion and the currency in research.

Similarly, collaborative research signifies that at least multiple parties agree to the value of that research.

Monitoring costs for both sponsored and collaborative research could be lower than compared to lone research.

Opportunistic variations in ascertaining quality of research could again be lower in collaborative, contract, and sponsored researches. Although, lone research alone can be potentially most promising. Ignorance and uncertainty in lone research are most.

Therefore, as shown in the following Figures-28, 29, 30 and 31 – these four modes of undertaking research refer to variations in quality of research, hence consequently to quality of manpower re-generated or generated therein.

Figure-28: Respondent as lone researcher

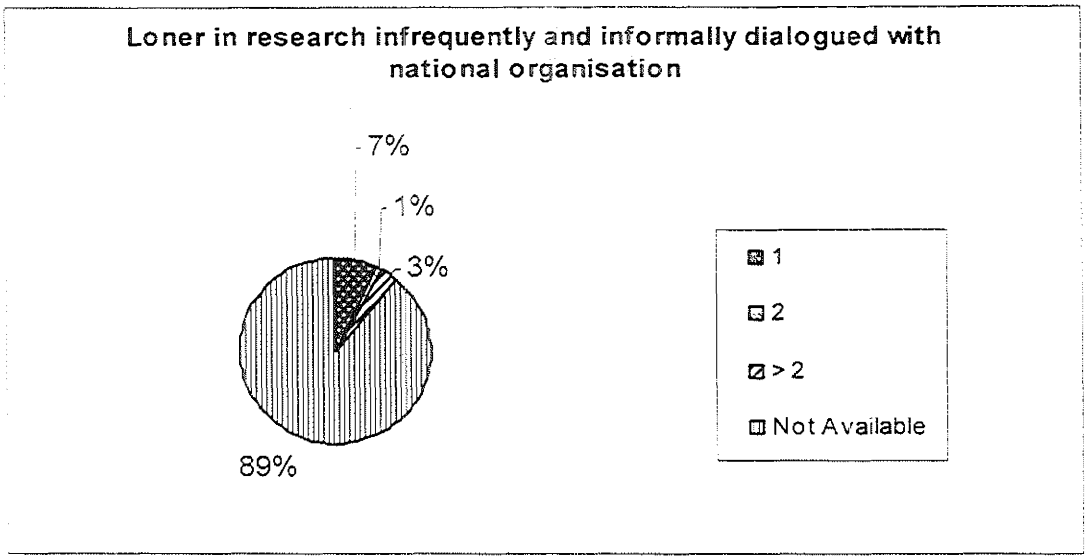


Figure-29: Respondent undertaking contract research

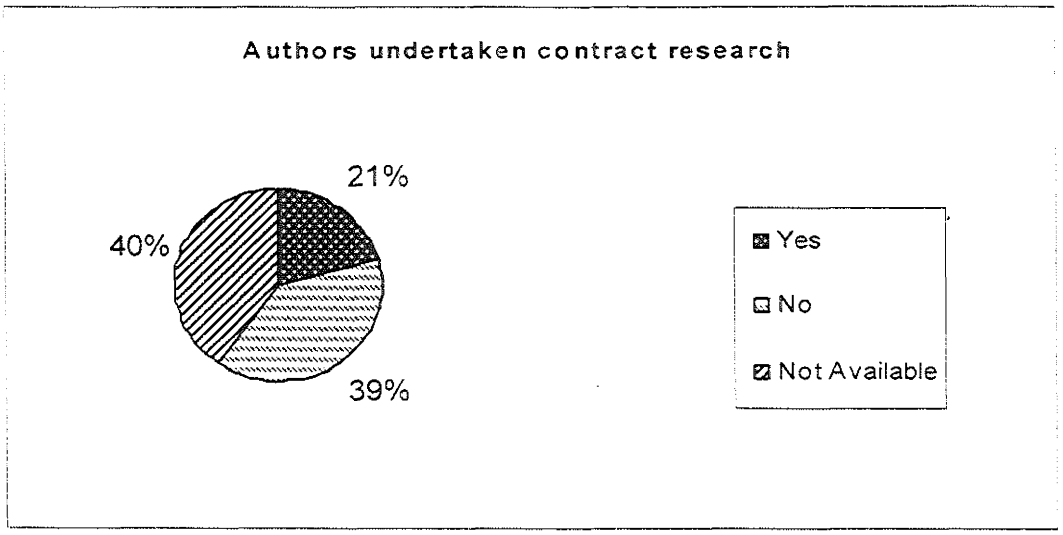


Figure-30: Respondent undertaking sponsored research

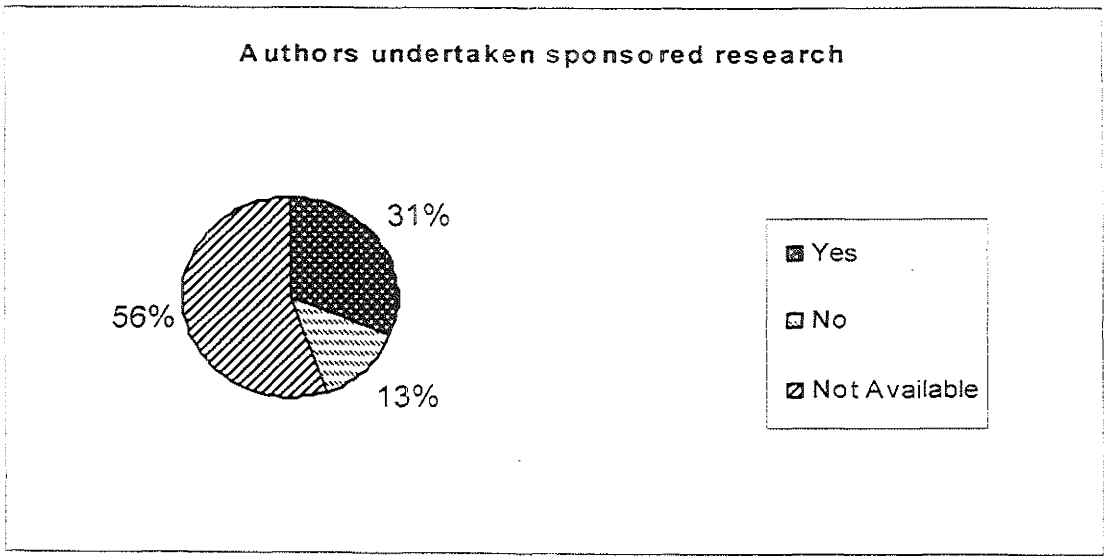
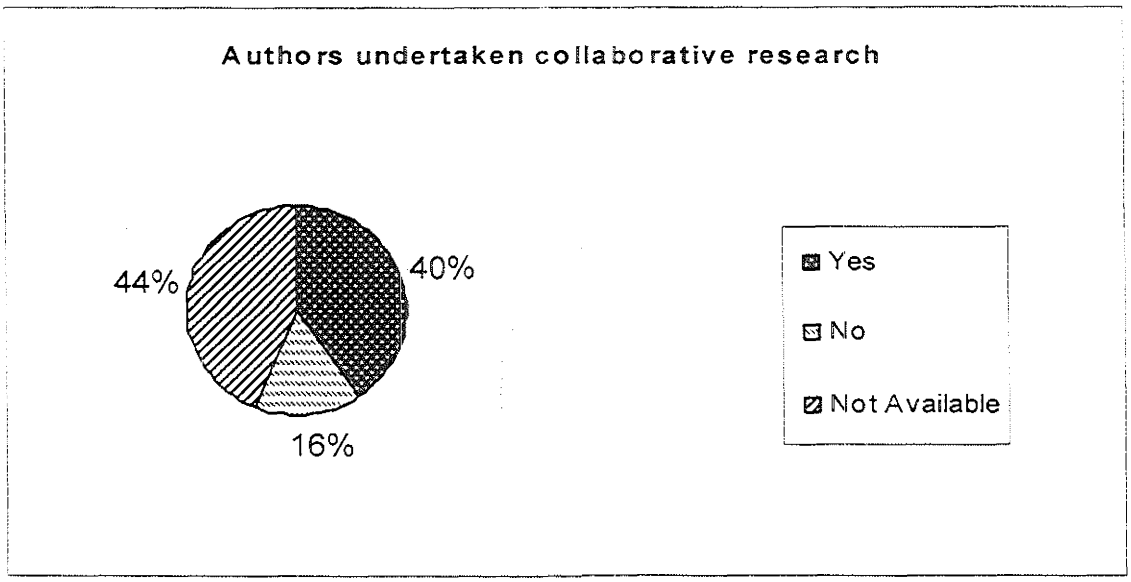


Figure-31: Respondent undertaking collaborative research



Quantity of researchers currently working for a field or are being trained for that field are critical because often even if supported by enough resources of finance and infrastructure in the absence of minimum numbers of researchers in a country, that country fails to take off in that field. Such minimum numbers could be called critical numbers, and these vary according to the nature of sciences and technologies.

Most often, as was brought out in the previous discussion on public space, Indian research suffers from widely distributed but very thin and sub-critical numbers of researchers. This gets reflected in both numbers of current researchers and in the numbers of students being trained up.

Following Figures-32 and 33 exhibit these aspects. Figure-32 shows that very large number of respondents is aware of and is anxious about the sub-critical numbers. The following Figure-33 provides widely fluctuating estimates by respondents on how many say doctoral students are needed to be trained now. Lack of common discourse amongst the professionals in a sub-field has made the estimates they made unnatural and widely varying.

Figure-32: Whether critical numbers of researchers are necessary for a sub-field

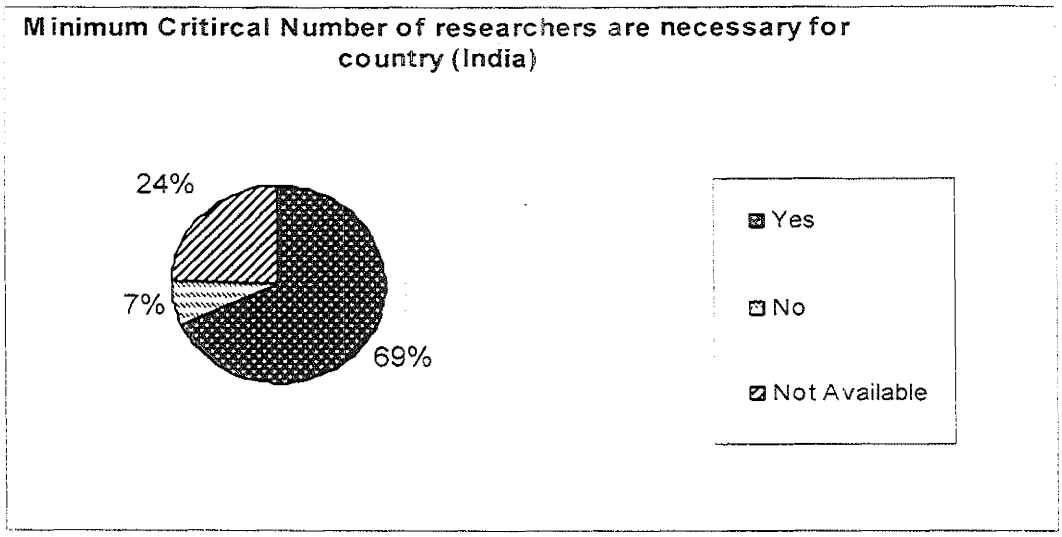
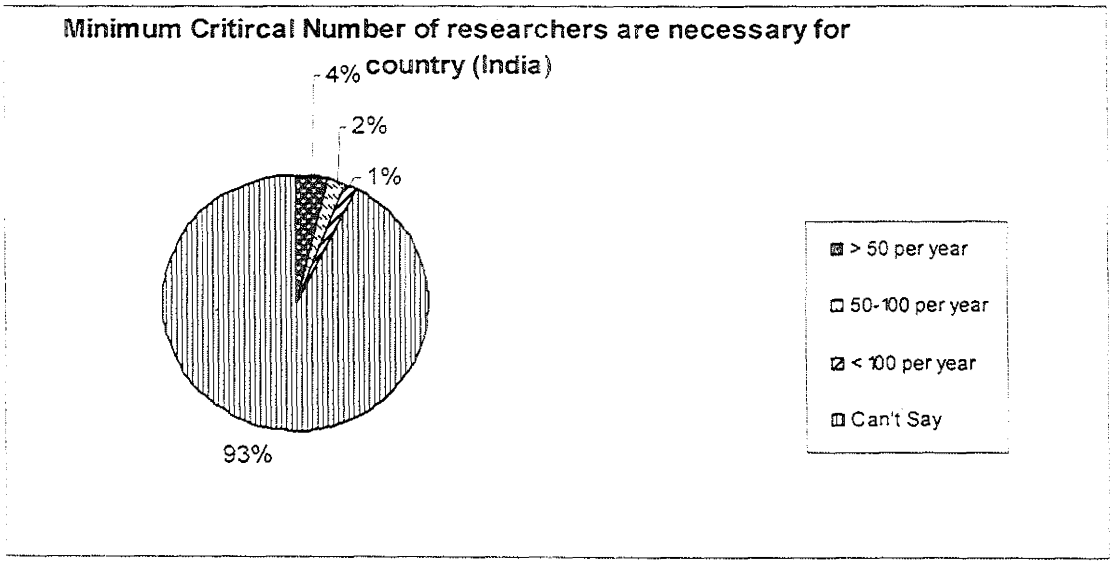


Figure-33: Quantity of critical numbers of researchers-generation necessary for a sub-field



There are centers of excellences in India. However, organizations close by rarely benefited from close geographical proximity to such centers of excellences. Rather often bureaucratic structures of university, the inertia of curricula and the vested interests in research and in academics have together prevented diffusion of state-of-art teaching and research from the centers of excellences. The latter remained in isolation.

Following Figures-34 and 35 exhibit two aspects of such diffusion.

Figure-34 captures diffusion through collaborative research. Given the resources problem of a researcher from small town, it should appear lucrative to collaborate with centers of excellences. Numbers of such efforts, however, are very limited.

Figure-35 captures diffusion through teaching and in updating of curricula. Possibly this aspect is even more important than collaboration in research. Old curricula and old pedagogy ruins the entire lot of reproduced manpower.

Consequently, without diffusion sustenance of quality would appear impossible; and possibly, even in near-term, generation of good quality manpower becomes near impossible from even the centers of excellences.

Figure-34: Social diffusion – collaboration with professionals from small town

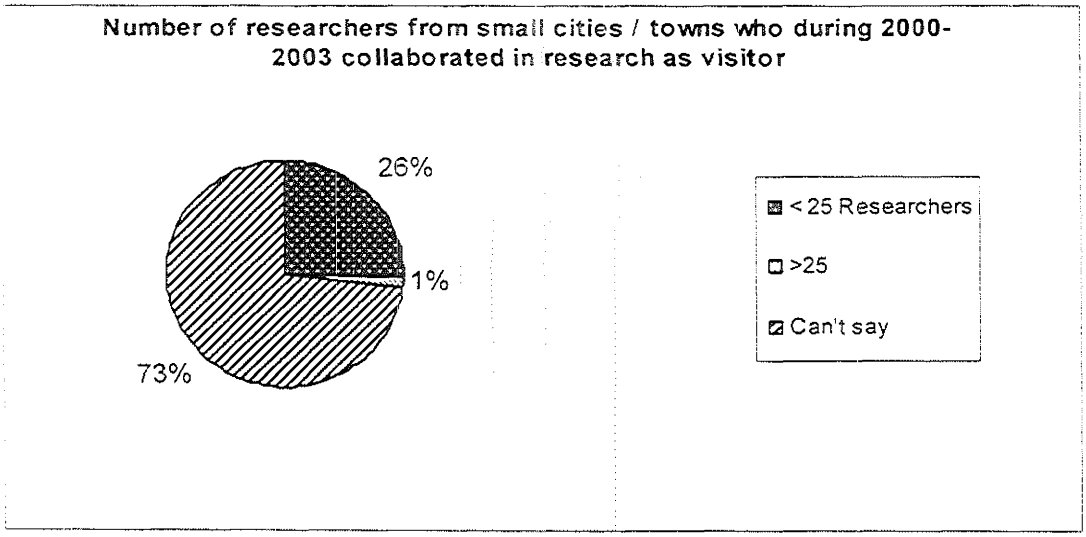
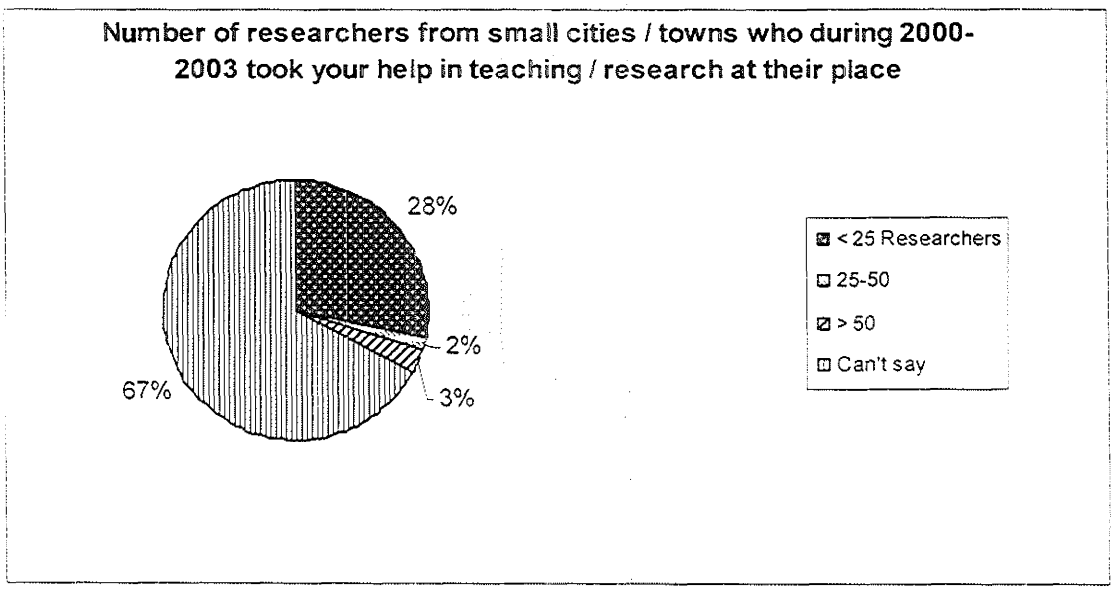


Figure-35: Social diffusion – elevating teaching & curricula at small towns



Quality of manpower, rather unfortunately, gets measured in general in this country by research publications in international journals alone. Publications in national journals are generally treated with contempt and these are subjected to disincentives.

However, much more important possibly are several other modes of outputs. These new modes could be from engineering or technological perspectives such as in designing new instrumentations or prototypes or algorithms or new materials or new biological entities. Other forms of new modes would include designing or setting up new experiments, for example. No less important, however, should be designing or offering new teaching courses possibly through new course materials.

Following five exhibits, Figures-36, 37, 38, 39 and 40 capture these aspects of quality. These Figures capture the fact that this country does not value the other modes we referred to above.

International publication of research papers are treated with most respectability, and all the rest including research publications in domestic journals are treated with contempt or with nonchalance. Responses shown in the Figures attest to that fact. Variations in responses which is at its peak in Figure-36 testify to this disincentive in institutions of science and technology in this country.

Figure-36: Publication in international journal by author alone

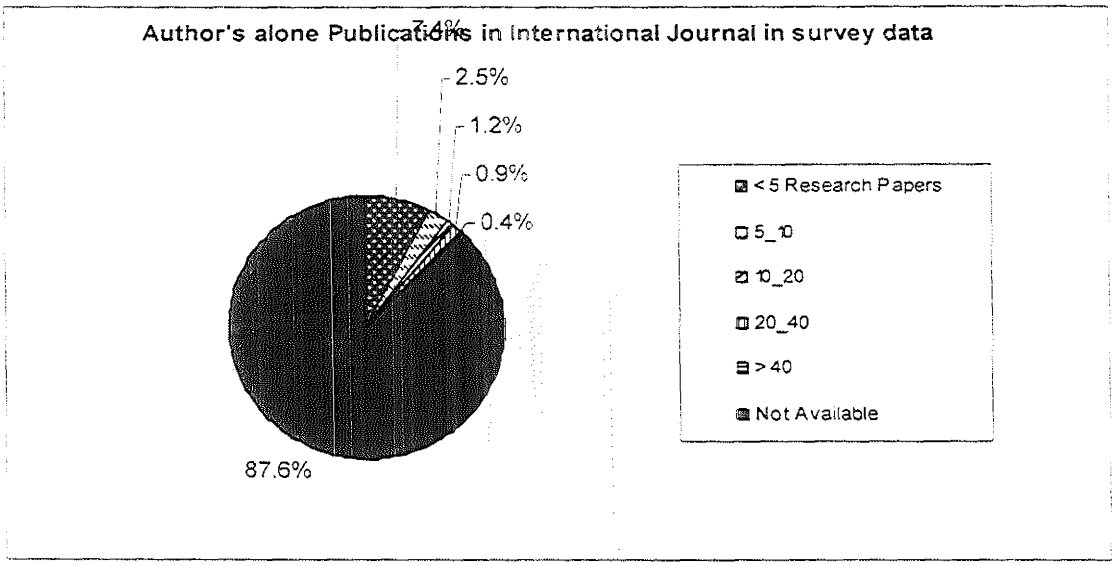


Figure-37: Publication in national journal by author alone

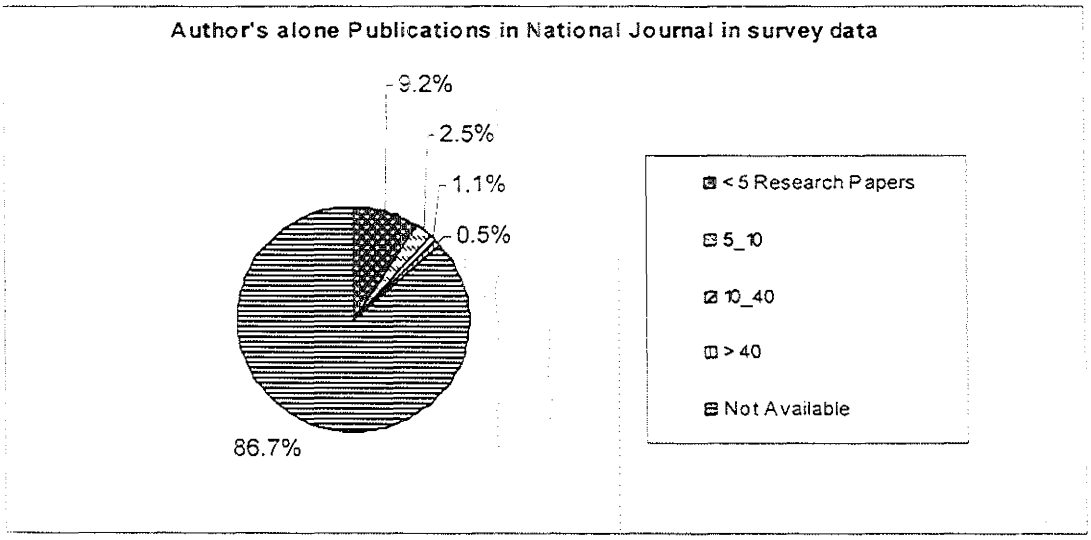


Figure-38: Designing alone novel experiments/research/software

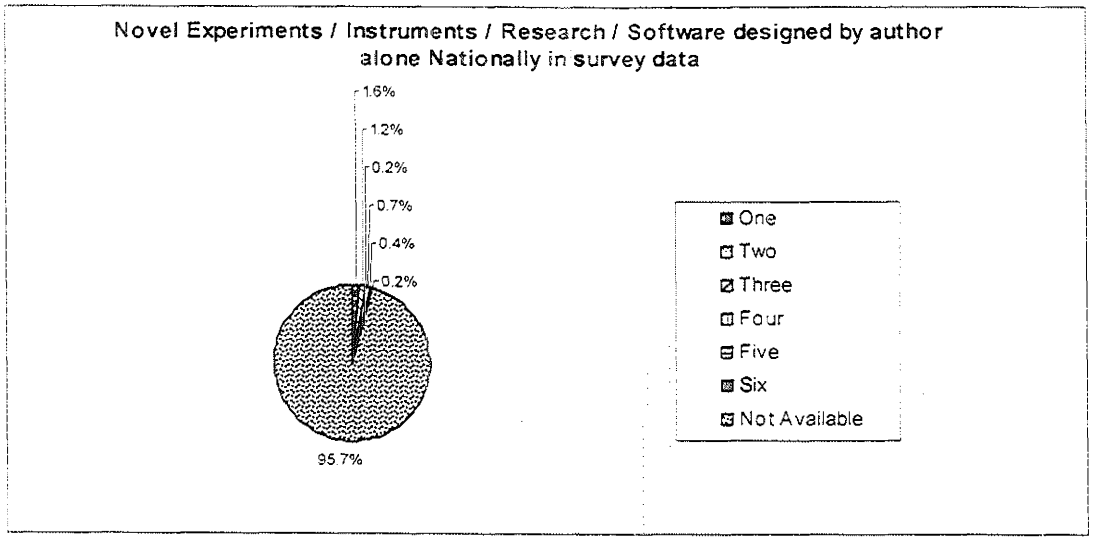


Figure-39: Designing or offering with others novel teaching courses/lecture notes

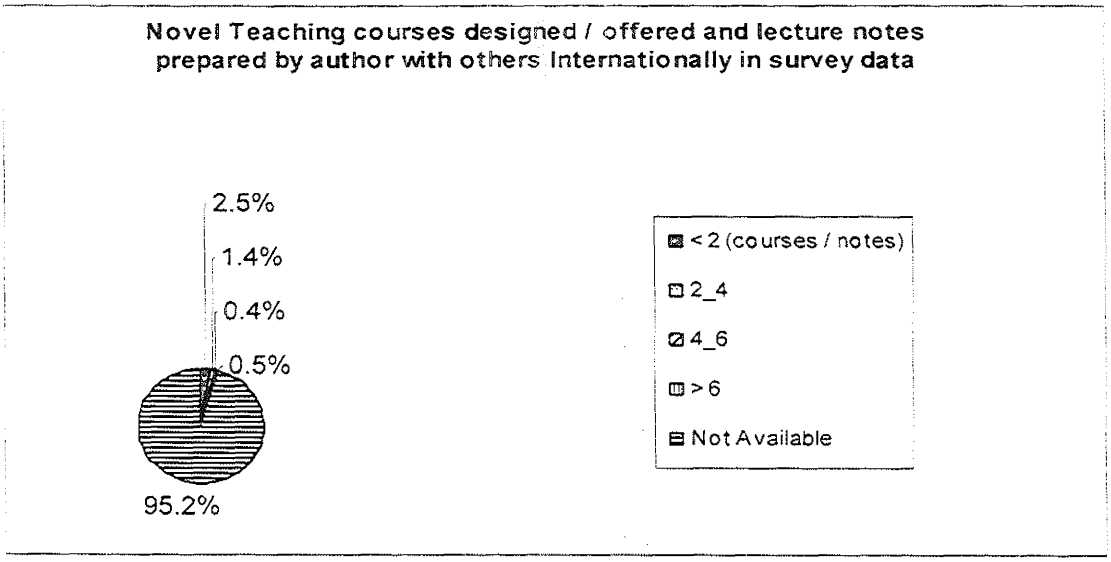
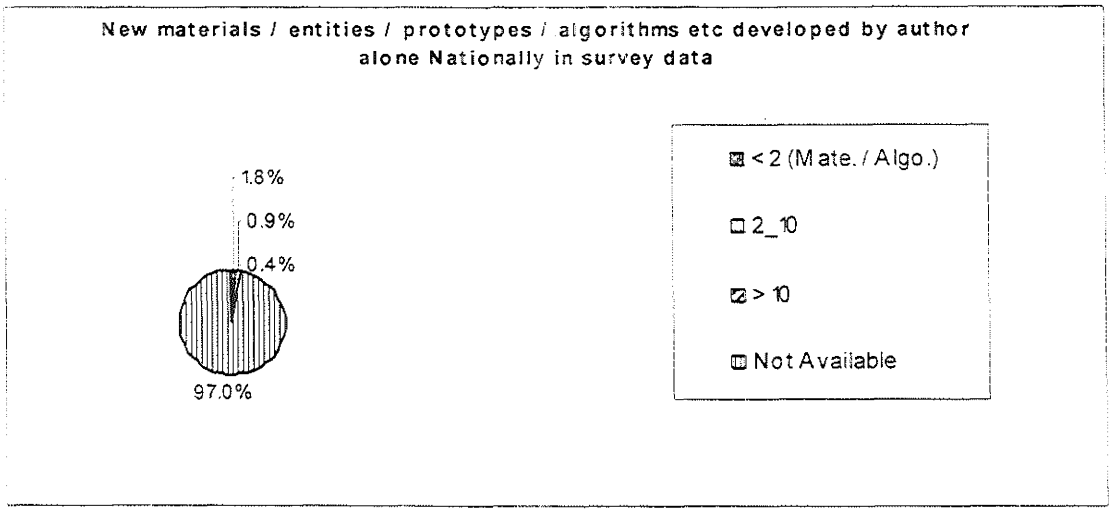


Figure-40: Developing alone new materials/entities/prototypes/algorithms



Very little of science and technology is indeed international. Choice of research projects/programs is mostly strategic in nature. Directions of research often depend crucially upon political-economic underpinnings of domestic interests.

There are thus two domains of research. The first domain which is not public refers to funding of research, guiding and directing research thrusts, and similar others. The second, which claims to be a global public domain, refers to published research outputs in global journals.

Domestic peers therefore largely keep the first domain to reviewing mechanisms. The second domain allows limited entry to professionals from elsewhere.

Following four Figures-41, 42, 43 and 44 exhibit these aspects.

Figures 41 and 42 show pre-grant reviewing of research projects. Reviewing of international research projects is surely fewer in number – more importantly, reviewed projects that are putatively global do belong to grants from trusts meant for international disbursements or to funds from global bodies, such as the United Nations. Never possibly an Indian national would review a grant of the US body, such as the NSF.

Reviewing pre-prints for international journals, however is a little more common. Figures 43 and 44 compare such reviewing for international and national journals. Reviewing for national journals appear to be more frequent.

Figure-41: Reviewing international research projects at the pre-grant stage

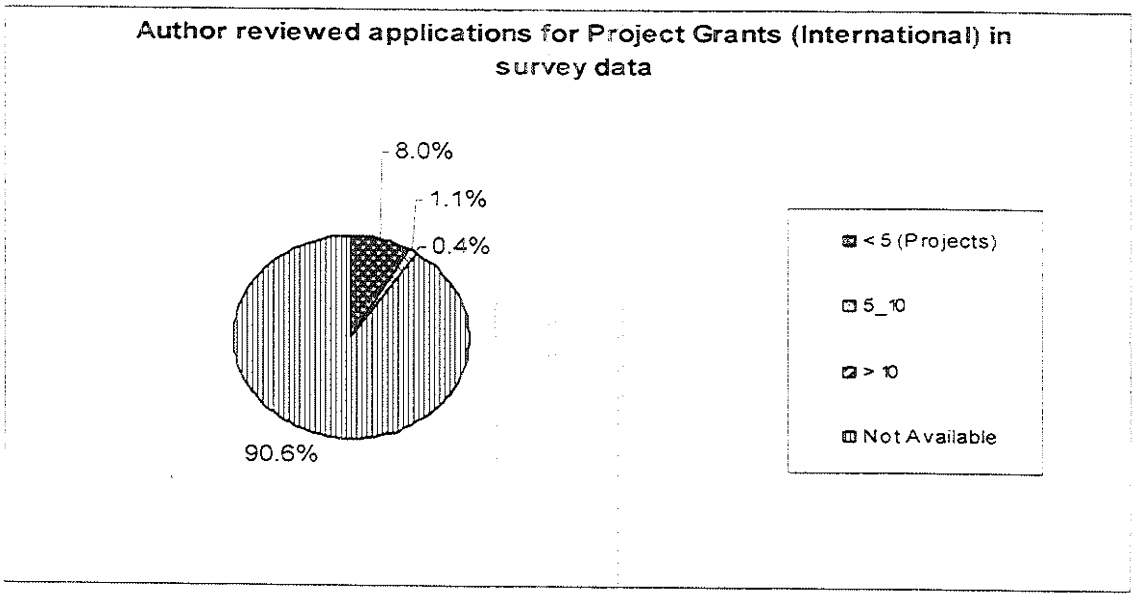


Figure-42: Reviewing national research projects at the pre-grant stage

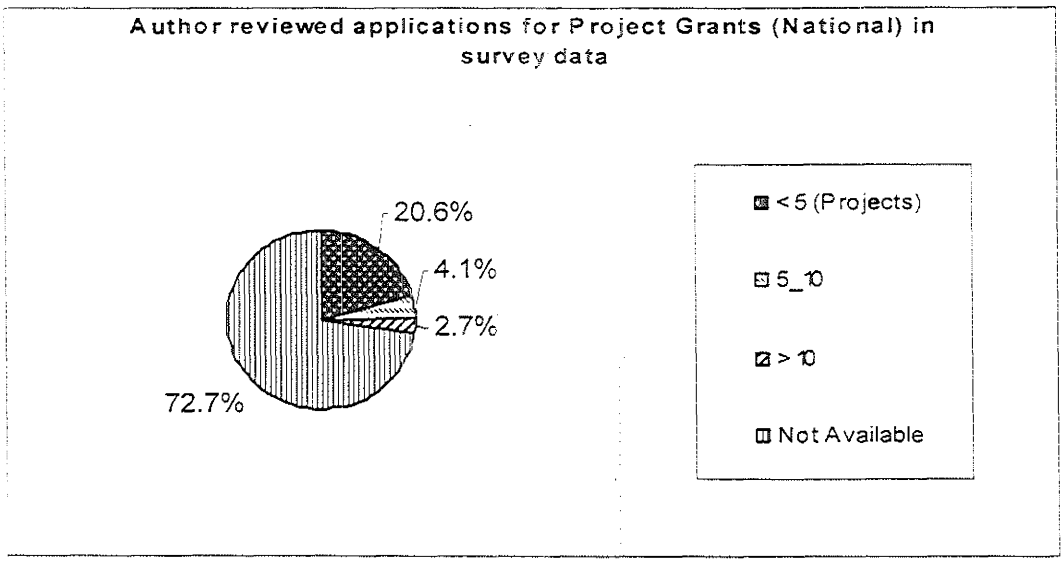


Figure-43: Reviewing international journal papers before publication

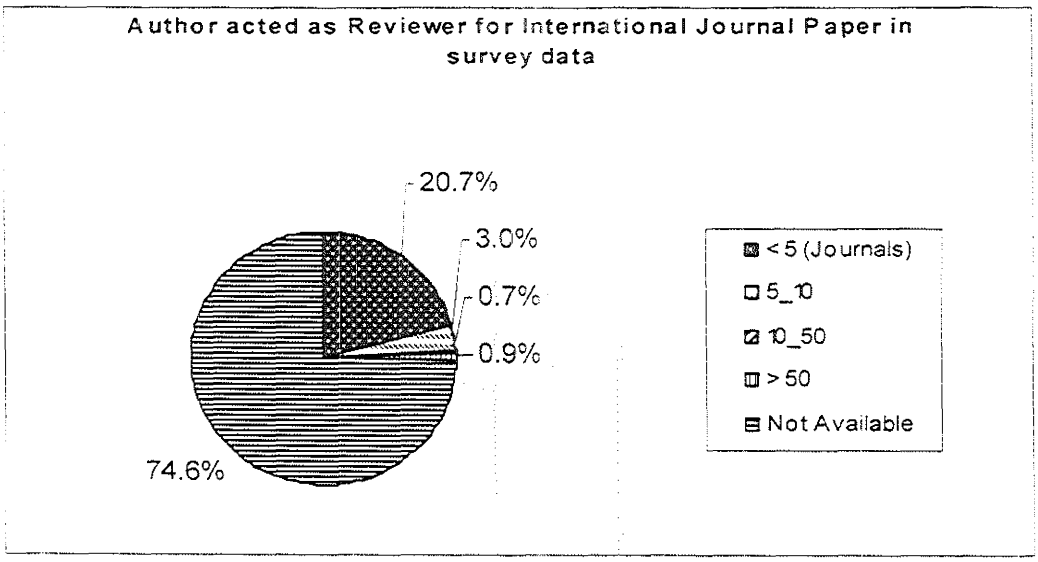
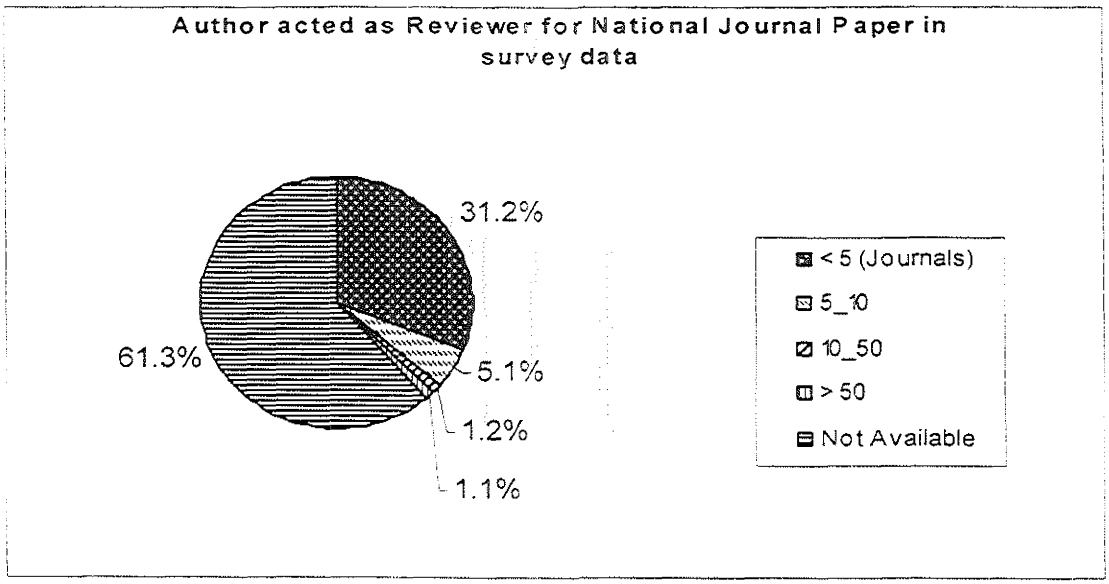


Figure-44: Reviewing national journal papers before publication



Chapter 3:

Analysis on data from public websites

This chapter draws results from data available in public domain on either organizational websites or on individual websites.

Websites of Indian organizations, even those with very high reputation, are most poorly designed. Moreover, these show the bureaucratic stranglehold – most often websites present data on 'all' members; and data on individual are not allowed to be displayed. An individual member often cannot attach personal homepages to organizational site. The head of such an organization decides what data can individual display. As a result, deciphering manpower quality through gleaning data from websites of organizations become extremely difficult, more because there are few data common to all or data that can be put on time series.

Notwithstanding these difficulties we accessed websites of all possible Indian organizations to get at respective homepages of members of those organizations. Unevenness of data definitions prevented us from studying and inferring on the population.

In the following, however, we present the little that we could gather from that Herculean effort.

Websites are maintained ordinarily by organizations in metropolitan cities and well endowed with funding. In fact, most universities do not maintain websites with access to individual homepages. The same holds true for most R&D laboratories under the CSIR or the DRDO, etc.

As a result the data presented here is partial only. However, we can take consolation in the fact that as evidenced in Figure-1 distribution of data over cities large and small – that is metro and non-metro is even.

However, distribution of our data over organizations is skewed in favor of those who receive very large funding compared to the ordinary. Such organizations we might describe as 'major', and this includes all IITs, TIFR, IISC, ISI, Bose Institute, IMSc, and similar others. The minor organizations will include those with comparably much smaller funding support. Figure-2 exhibits distribution of data over organizations major and non-major.

These two aspects – namely, geographic proximity to a metro city with deep and large social capital, and the quantum of resources available internal to an organization – determine to a great extent both the quality of research output and quality of manpower output.

In a regenerative system these two types of outputs are interdependent, and the quality of manpower depend on the quality of research, and vice versa.

Figure-1: Distribution of data over cities and towns

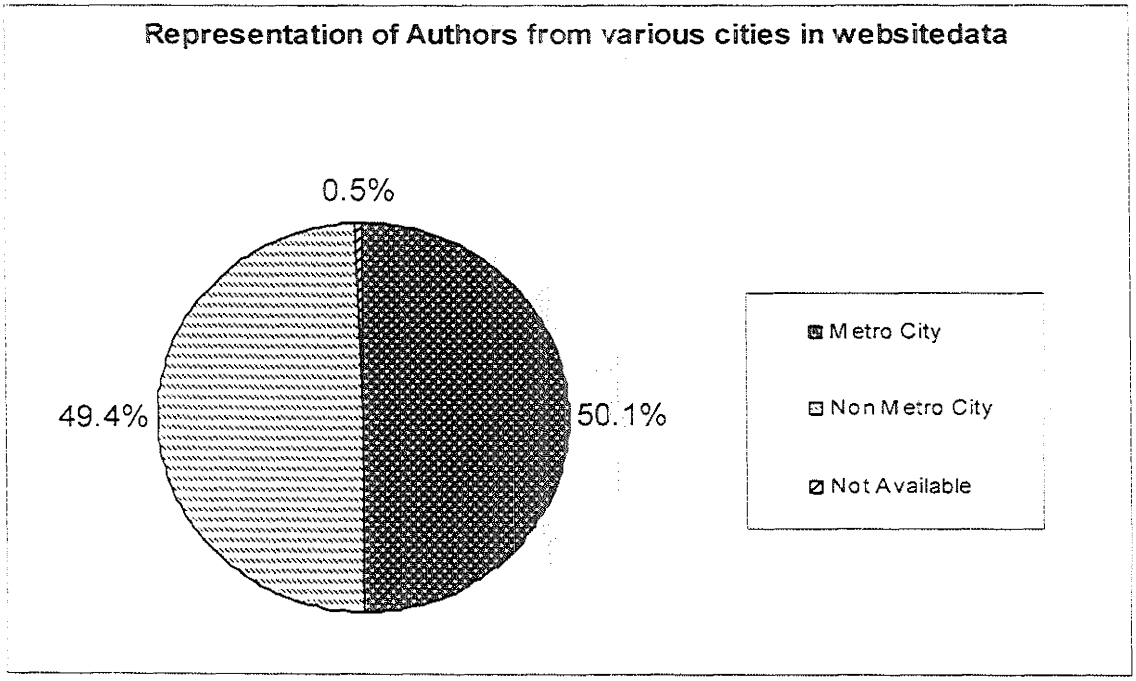
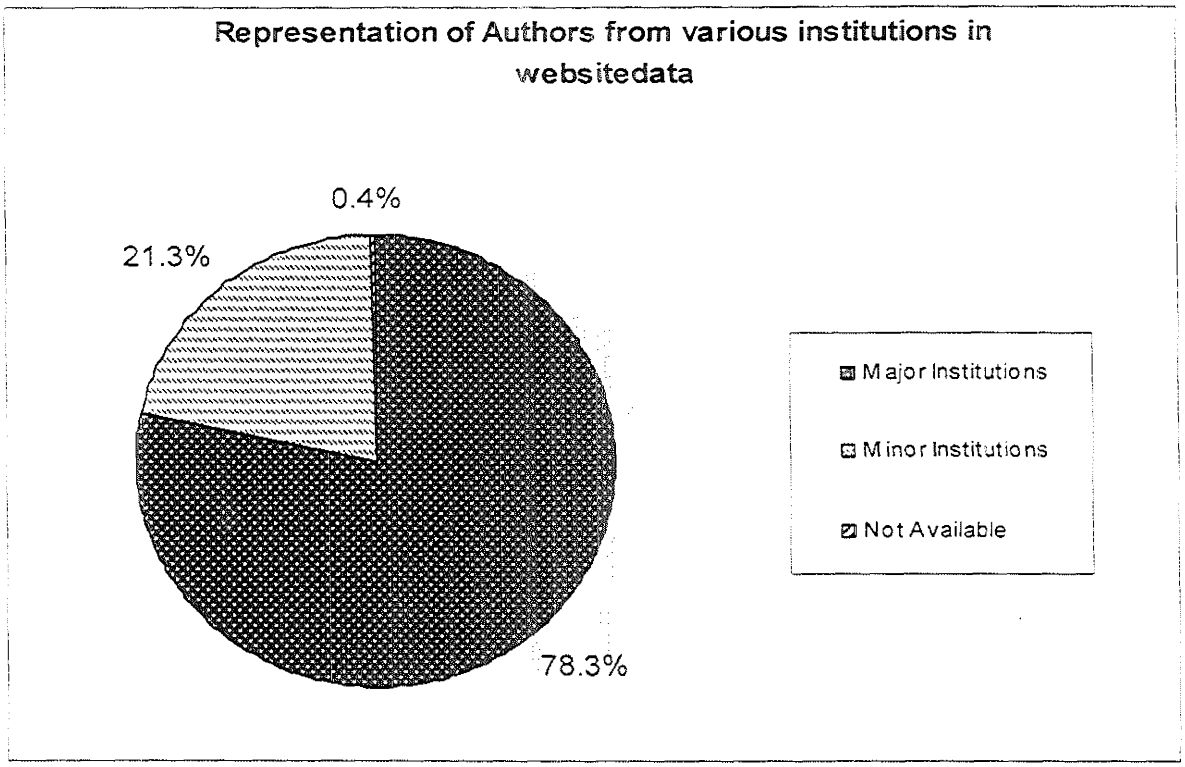


Figure-2: Distribution of data over S&T organizations major and minor



One important aspect, as was also evidenced from the survey data, regarding quality of manpower is the extent to which domestic organizations are capable of providing high-level manpower.

Firstly, such a capability refers to the capacity building aspect of domestic organizations. The degree to which domestic organizations can fulfill the domestic requirement of quality manpower represents sustainable capacity of domestic institution.

Website data refers to the representative national pool of high quality manpower, hence, as Figure-3 shows domestic major institution can fulfill at least nearly half of the required manpower at the level of earning doctorates. As this Figure shows others who are not from major institutions could have earned doctorates from either non-major organizations or from organizations abroad – and since for nearly one fourth data was not available – it may be surmised that non-major organizations might not have capacity equivalent to the major institutions to train and guide doctoral candidates.

Another dimension of capacity can be inferred from Figure-4 referring to post-doctorate research training. Nearly one fourth candidates earned such trainings from abroad – for the rest and for whom data is not available, some did not do post-doctorate, and the rest must have accomplished post-doctorates from domestic organizations. Since most non-major organizations do not have resources to sustain post-doctorates, it appears that for most of those earning post-doctorates from India must have received the same from major organizations.

Figure-3: Manpower with doctorates earned from 'major' organizations

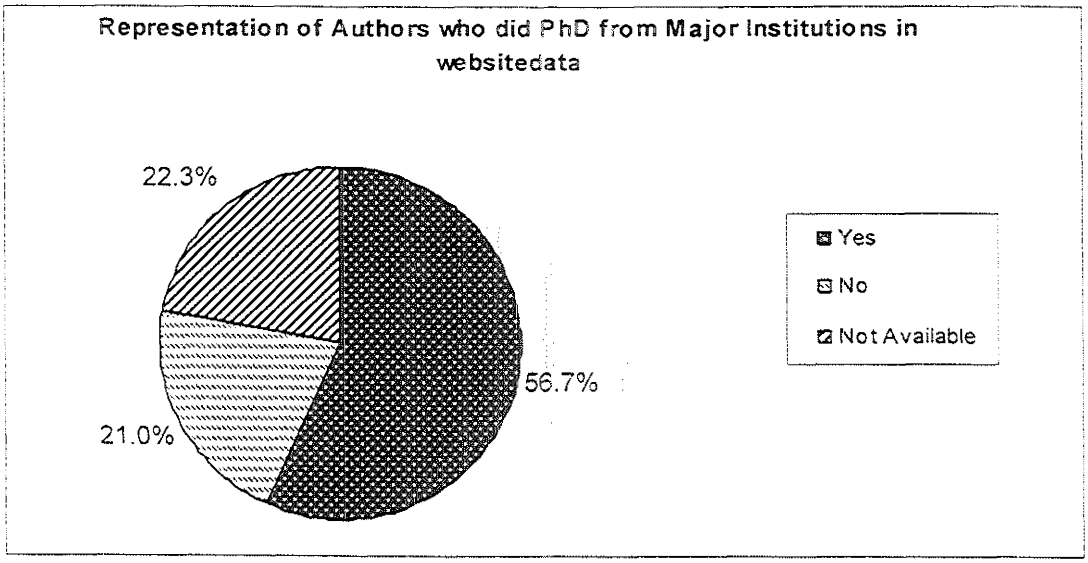
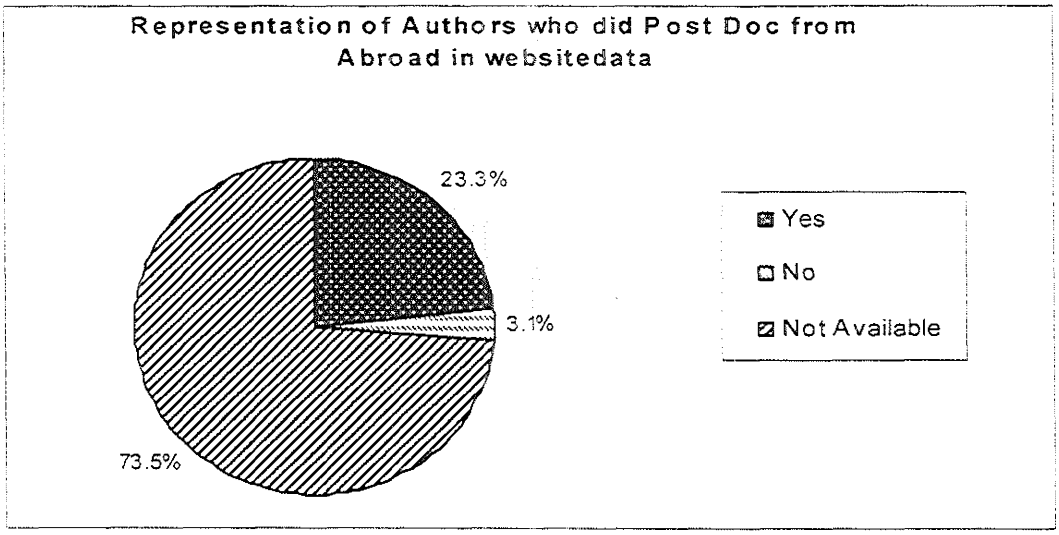


Figure-4: Manpower with post-doctorates done from organizations abroad



Generating quality manpower at the doctorate level is a process that re-generates the quality of the guide academician/researcher. Figure-5 exhibits available data on number of doctorate students guided in specialized fields.

Figure-5: Doctoral students trained

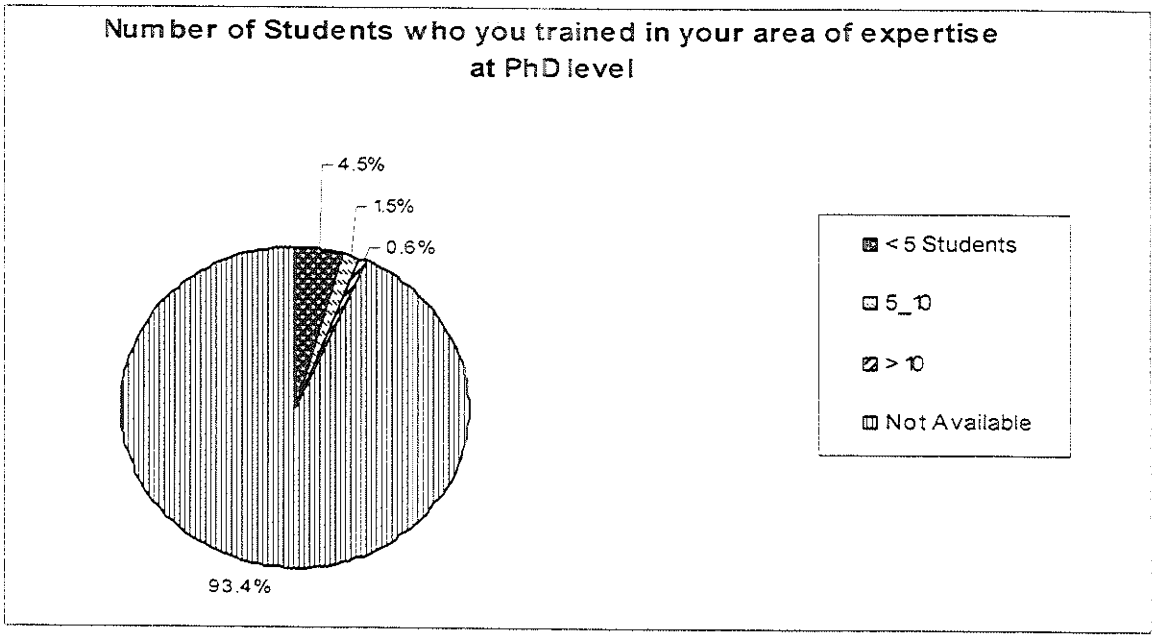
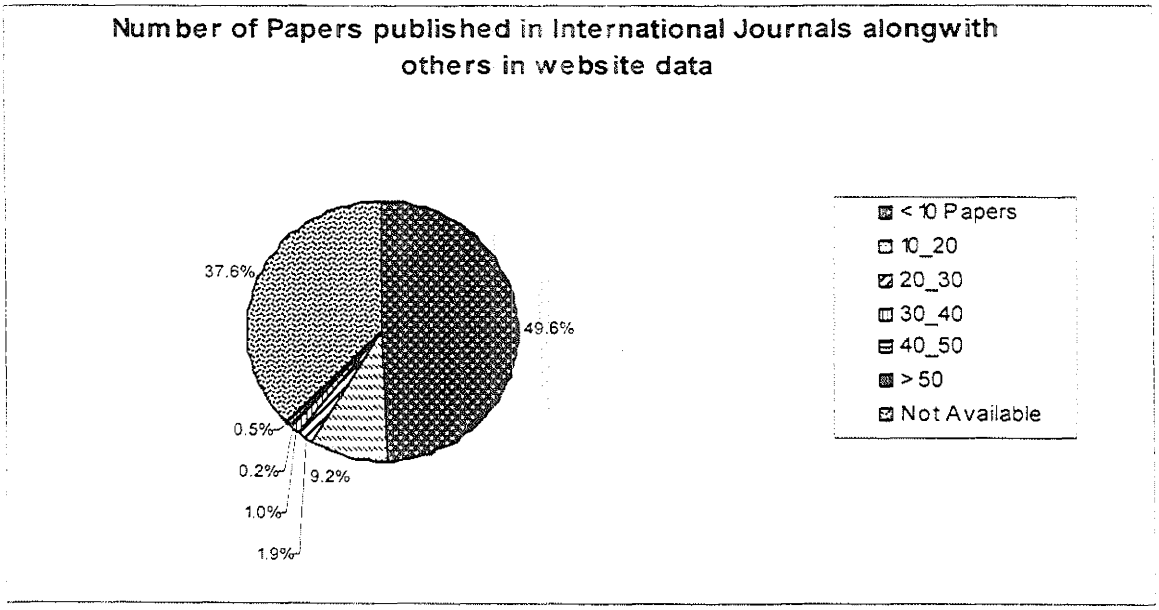


Figure-6 exhibits another important aspect of quality of manpower in domestic organizations.

Co-authoring represents research collaboration. Co-authoring as such indicates the capacity of domestic institution to sustain large collaborative research projects and programs.

Publishing in international journals indicate that domestic manpower can produce output benchmarked globally. Figure-6 exhibits such capability. It must be recalled that rather often complete list of publications are not available at websites. Hence Figure-6 exhibits domestic capability on the lower side. Even then numbers of papers co-authored are fairly high.

Figure-6: Co-authored papers in international journals



Chapter-4:

Biotechnology firms and manpower

Definitions on what constitutes biotechnology vary widely. As a result number of firms and types of activities of firms under biotechnology do vary widely. There are many claimants to such classification because often government grants or reputation would be easily accessible if a firm gets classified under biotechnology.

Our principal task is to look into quality of manpower engaged in biotechnology. Therefore definition of biotechnology would determine whether corresponding manpower is available in the country and whether firms have been employing biotechnology manpower of quality, and also whether on-the-job experience adds up to the quality of manpower.

In the absence of any agreed upon definition of biotechnology we accessed database provided by the Biotechnology Association of India. Data provided by the Association is the only reliable source for us. The following analysis is based upon their data.

Manpower being generated in the area of biotechnology from several universities or research organizations has been discussed in Chapter-8.

One objective of this research project has been to look into aspects of social capital in a small geography, say a particular city. Our proposed objective was to undertake some census or survey on manpower in that city. However, sponsor did not provide grant for such activities. As a result we attempted an analysis of manpower quality and its formation in a single city based upon secondary sources.

Hyderabad is the most important city in India regarding drugs and pharmaceuticals. It has the maximum number of registered and unregistered firms, including family businesses in the area of drugs and pharmaceuticals. This city has several hospitals and clinics. Number of specialized research centers devoted to several aspects of biotechnology, molecular biology, and other areas of chemicals and biology. Therefore, in this entire report we have captured at several chapters important data-analyses on Hyderabad. In the present chapter too our emphasis is on Hyderabad as a spot of social capital in the areas related to drugs and pharmaceuticals.

As discussed in the previous page, definition of biotechnology varies widely, resulting into classifying firms with marginal exposure to biotechnology under biotechnology head. Moreover, biotechnology is a generic technology having diverse applications in many areas including drugs & pharmaceuticals, agriculture, environment, industry and similar others. We are, however, interested in biotechnology related to drugs & pharmaceuticals.

In the following Figures-1 and 2, we exhibit two aspects of the sectoral distributions of biotechnology firms at Hyderabad.

Figure-1 shows that nearly half of the firms are engaged in the health care area. There are a few firms who have interests simultaneously in drugs & pharmaceuticals (health care) and environment or industrial biotech or agriculture. Again, some firms belonging to industrial biotech are indeed engaged in biotechnology related to drugs & pharmaceuticals.

Figure-2 captures recent data on turnover, export and domestic sales. One caveat is that several large drugs & pharmaceuticals firms have opened up fledgling small start-ups under biotechnology as a separate firm – as a result turnover data on individual firm basis fails to capture the group-turnover. Group turnover, however, is the key data. Moreover, several firms are start-ups, and as a result often data on several years are unavailable.

Figure-1: Distribution of biotechnology firms across sectors in Hyderabad

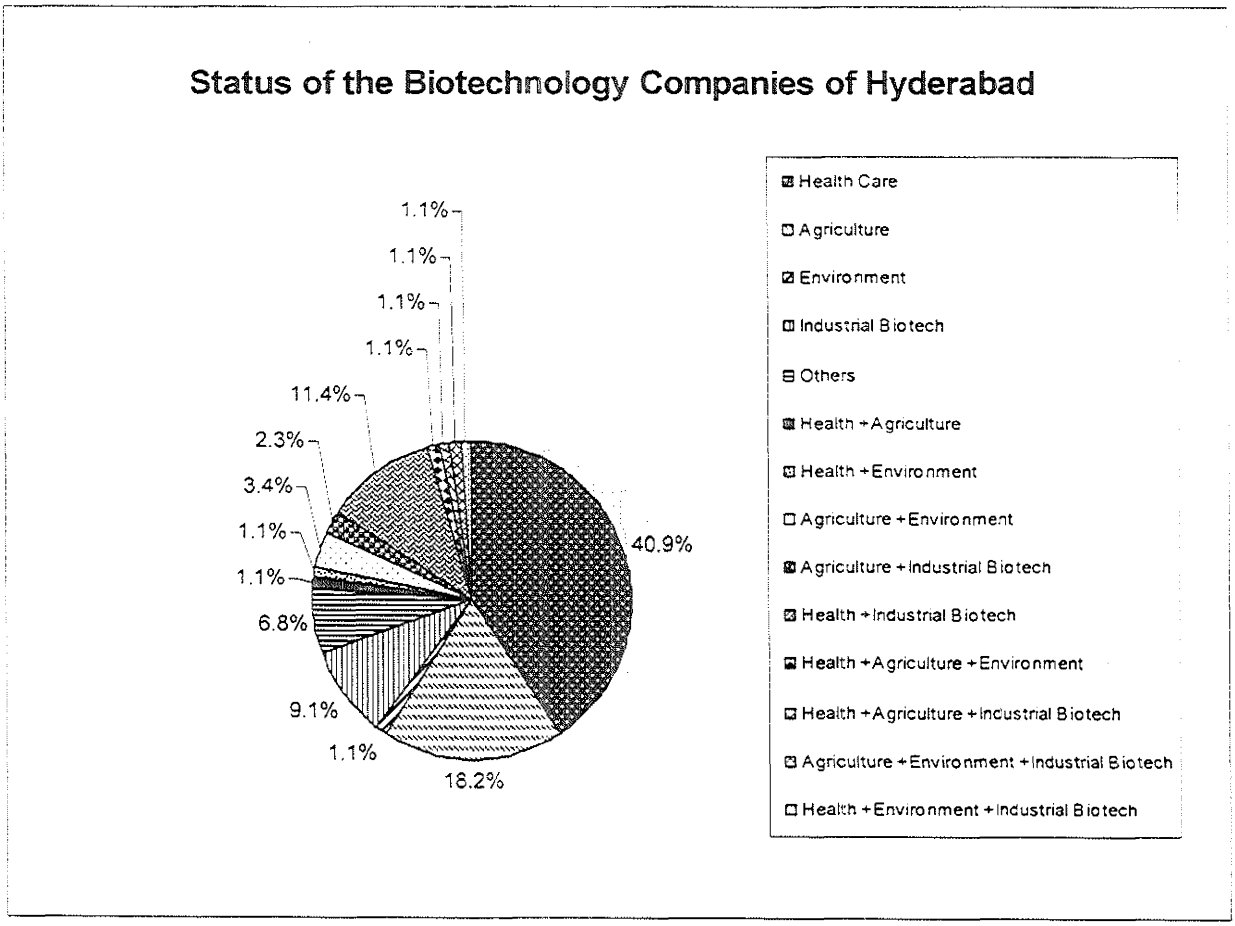
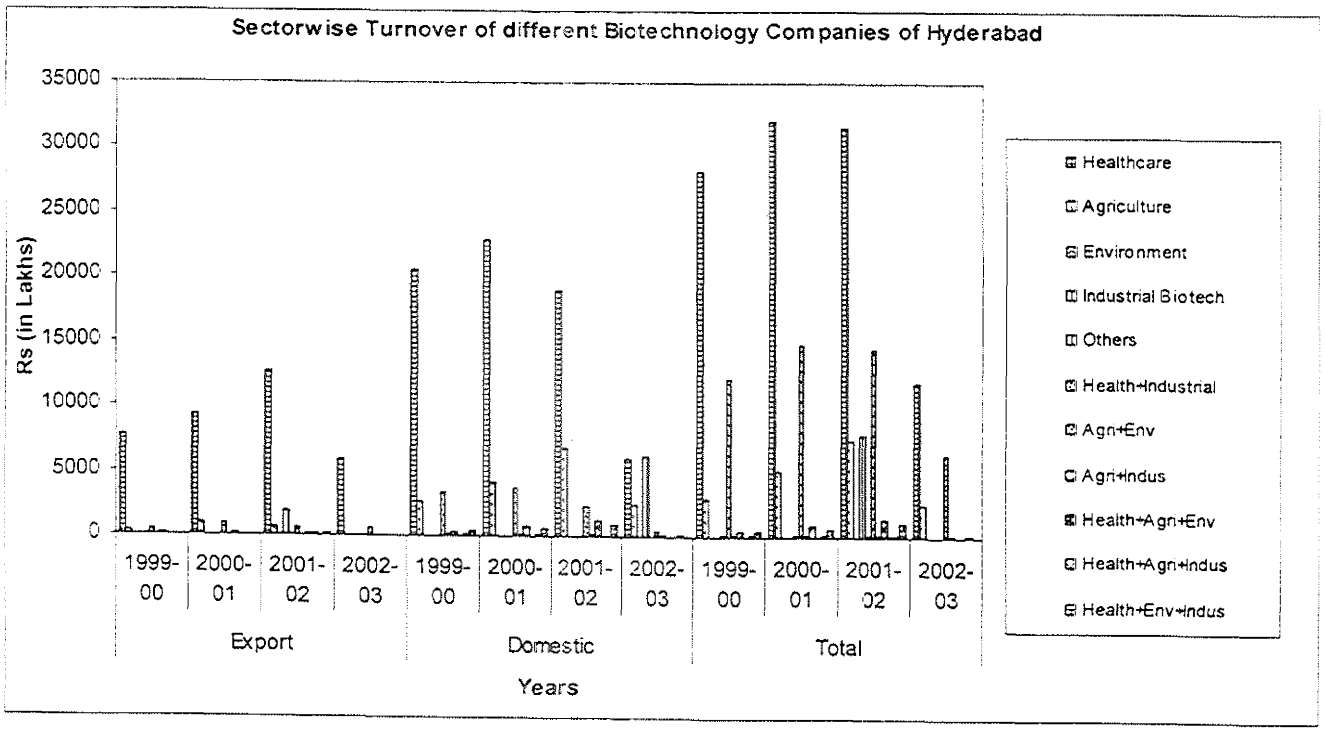


Figure-2: Turnover of biotechnology firms in Hyderabad across industrial sectors



Employee size of firms do matter in the leveraging of knowledge generated within the firms either through processes of production or through specialized R&D centres. There are, however, exceptional cases when small start-ups in the high technology areas act as incubation and innovation centres of very advanced R&D ideas generated within university or research centres. At hyderabad although there do not appear to be a single firm of the last type. Firms at Hyderabad are of traditional types, having occasionally R&D set ups.

In such traditional firms leveraging of knowledge follows law of large size. Hence, size distribution of firms indirectly speak about leverageable knowledge. This also speaks about knowledge that gets generated within a firm as on-the-job.

Following three Figures-3, 4 and 5 exhibit employee aspects of biotechnology firms at Hyderabad.

Figure-3 presents distribution of firms along size of employees. Nearly half of the firms are small employing less than 50 employees.Tiny fractions employ between 100 and 500, or more than 500 employees.

One caveat – some drugs and pharmaceuticals firms have opened up tiny start-ups employing less than 50 or between 50 and 100 employees. Size of such firms therefore conceal the fact that indeed such firms enjoy privileges of knowledge management pertaining to large firms.

In all such firms employees looking after production or R&D have been separately shown under 'technical employees' – such employees are different from those who take care of marketing, sales, finance, administration and such other non-technical affairs.

Generation of on-the-job knowledge therefore depends mostly on the number of technical employees. Figure-4 captures distribution of technical employees across biotechnology firms in Hyderabad. This size distribution shows then the potential sites of knowledge generation and knowledge reproduction.

In this sense then the ratio between technical and total employee can be used to classify firms along importances of sites for knowledge generation. Such a distribution captures an important dimension – as shown Figure-5, that about 30% of biotechnology firms in Huderabad employs technical people as more than 60% of total manpower. In fact, most firms employ sizeable fraction of technical employees. This indeed is a redeeming aspect.

Figure-3: Size distribution of biotechnology firms at Hyderabad according to number of employees

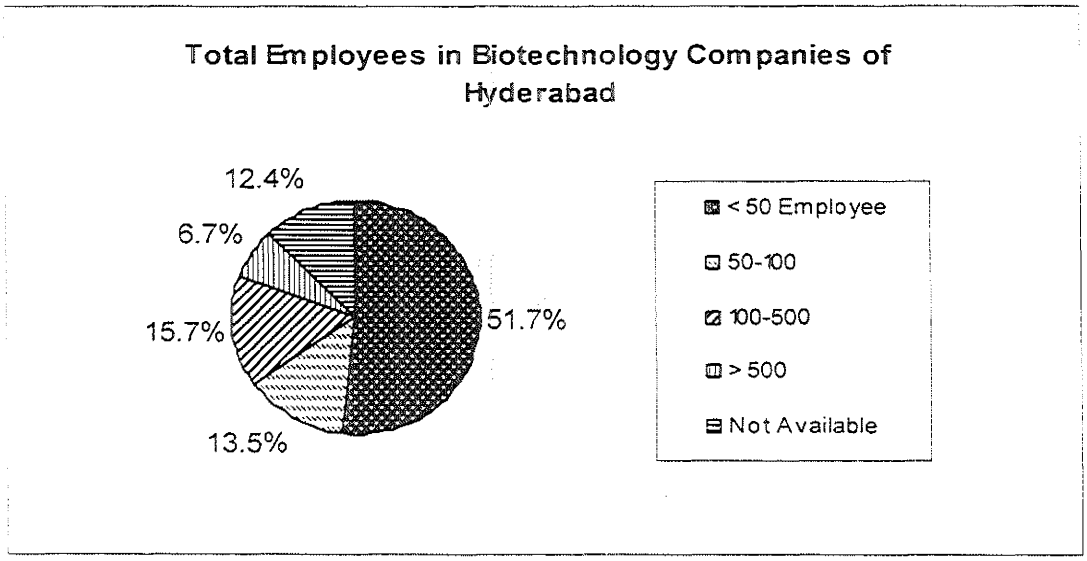


Figure-4: Size distribution of biotechnology firms at Hyderabad according to number of technical employees

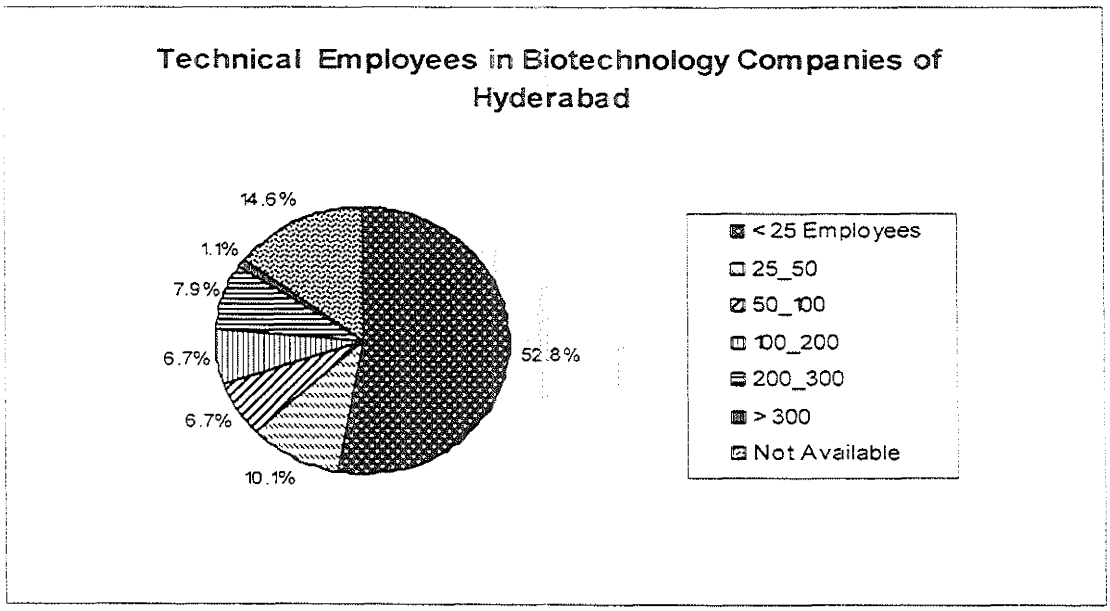
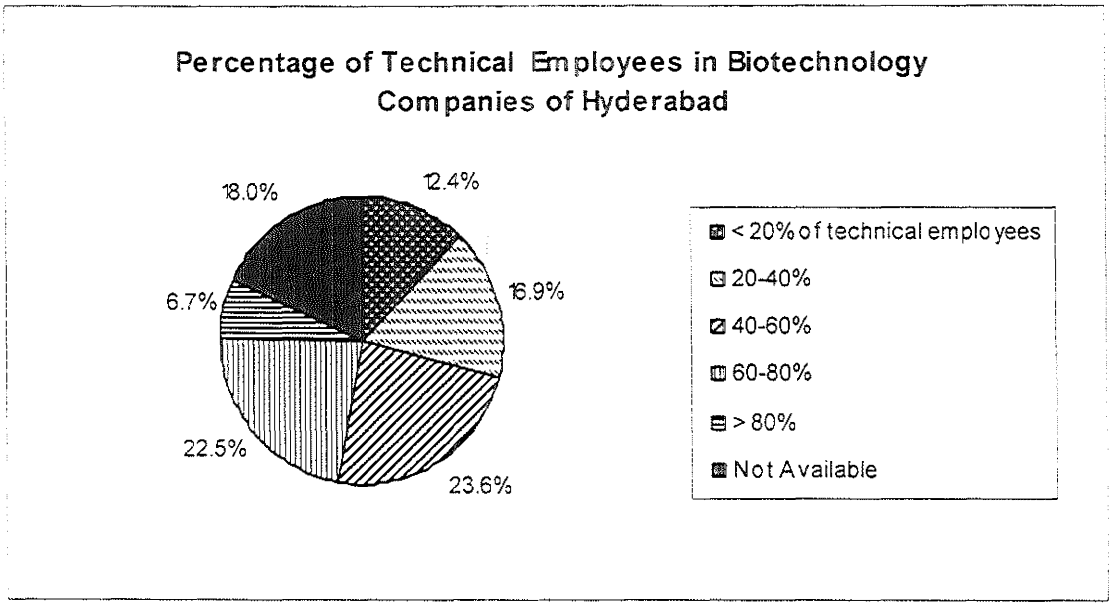


Figure-5: Distribution of biotechnology firms at Hyderabad according to the ratio between technical and total employees



Ownership pattern is important. Private ownership might indicate that firms would manage knowledge as per incentives in the marketplace. However, publicly owned firms might take up advancing knowledge as public good; and so would be the case for non-profit organization presumably.

Therefore the latter two types of firms can take up long-term R&D issues, while privately owned firms or firms under proprietorship would in all liklihood and given their small sizes be involved in day-to-day management of knowledge.

Following two Figures-6 and 7 capture distribution of firms along ownership in two cities, other than Hyderabad, and these are Mumbai and Bangalore.

Figure-6: Distribution of biotechnology firms at Mumbai according to ownership

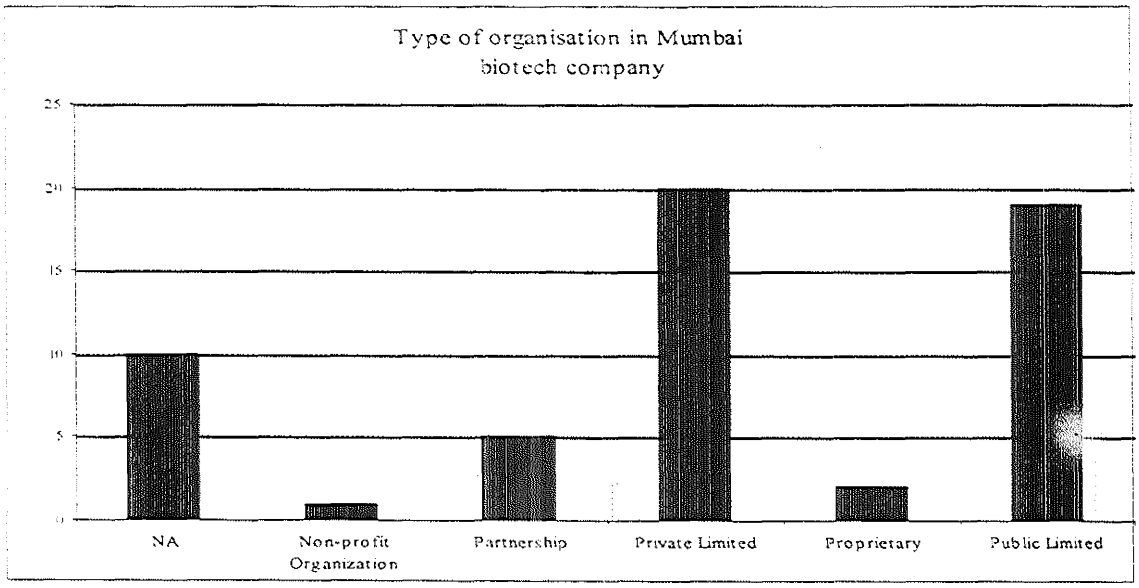
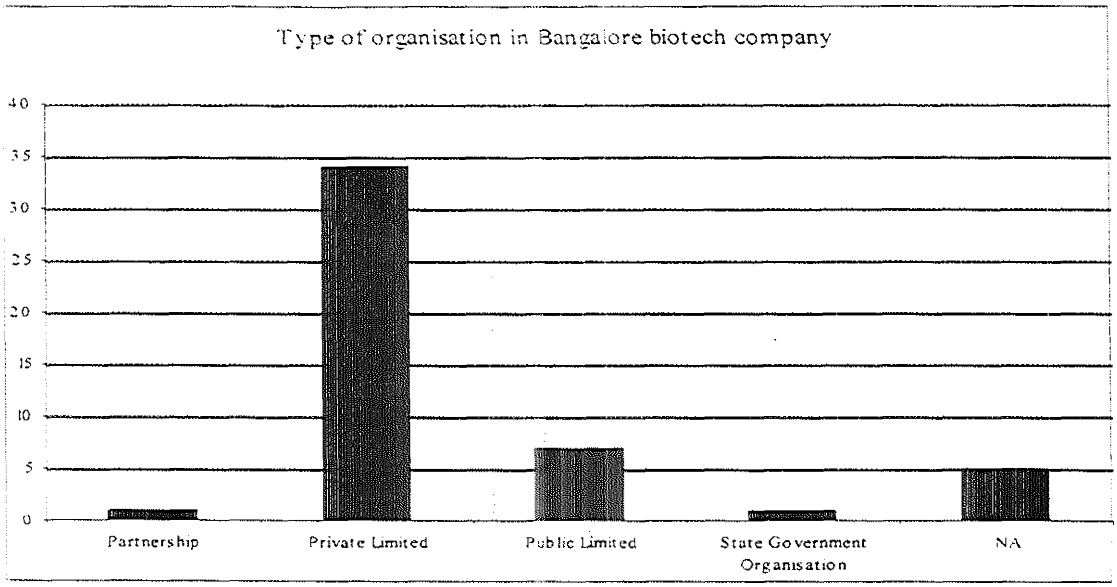


Figure-7: Distribution of biotechnology firms at Bangalore according to ownership



Chapter-5:

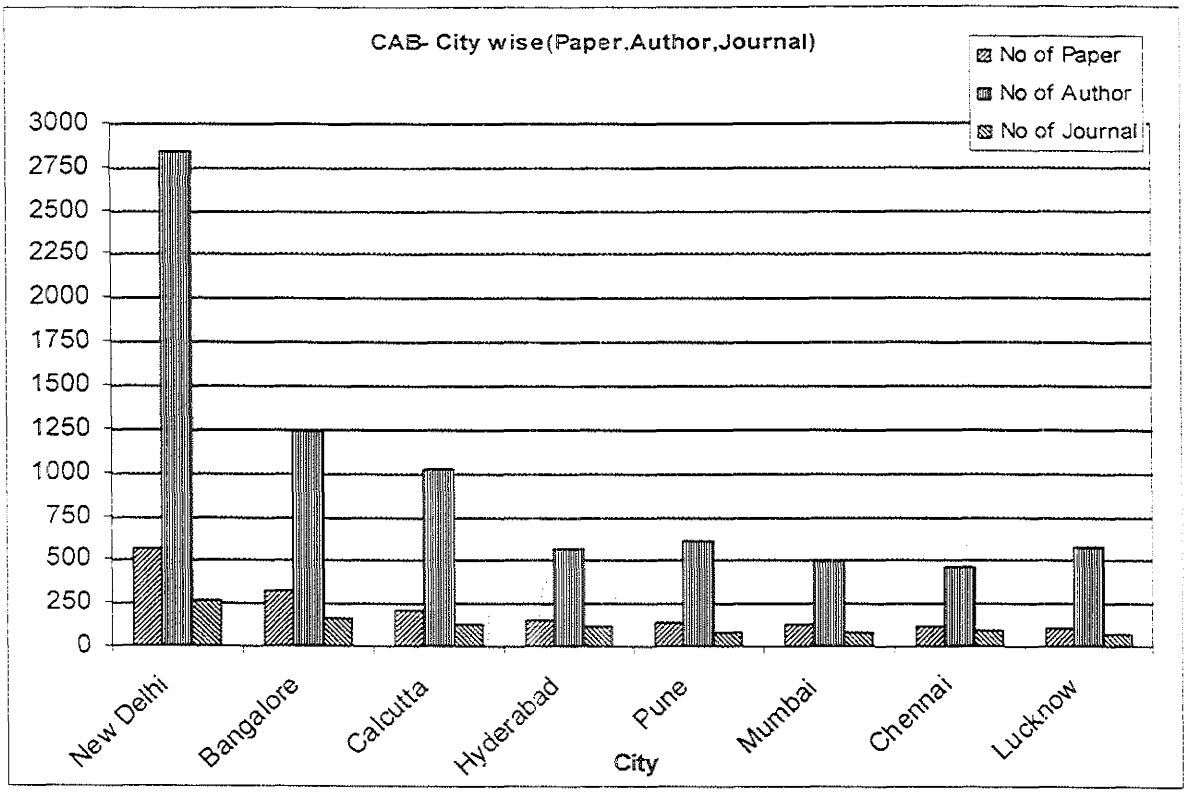
Quality of manpower and research in chemical and areas related to drugs and pharmaceuticals

Quantity of research output is an indicator of the strength of a national innovation system. Total quantity cannot be known exactly since no database captures the entire output. However, Chemical Abstracts contain most of the significant publications in and areas related to chemistry, such as areas of medicine. We looked for Indian publication in a few areas for the decade of 1990. The following Fig-1 presents distribution of Indian output across major Indian cities in three categories, namely total paper, total authors and total number of journals these papers were published.

Quality of manpower can be assessed severally, however, the most commonly accepted mode is to assess manpower-quality through assessment of the quality of its output. Quality of output therefore acts as the representative variable of the quality of manpower. The following figure captures that.

No less important is the quantity of manpower engaged in and around these areas of medicine-related chemistry. This figure also represents the degree of co-authorship, where Delhi stands highest. Degree of co-authorship represents the degree of jointly undertaken research. Another significant dimension, captured in the last column of each city, is the numbers of journal accessed, indicating possibly the breadth of journal availability as well as the breadth/spread of thematic variations in research. On this last score too Delhi stands at the top.

Figure-1: Distribution of output, authors and journals in few areas of chemistry



The following four Figures-2, 3, 4 & 5 represent the quality distribution of Indian output in a few areas of chemistry and drugs & pharmaceuticals. Therefore, these figures capture the quality of manpower in India as well. Period covered is the decade of 1990s. Contrary to ordinarily held belief, journals most frequently publishing Indian output are no less significant (considering that Impact Factor of a journal is a dummy of significance of a journal) than journals publishing only a few of papers from India. There does not seem to be any correlation between popularity of journals and its significance represented by Impact Factor. Inter alias, average significance of Indian output is of average value.

Figure-2: Impact Factor of most popular journals

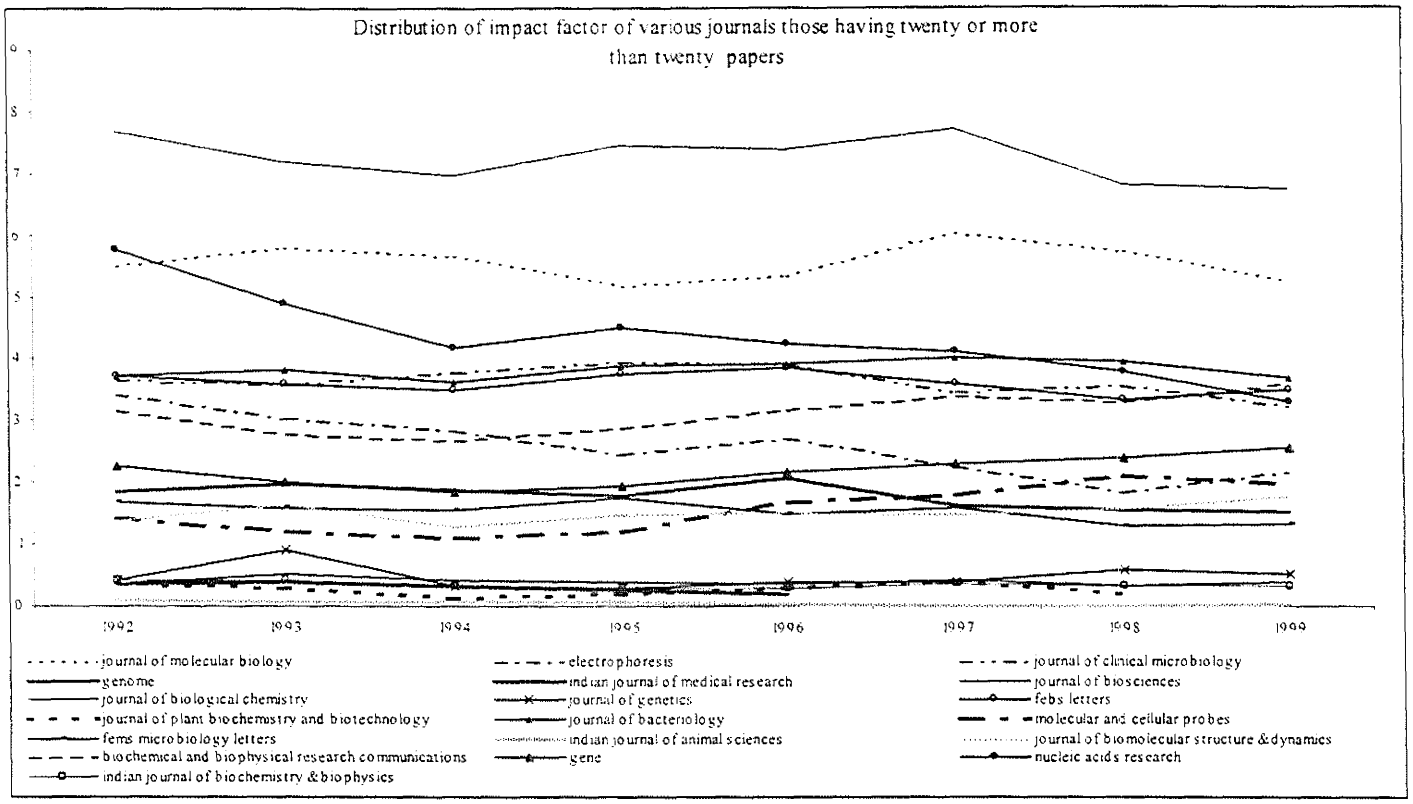


Figure-3: Impact Factor of less popular journals

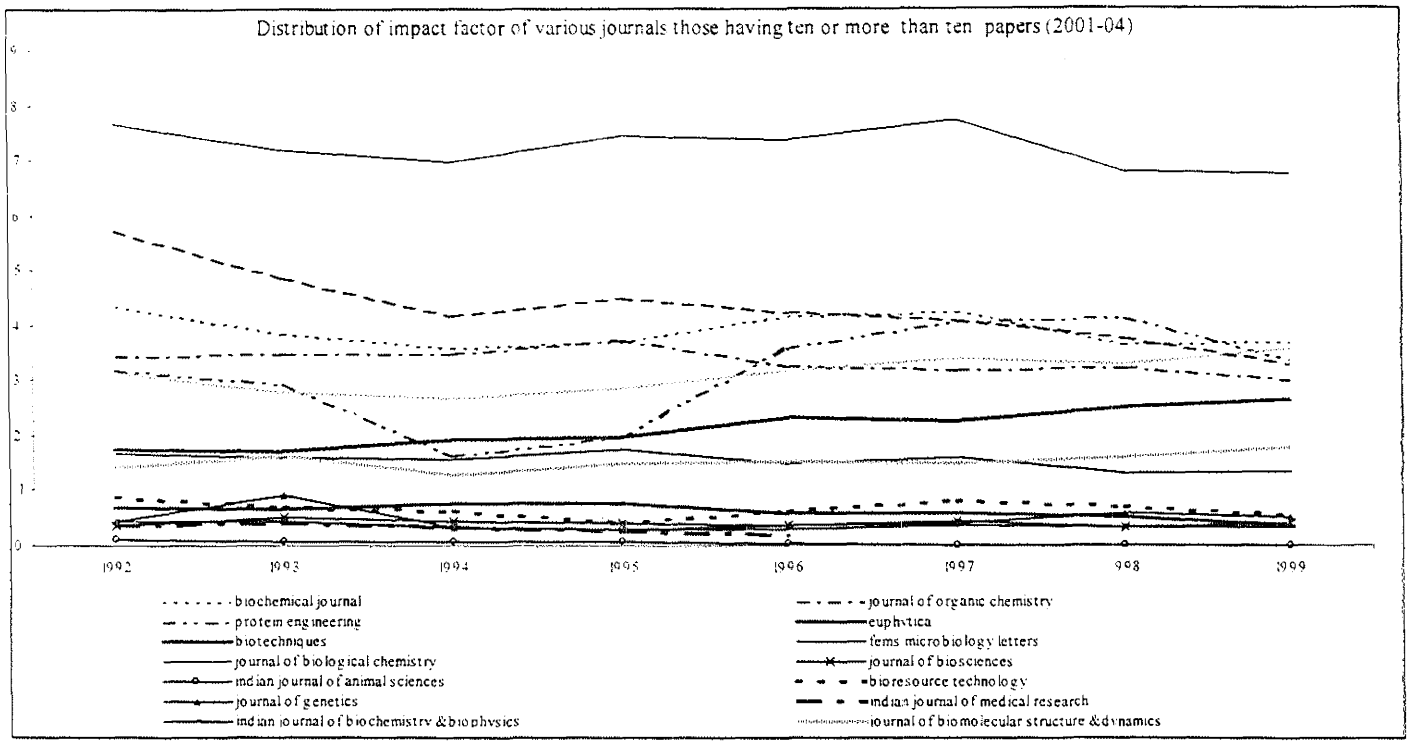


Figure-4: Impact Factor of even less popular journals

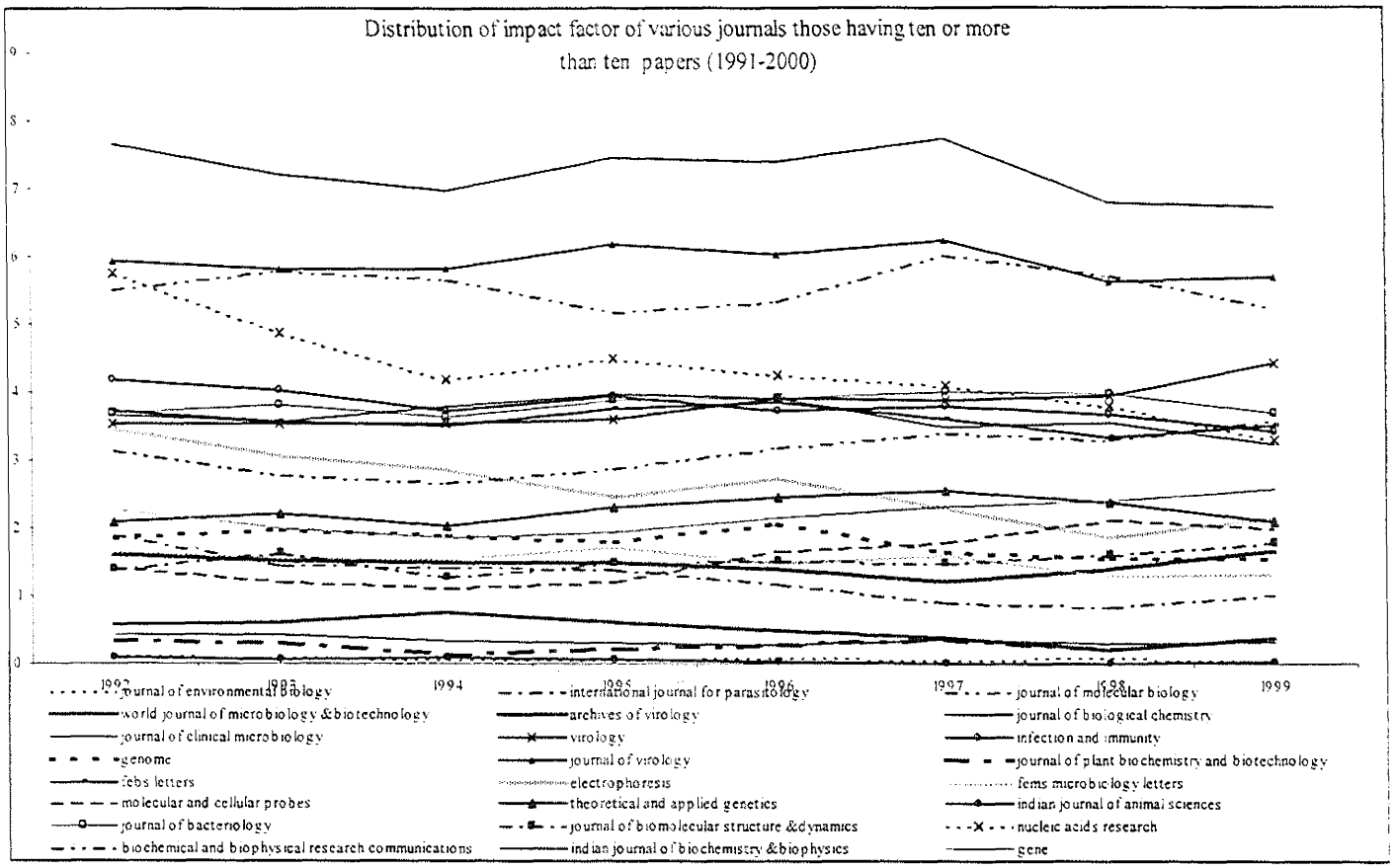
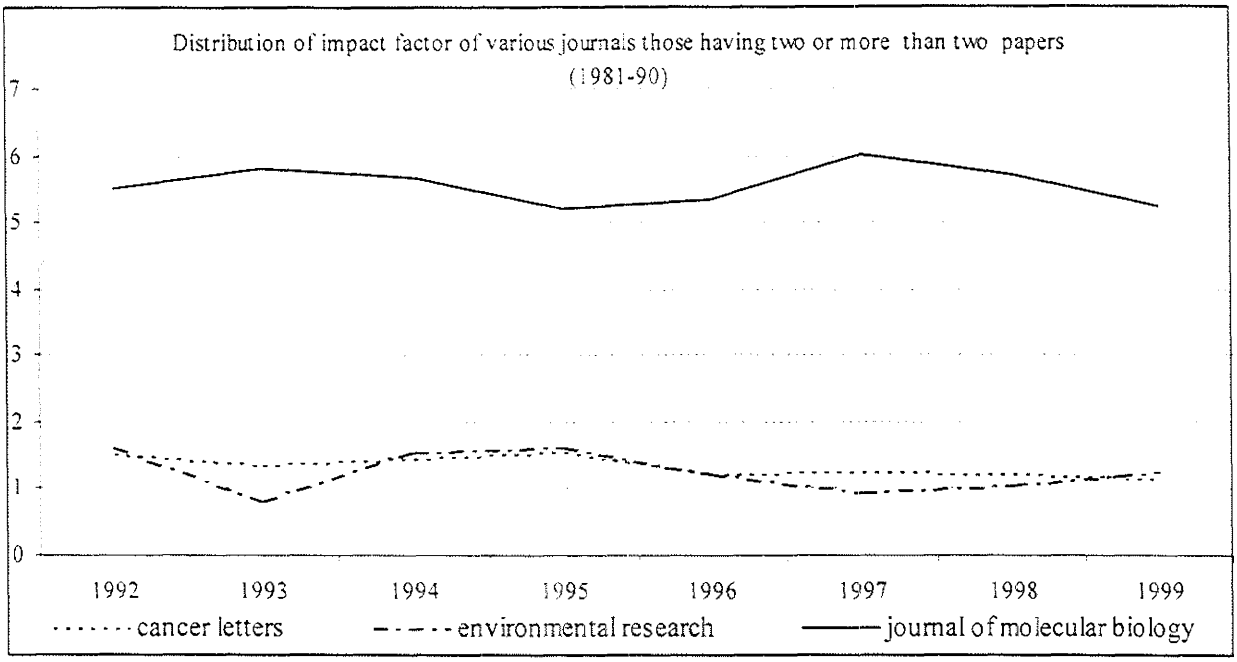


Figure-5: Impact Factor of least popular journals



The three Figures-6, 7 & 8, in the following part represent in another way the quality or significance of Indian publications, or inter alias the quality of Indian manpower in few areas of chemistry related to drugs & pharmaceuticals.

The most significant aspect following from a comparison between these three figures is that Indian researchers chose most often, such journals, as have higher values of significance, represented here by the Impact Factor. However, the average value of significance is not very high, possibly a little lower than the average values of the better-known journals.

However, very high quality of output captured in very high value of Impact Factor, appeared only occasionally – as Max. values column of Figure-6 shows that papers appearing in journals with IF value above 15 are few only. The subsequent figures show that such Max. values of journal IF are much lower for journals publishing several papers.

An immediate conclusion, therefore, is that while quality of average Indian publication, hence quality of average Indian manpower is fairly or moderately good – there are very few very-high-quality manpower in India.

Figure-6: Year-wise distribution of IF of journals publishing only one paper

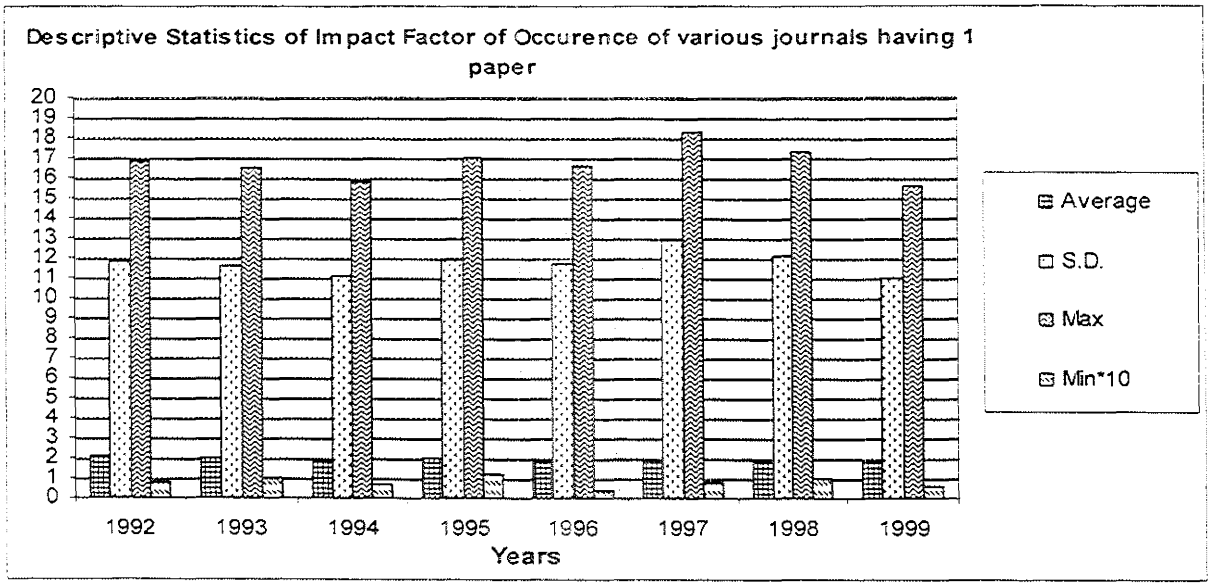


Figure-7: Year-wise distribution of IF of journals publishing only ten papers

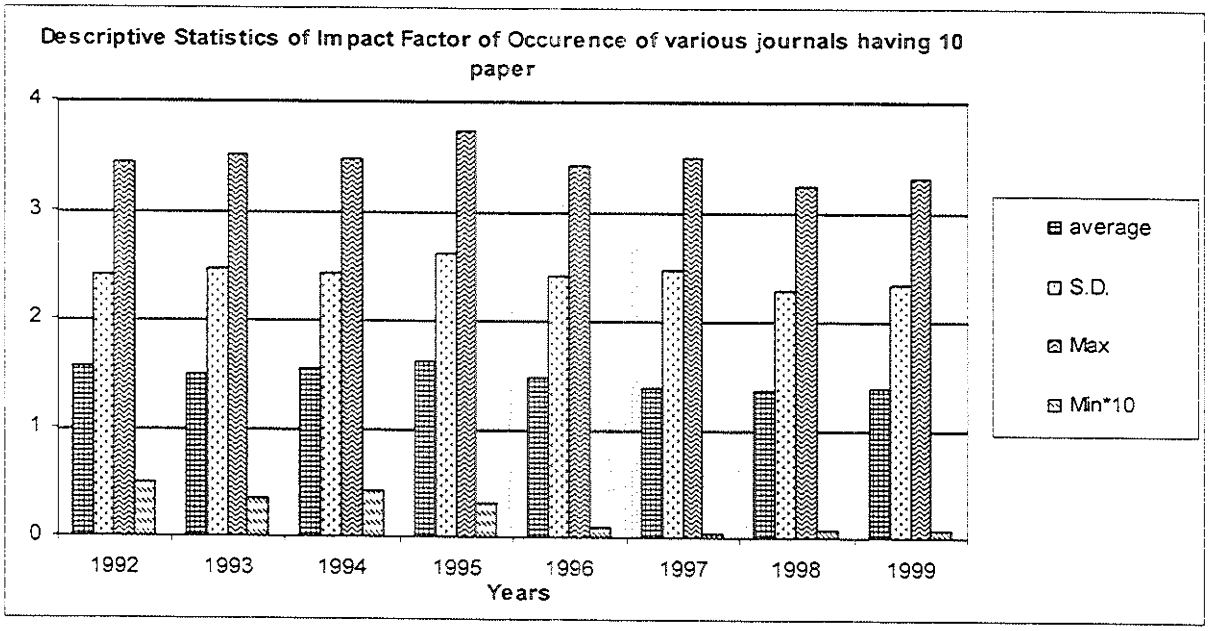
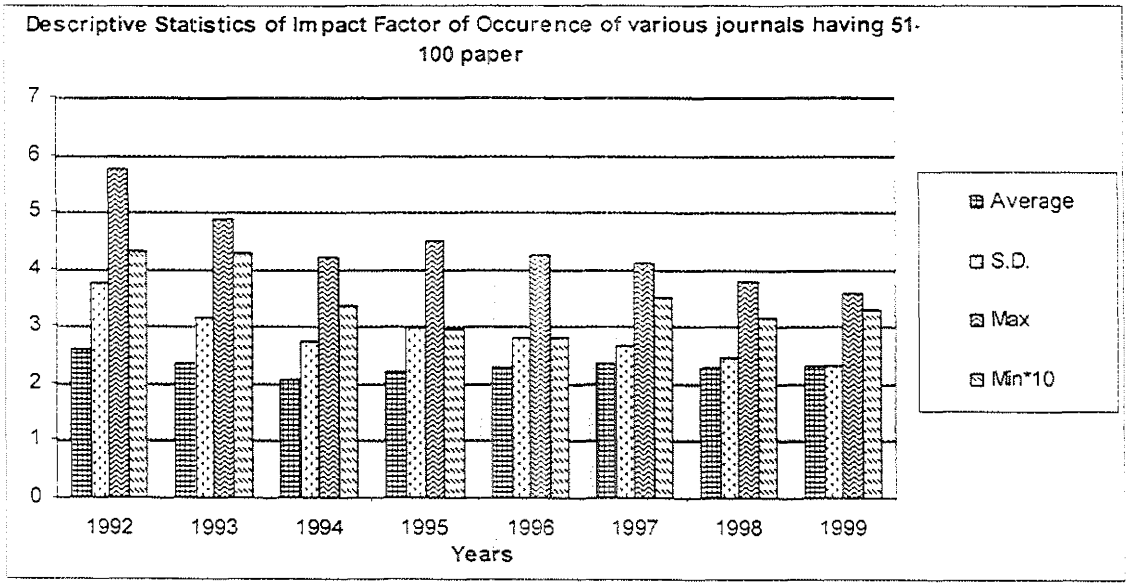


Figure-8: Year-wise distribution of IF of journals publishing papers between 51-100



The following four Figures-9, 10, 11 & 12 capture both quality and quantity of Indian manpower in specific sub-areas of specializations. Sub-areas considered are Organic chemistry, Protein crystallography, Nucleic acid and Proteomics. The data for 2004 is incomplete (capturing output of a few months only) – so these figures should be read upto 2003 only.

Figure-9: Quality and quantity of manpower in organic chemistry

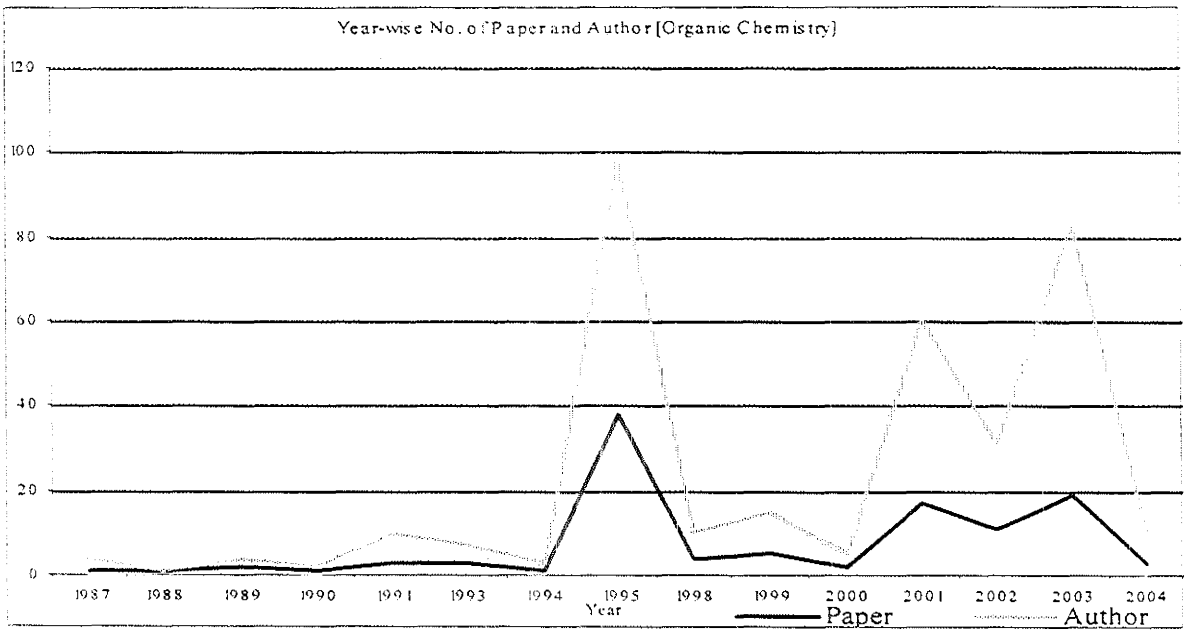


Figure-10: Quality and quantity of manpower in protein crystallography

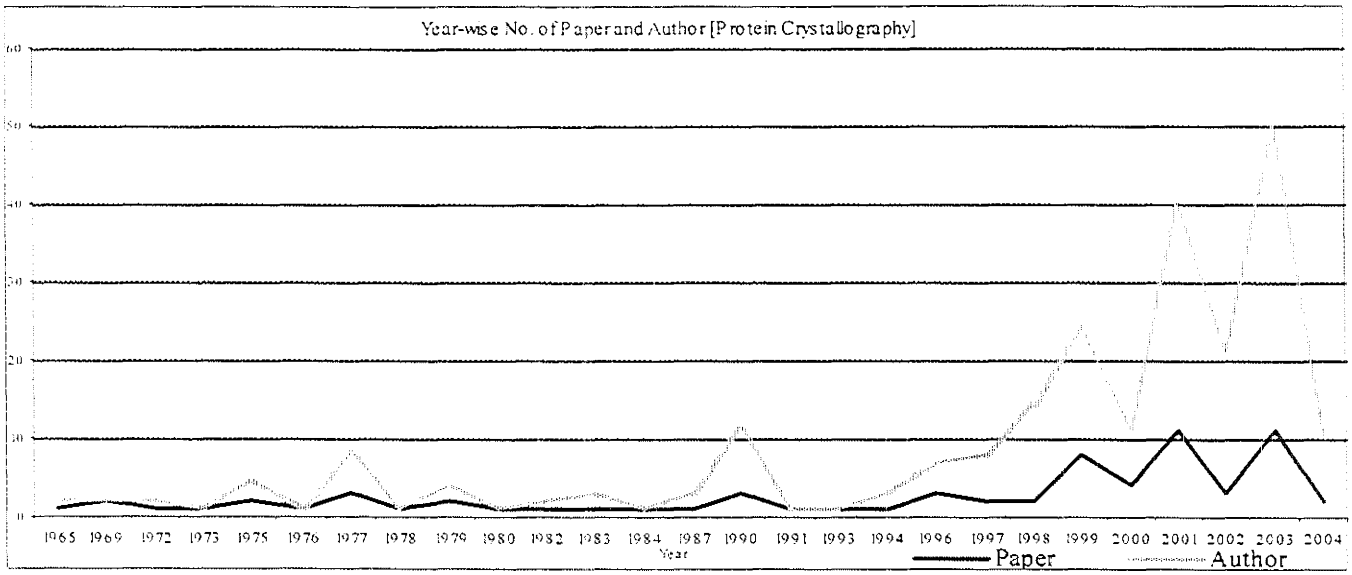


Figure-11: Quality and quantity of manpower in nucleic acid

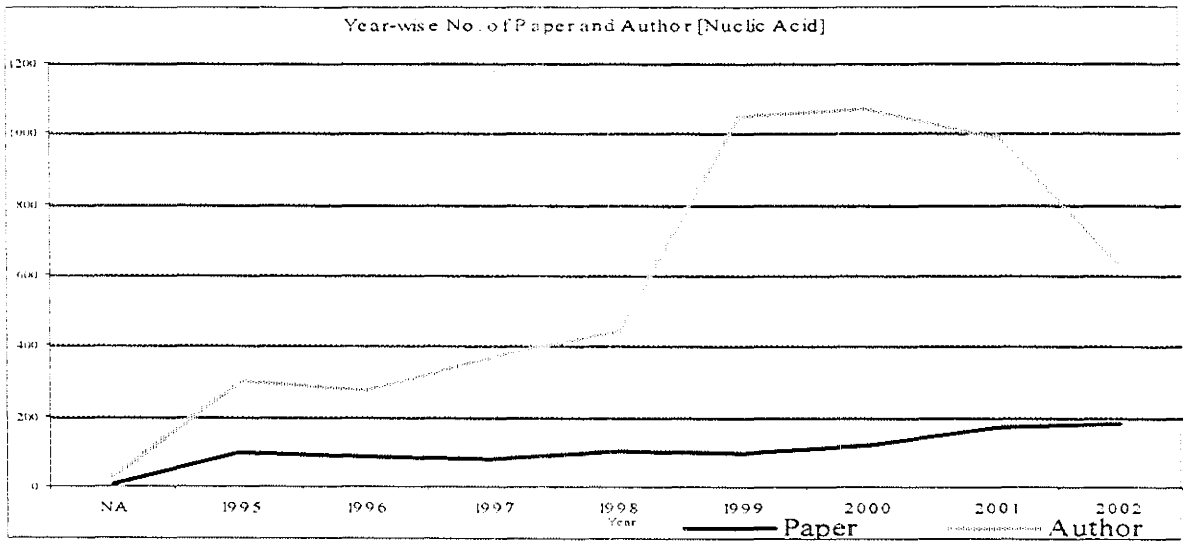
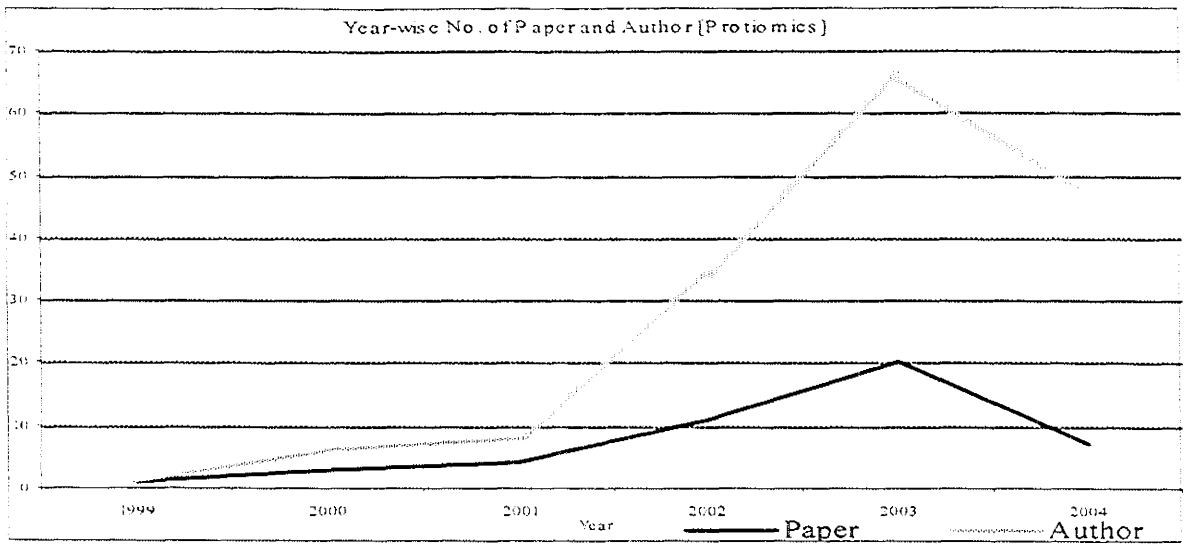


Figure-12: Quality and quantity of manpower in proteomics



Simple averages of productivity measure, such as "(Total paper)/(Total author)" capture average-quality of national manpower. The following Figures-13, 14, 15 & 16 represent such average-quality of Indian manpower in a few select areas related to drugs and pharmaceuticals. Moreover, these figures present annual data on number of authors engaged in research in those areas and their output quantity. Areas covered are Chemical biology, Medicinal sciences, Biopolymer and Chemistry. These data are from the Scirus database.

Figure-13: Annual changes in number of authors and research papers in chemical biology

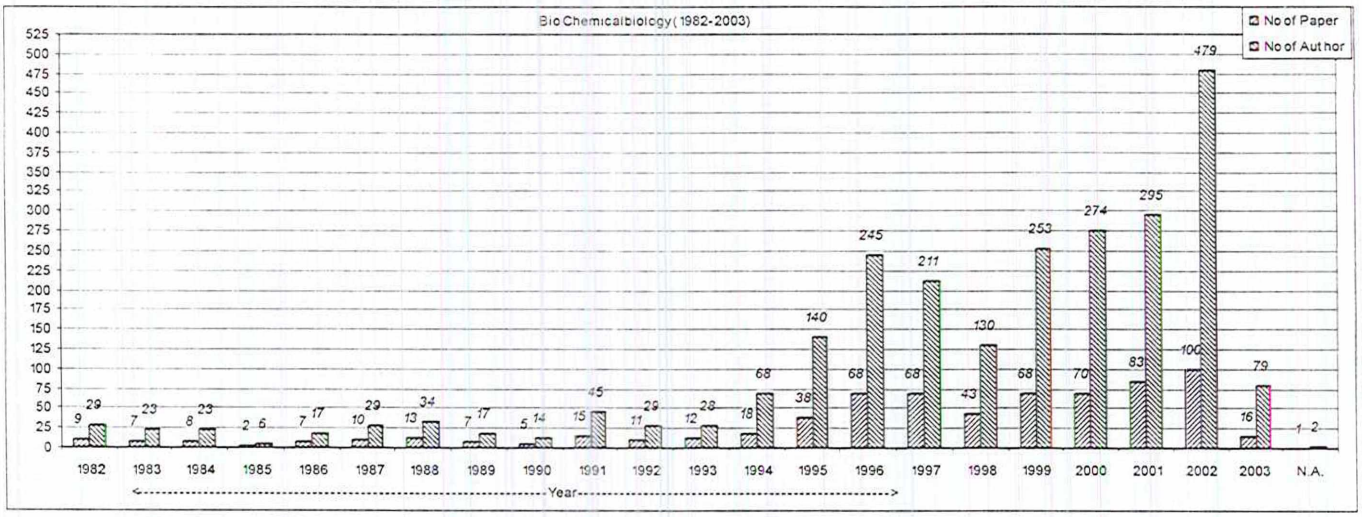


Figure-14: Annual changes in number of authors and research papers in medicinal science

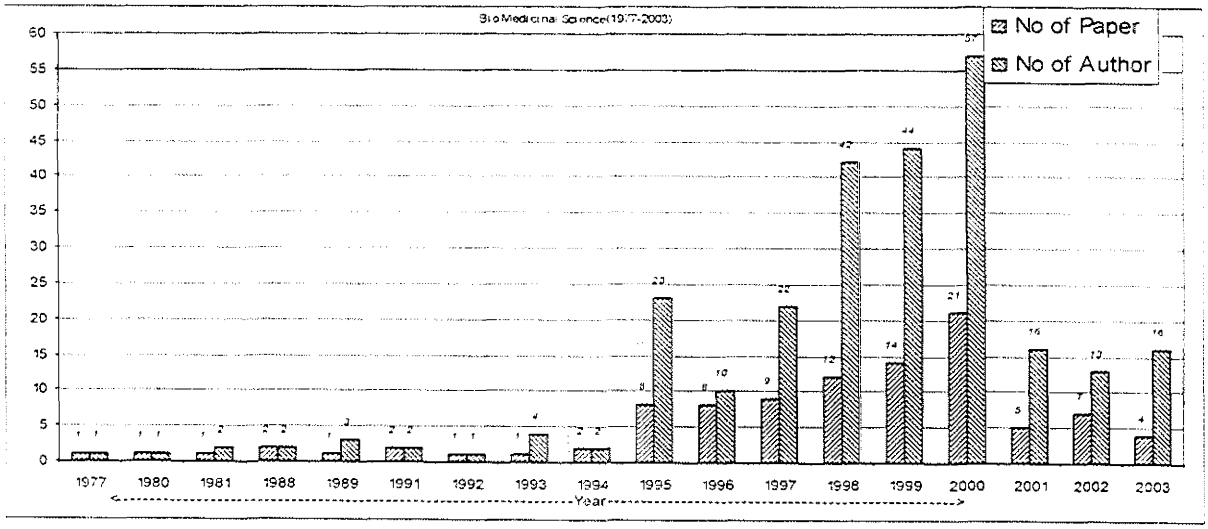


Figure-15: Annual changes in number of authors and research papers in biopolymer

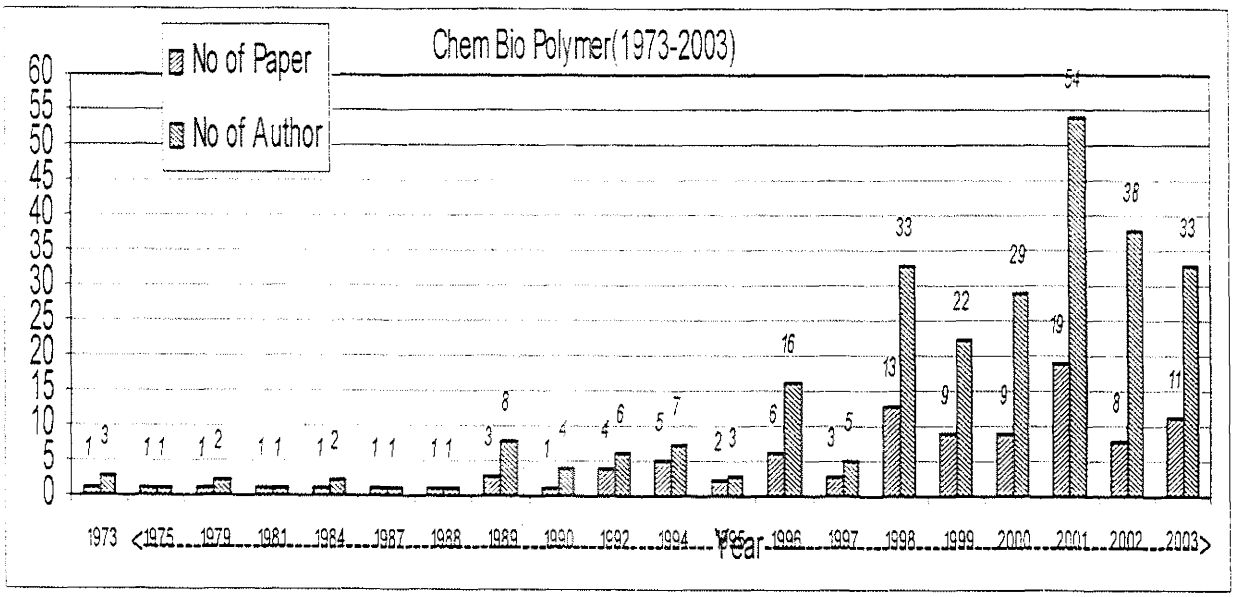
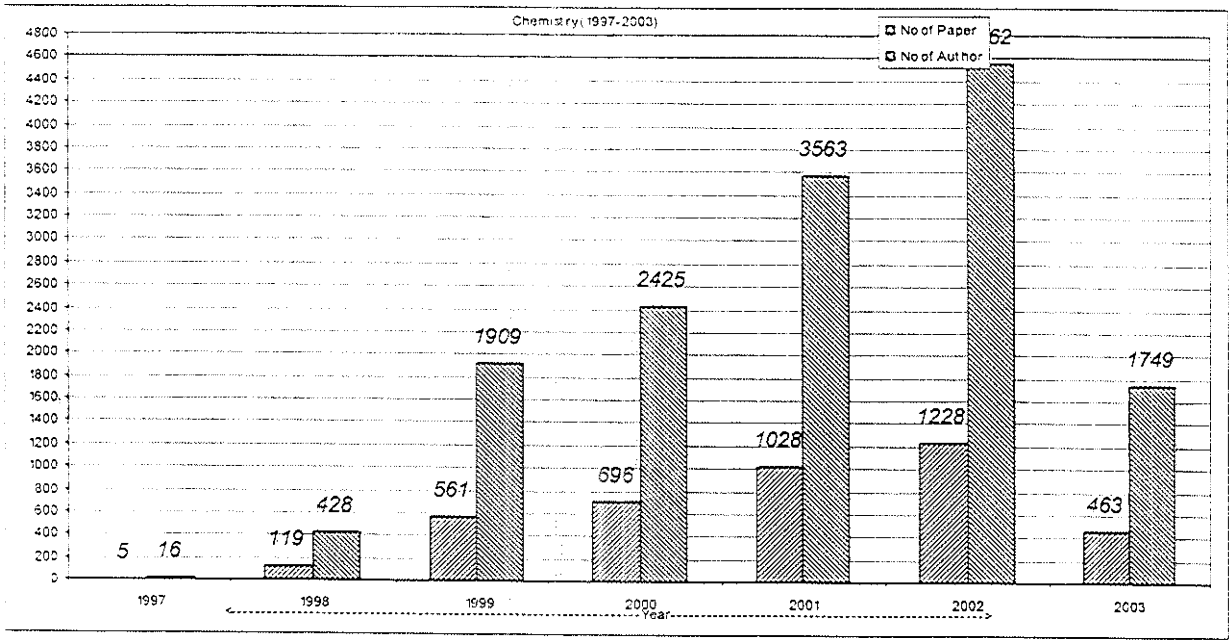
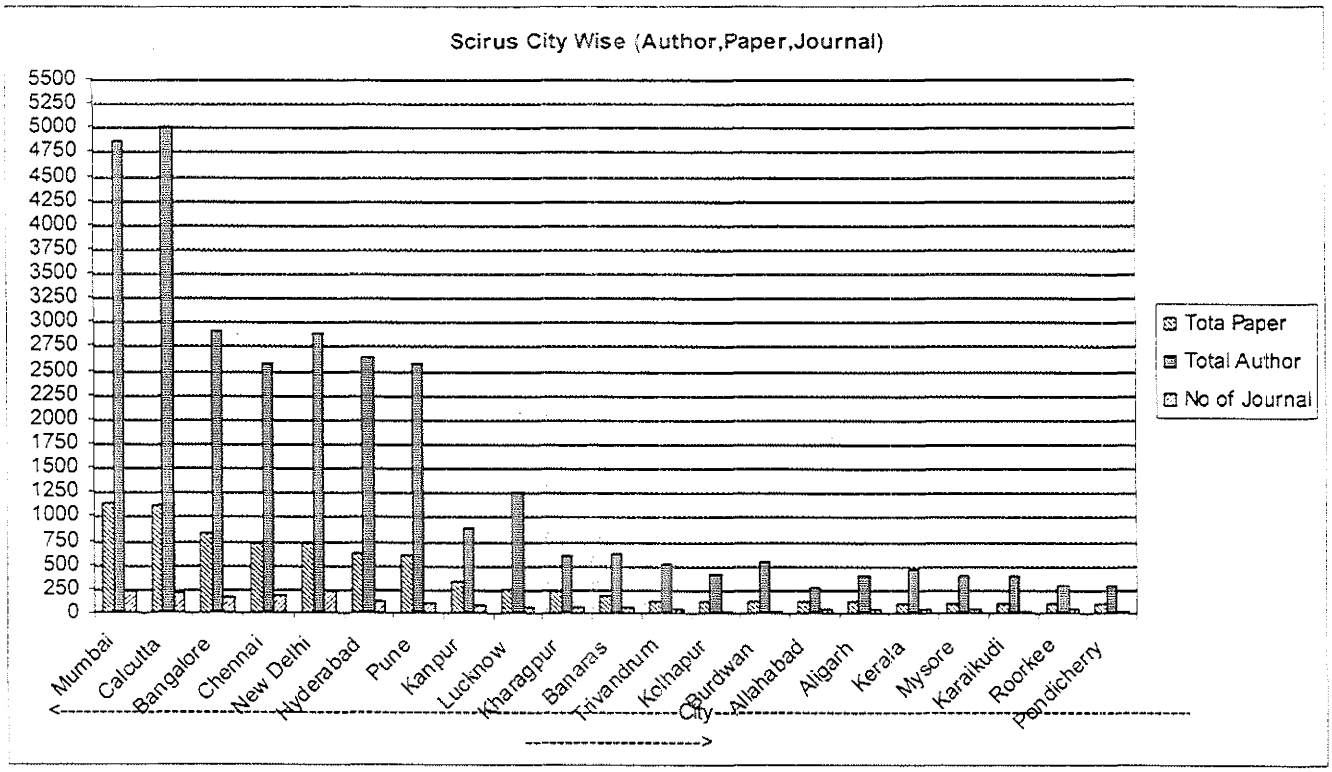


Figure-16: Annual changes in number of authors and research papers in chemistry



This Figure-17 represents city-wise distribution of gross-quality (that is, quality over several years) as well as quantity of manpower and generated output in areas described above, such chemical biology, biopolymer, medicinal science and similar others. This result is at variance with Figure-1 on two counts: first, sub-areas considered are not identical; second, source databases are different.

Figure-17: City wise distribution of gross-quality, total manpower and total output in select areas of drugs & pharmaceuticals



Quality gets assessed through number of papers. However, quality gets boost when there are more than minimum critical numbers of researchers in an organization. This is a quantity-led bootstrap on quality dimension.
Conversely then numbers of research papers and numbers of professionals assist each other.
No less important should be an even distribution of these two parameters across organizations. Inter-organizational competition and benchmarking could then exploit resources distribution across organizations to the optimum.
In the following Figure-18 we define an active address as such an organization having some minimum values of these two parameters. Figure-18 presents cumulative distribution of both these parameters when plotted each against the other. For an even distribution there should have been a straight line cutting across mid-range. However, the skewed rise of the curve indicates addresses are unequally active, or some addresses are super active, owing possibly to the quantity-led bootstrap effect mentioned above.

Figure-18: Assessing quality of active organizations through cumulative distribution of productivity in research papers

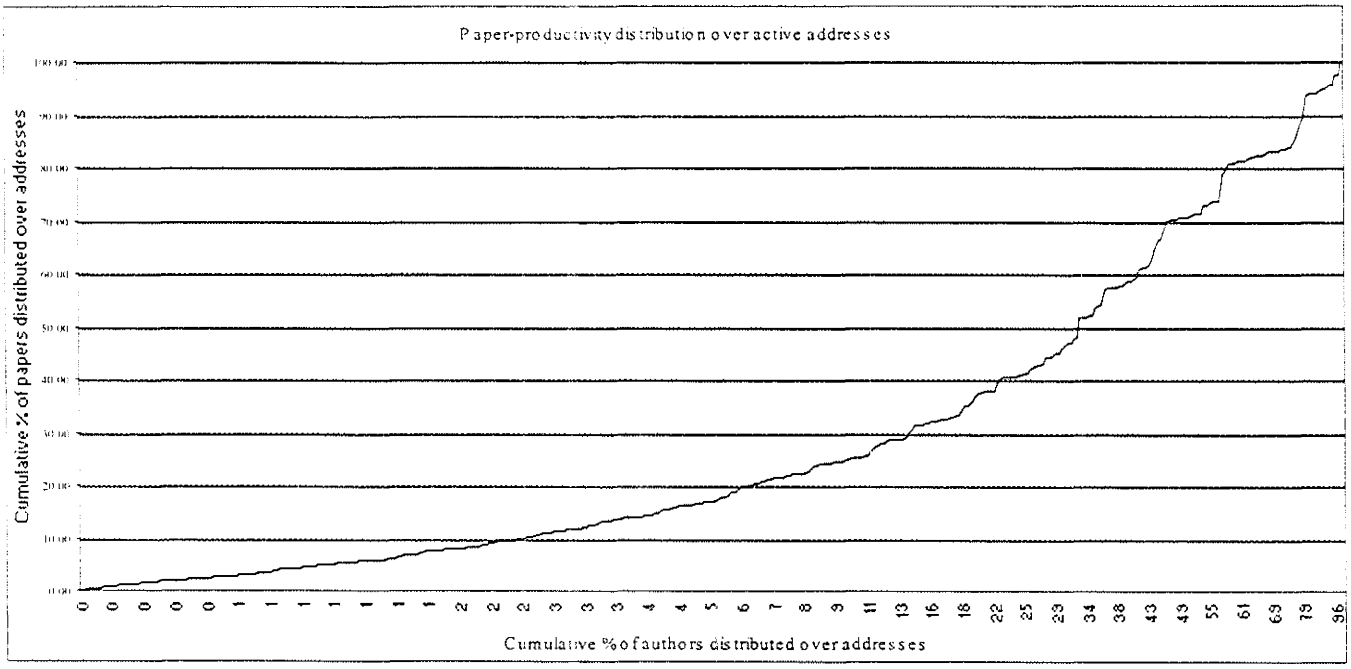
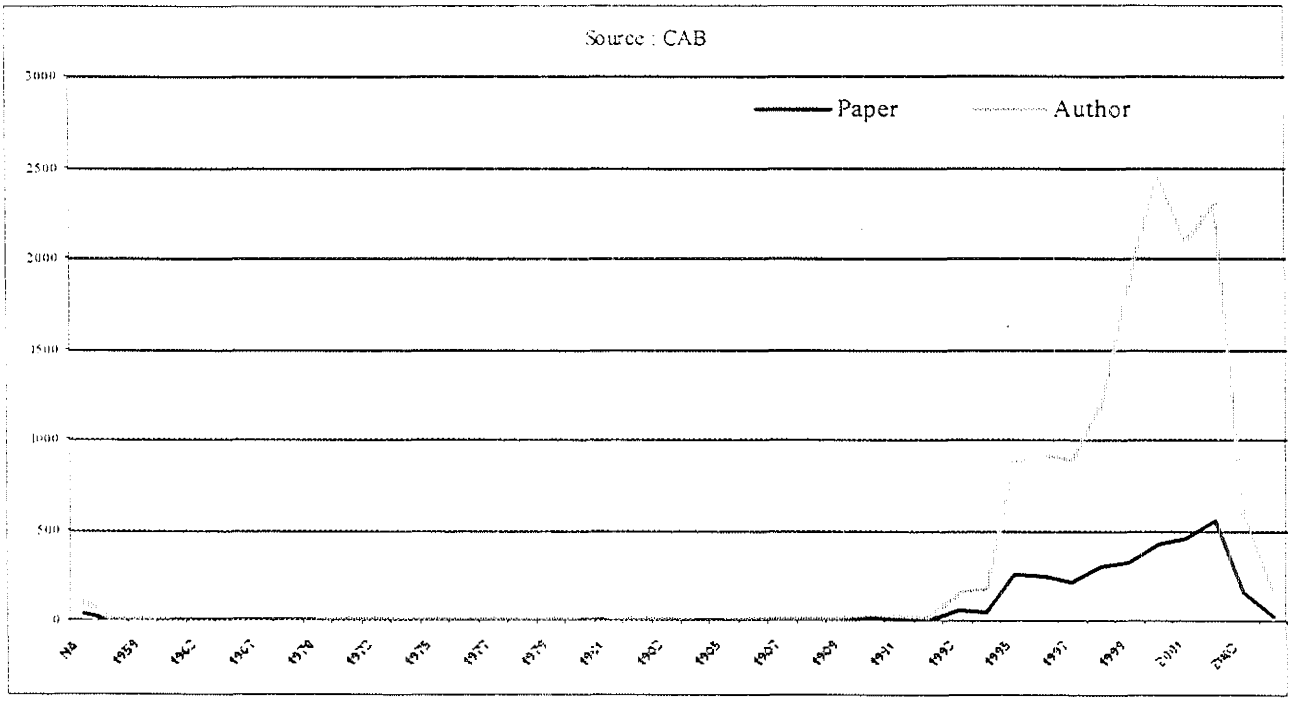


Figure-19 exhibits research productivity based quality in chemical and related areas. Based on Chemical Abstracts, with the limitations that pre-1992 data is under-represented hence may not be considered, this Figure shows that with five authors per paper the decade of nineties experienced a sharp rise in professionals engaged as well as papers produced in life sciences or drugs & pharmaceuticals related areas of chemical sciences. Data for 2003 appears to be incomplete. Hence there is no sharp decline possibly as shown the Figure.

Figure-19: Annual distribution of research productivity indicating quality-trend in areas of chemicals related to life sciences



Chapter-6:

Patenting activity from India

Patenting should be considered first and foremost as strategic. However, several professionals consider patenting as indicating levels of inventiveness.

At present patenting in chemicals, and related areas of drugs & pharmaceuticals are undergoing a major overhaul consequent to changes brought about by the World Trade Organization and the Trade Related Intellectual Property Rights Agreements. As a result status of patent has shifted closer to the strategic dimension.

As an indicator of strategic patenting, one might refer to the Patent Triad that is patents when applied for or granted by the three systems of European, Japanese and the US. It is a pity that India does not figure in the patent triad.

Most Indian patents in the areas under consideration have been granted in India and for some in the USA subsequently.

Patents granted in US could therefore reflect both quality of patents and the strategic value of patents.

In the following we discuss data on patenting by India/Indians from the US patents office (USPTO).

In the following two Figures-1 and 2 US patents granted to India (searched as under 'ICN' and 'Abst') have been exhibited.
Subject areas of patent can be searched in several modes. We searched for in the abstracts.
We searched for the category inventor's country ('ICN').
Figure-1 exhibits data on hydrocarbon area – a broad area under chemicals. This Figure shows how in recent years Indian patenting in US under this category has fallen.
In the next Figure-2, data on polymer area has been exhibited. This clearly shows how in recent years Indian patenting activity under USPTO for polymer has increased.

Figure-1: Yearly distribution of US patents granted to inventor's country India in hydrocarbon area

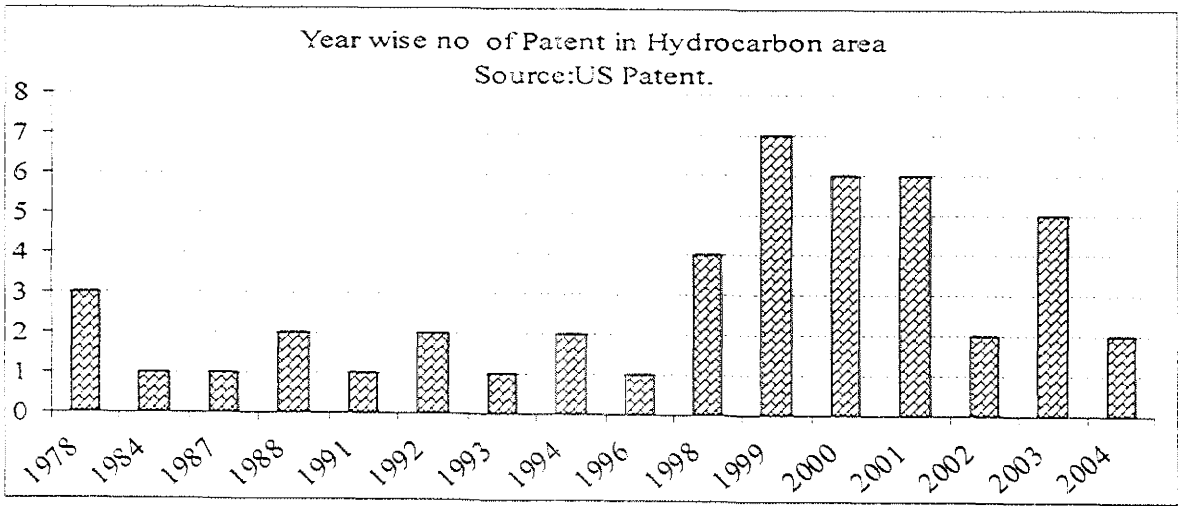
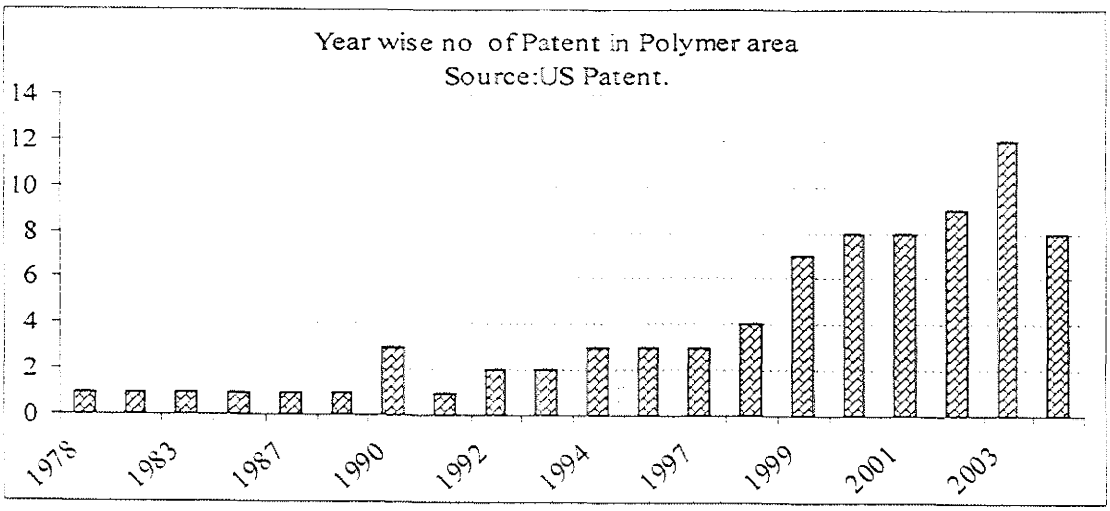
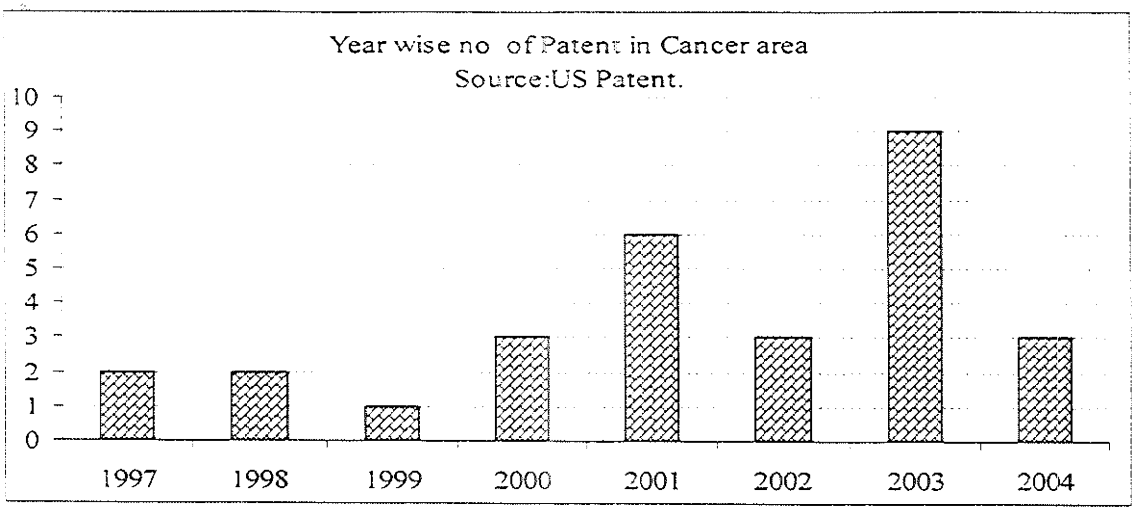


Figure-2: Yearly distribution of US patents granted to inventor's country India in polymer area



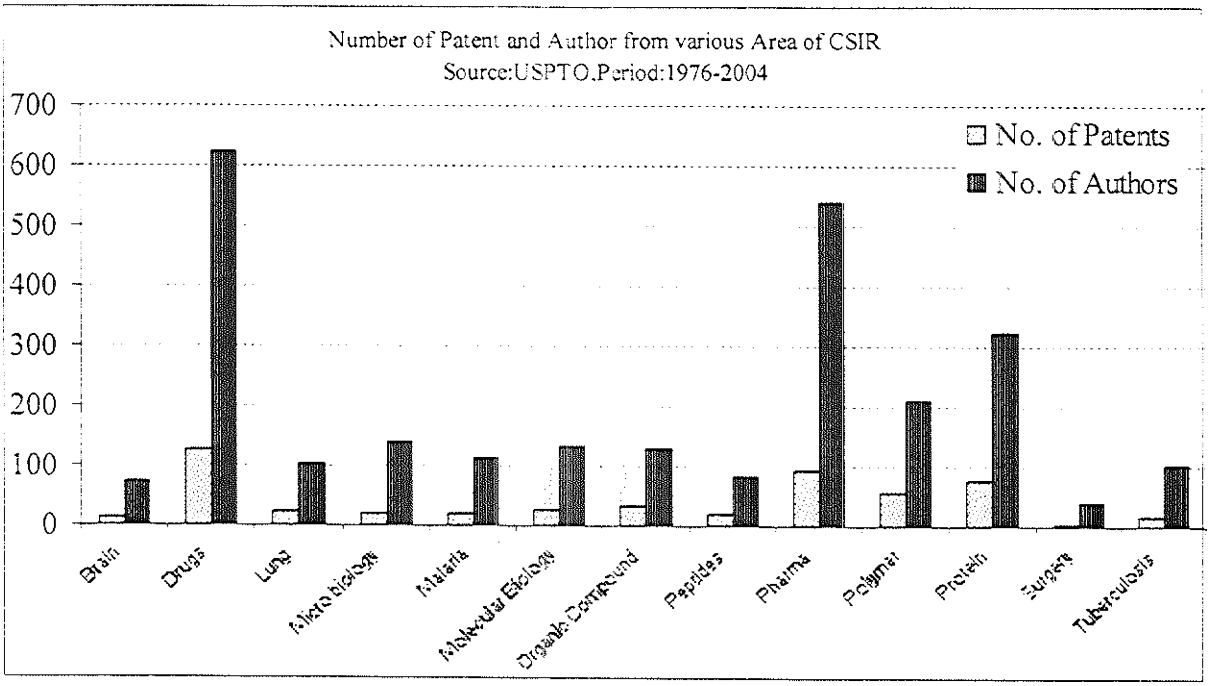
The next Figure-3 exhibits patents granted to inventors from India under the subject area cancer.
Subject cancer has been searched for under the abstract.
This shows that in recent years numbers of patents granted has experienced an overall upraise.

Figure-3: Patents granted to inventors from India for the area cancer



The major dilemma facing India is that while patenting is strategic few privately owned firms respond strategically to file for patents in the most important market US.
Publicly owned entity the CSIR in contrast has been granted the most of US patents, in contrast. The CSIR is not a corporate body. Strategic response of a public body beyond the public space of India, and for some putative national strategic interest adds a new and novel dimension to patenting by CSIR. Several such bodies in the developed countries do file for large number of patents, however, most often for keeping their own public space as competitive. CSIR's patenting in this perspective has novelty.
Figure-4 exhibits patents granted to CSIR in several areas during a period close to three decades.
We have chosen the areas of microbiology, molecular biology, brain, lung, malaria, peptides, malaria, protein, surgery, drugs, pharmaceuticals, organic compound, and tuberculosis. Each area has been searched for under the abstract of the patent documents. Along side number of authors writing patents have been shown.
Excepting drugs (and the very similar pharmaceuticals) in most other disease areas number of patents from CSIR are few only. In some applicable areas such as in protein patenting has advanced in recent years. Nearest in numbers of patents is polymer; however, patents by CSIR in the area nano is near zero.

Figure-4: US patents granted to the CSIR under several areas and the number of authors



The following Figure-5 shows distribution over cities of applicants of patents granted by the US.

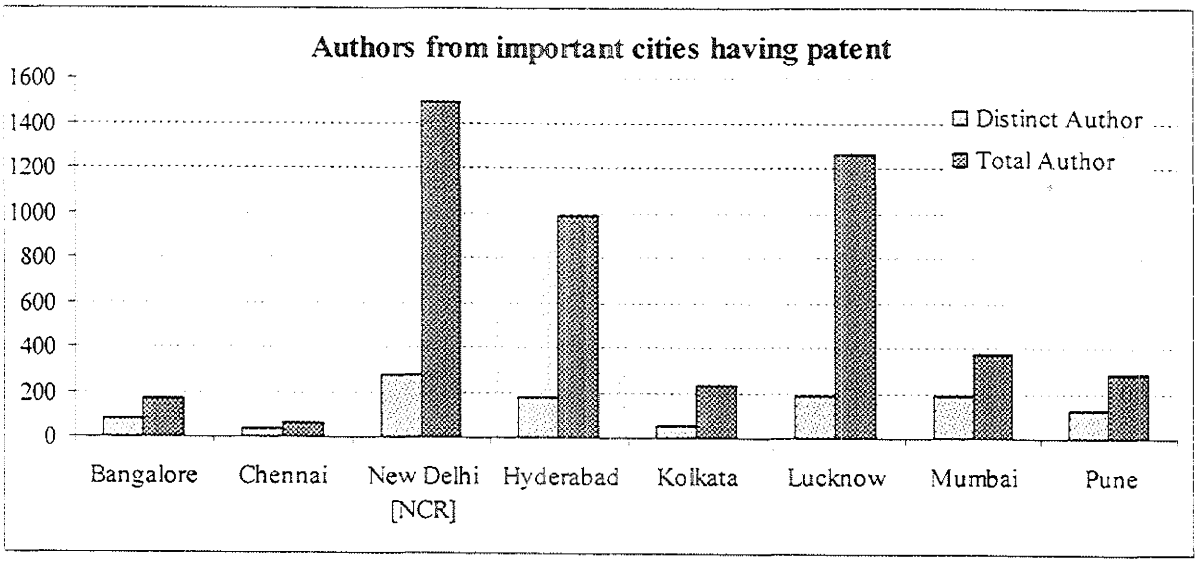
Patents granted signify a minimal quality of patents. Hence distribution of authors signifies a distribution of quality manpower.

New Delhi, Hyderabad and Lucknow top this list. This shows clearly how the area of drugs and pharmaceuticals dominated patenting activity from India under the areas of chemicals, diseases and drugs in general.

This Figure has another important dimension.

The sharp difference between numbers of distinct authors and total authors clearly show how some of the authors have remained multiple authors.

Figure-5: Distribution of US patents-granted applicants over cities of India

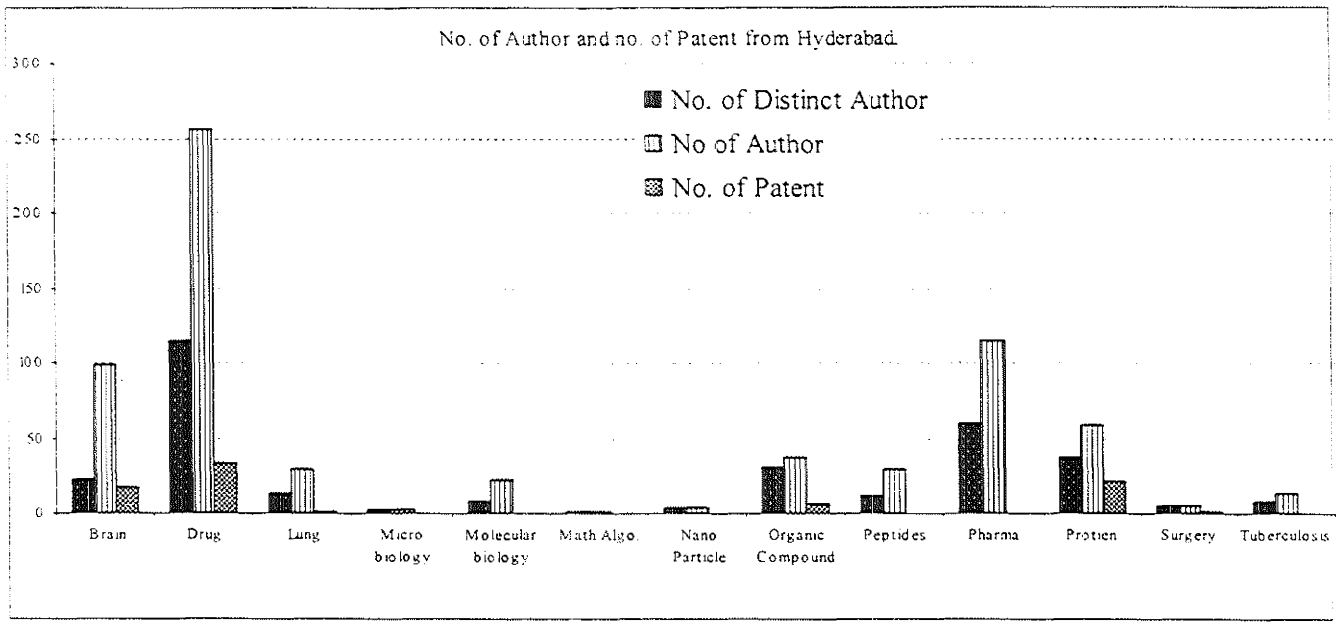


Looking back at the city of our interest, the Hyderabad as a city having social capital in the areas related to drugs and pharmaceuticals, the following Figure-6 exhibits numbers of total authors, numbers of distinct authors and numbers of patents granted by the USPTO in the areas of drugs, pharma, molecular biology, microbiology, brain, lung, mathematical algorithm, nano particles, organic compounds, peptides, surgery and tuberculosis.

Patenting in areas brain, drug and protein appear noticeable, and in other areas the numbers hover around zero.

In all areas, but especially in drugs and brain the difference between distinct authors and total authors are significant – indicating that at Hyderabad there are a few critical authors who can lead.

Figure-6: Numbers of authors and patents from Hyderabad in several areas of patents granted by the US



Chapter-7:
Quality, output and distribution of research outputs in drugs & pharmaceuticals related areas

Drugs and pharmaceuticals refer to an area where quality and domestic capacity depends on capabilities in several sub-fields of specializations and capacity built up in several institutional modes of organizations.

Drugs, for example, would depend on research capability and manpower quality first in some chemical areas, such as inorganic and organic chemicals. Drug delivery might heed polymer capability. However, drug designing would require capability in molecular biology, for example. Most importantly, all the stages of drugs, especially the stages of clinical trials would require capability, quality and capacity in medical research and medical manpower.

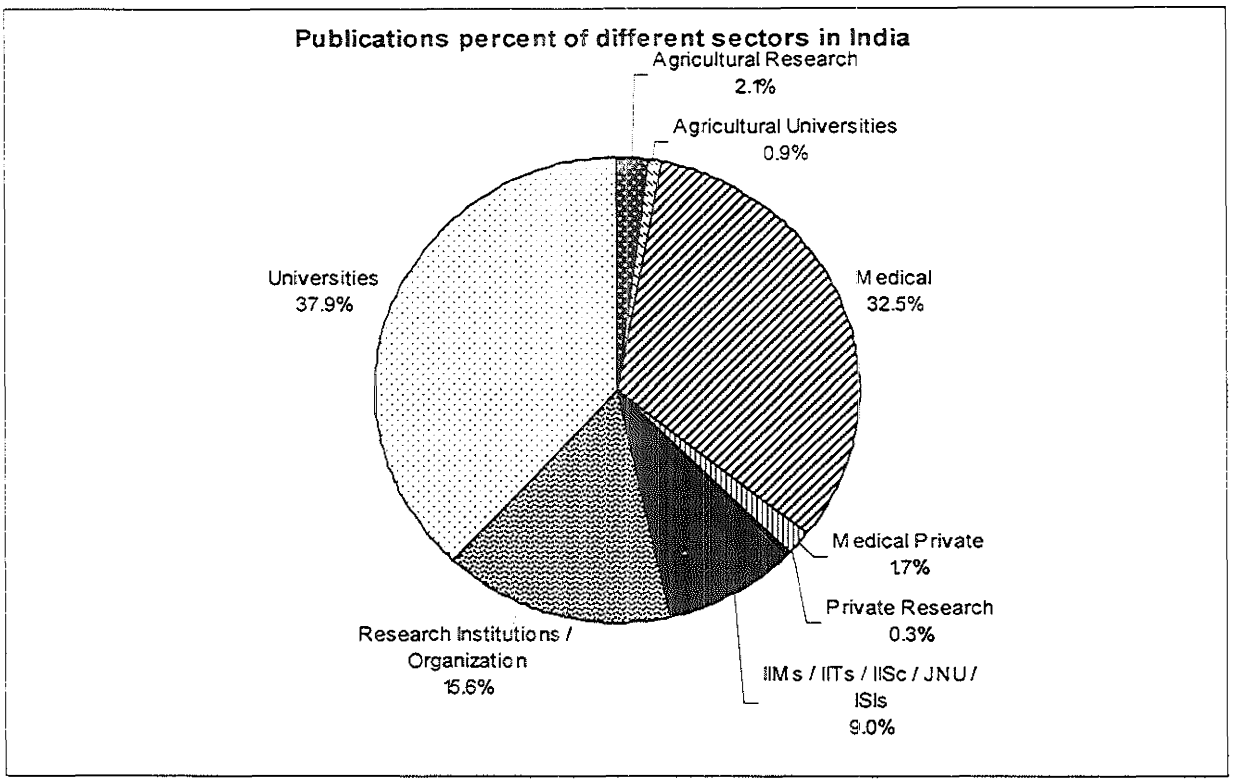
In this chapter we emphasise capacity, capability and quality in medical related areas.

Our data source is the Medline database.

Figure-1 exhibits distribution of medical and drugs & pharmaceuticals related outputs over several types of institutional modes. We differentiate between these institutional modes because each types of institution has distinct sets of objectives and goals, distinct patterns of research and manpower as well as knowledge (re)production patterns are unique to each. Uniqueness in (re)production of knowledge, sets of practices, rules and routines, incentives, and similar others differentiate between university, medical hospital, R&D organization, private firm, agricultural universities, and others. Therefore each of these would generate knowledge and ascertain as well ensure quality of manpower in unique manner. Each type would contribute to domestic endeavors in drugs & pharmaceuticals differently.

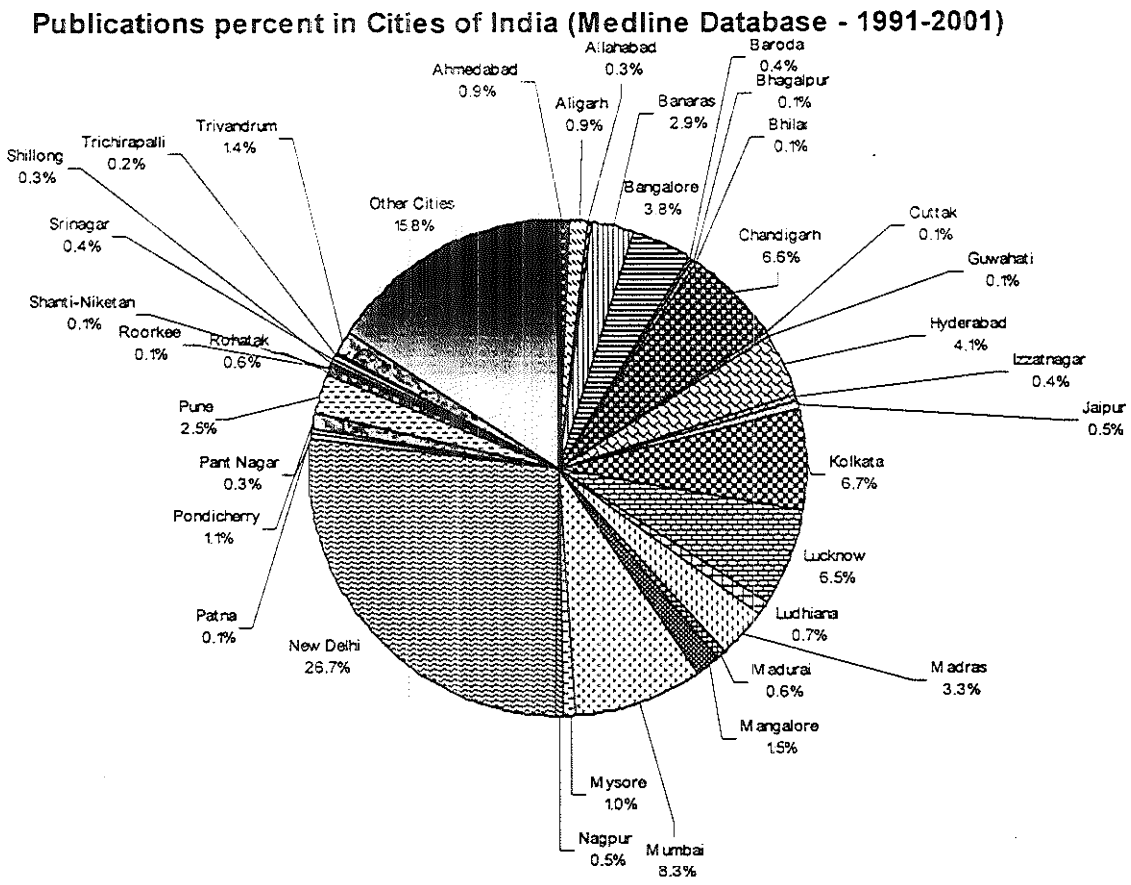
Figure-1 shows how systems of university and medical institutes occupy the positions of principal contributors, and how public R&D organization follow immediately these two sectors. Systems of IITs contribute much less. Contribution by private research is pitiably inadequate.

Figure-1: Distribution of medical related research output from different types of research/academic organizations



Distribution of research output is an indicator of capacity of domestic institutions.
Figure-2 exhibits that research output is well distributed over several cities. Delhi, howver, shares a very large output followed by Mumbai. Hyderabad is far behind and above that we have Calcutta, Lucknow, and Chandigarh. Very thin distribution over many more cities indicates that germinal capability does exist at those places. However, most often minimum critical quantity of output remains amiss.
This also indicates research capability at many places can generate quality manpower. Once again, critical quantity must precede.

Figure-2: Distribution of research output over cities of India in the areas related to medical and drugs & pharmaceuticals



Harping further on the capacity building aspect – in the following two Figures-3 and 4, we exhibit the cumulative distribution over cities both metro and non-metro.
Distribution indicates the degree to which capabilities are available and are regenerative over the geography.
As indicated in the previous Figure-2, metro cities produce disproportionately more output than the non-metro cities/towns.
Figure-3 exhibits the distribution over metro cities, while Figure-4 exhibits distribution over non-metro cities.
Skewness in distribution is much more pronounced over non-metro cities than over the metro cities, which apparently enjoy an evened out capability. Most non-metro locations are much below the minimum critical level of capability. This shows the great weakness in the domestic institution.

Figure-3: Distribution of research capability as reflected in output over metro cities

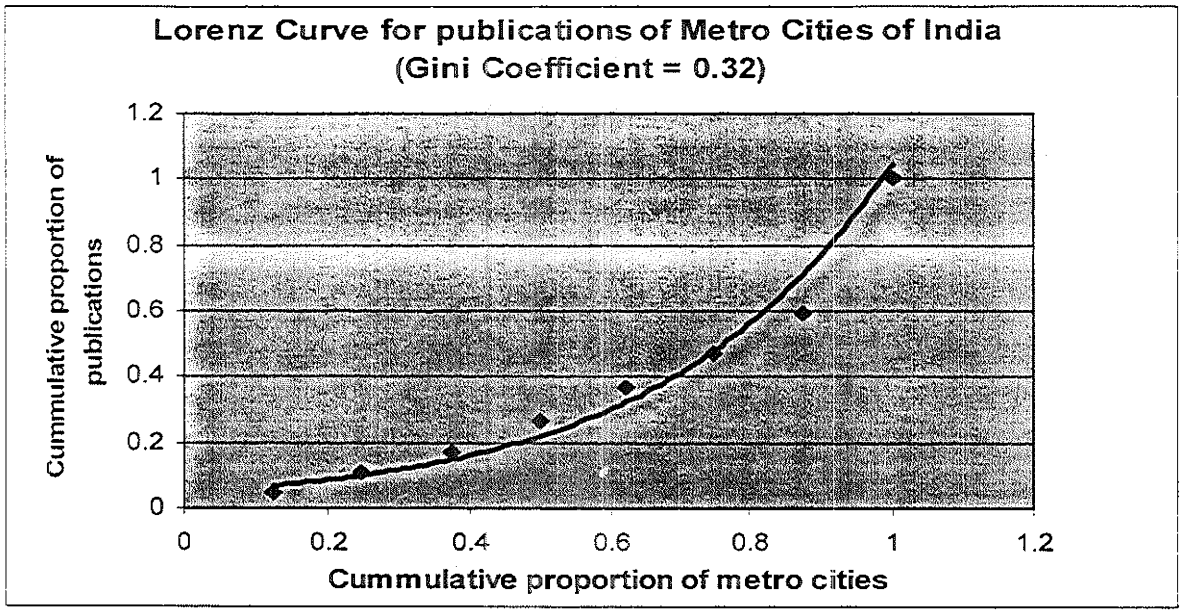
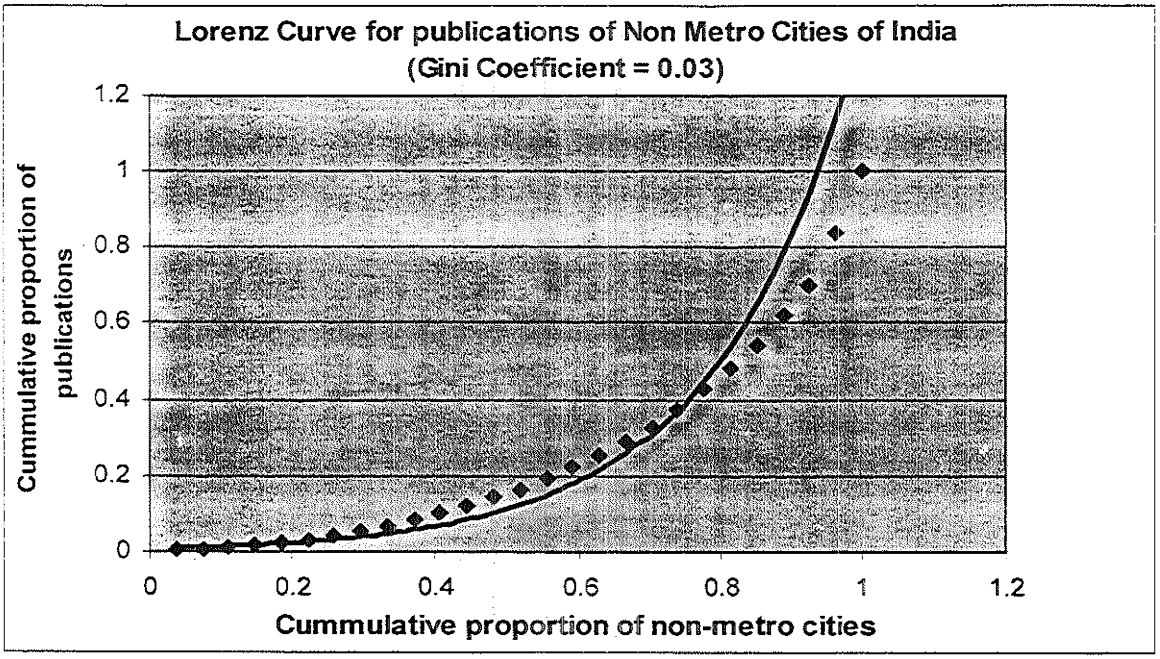


Figure-4: Distribution of research capability as reflected in output over non-metro cities

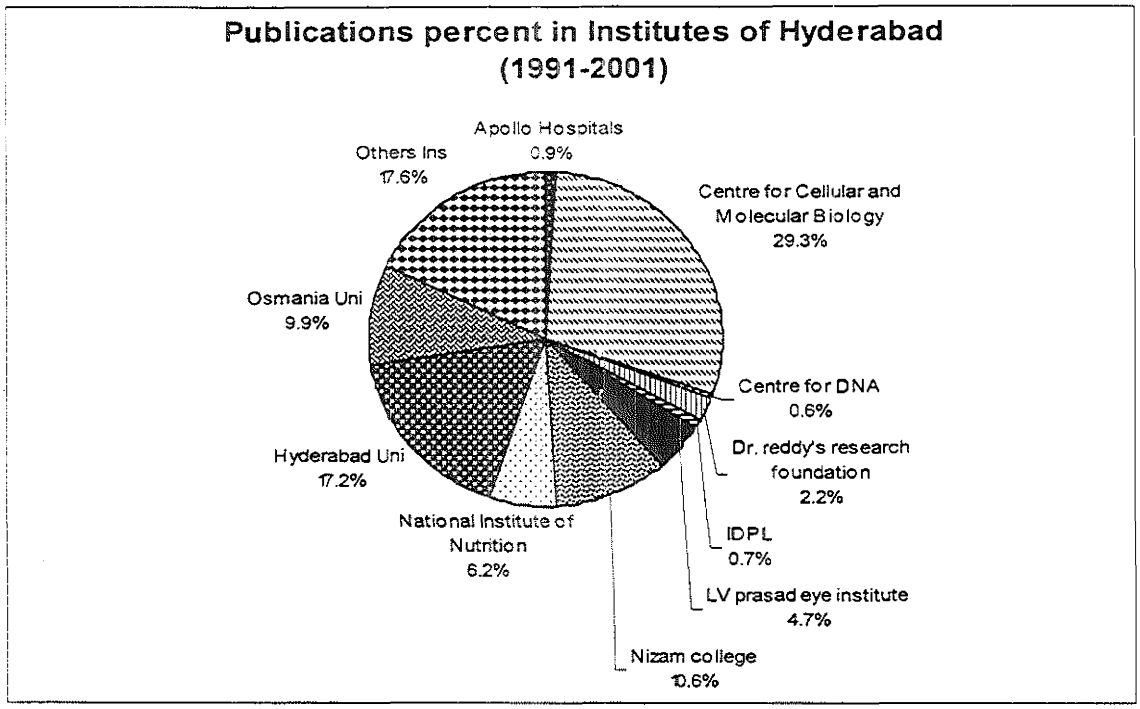


Looking back at Hyderabad in Figure-5 – the city with large social capital in the area of drugs and pharmaceuticals, we exhibit distribution of research output over city-based organizations.

As observed previously, two universities at Hyderabad occupy central position. Very close to the universities are the public R&D organizations, and strangely unlike all India picture hospitals in Hyderabad produced much less research output. However, better than national average is the output level of privately undertaken research at business firms.

Capacity of Hyderabad is thus tilted more towards the public good type social capital. Quality of research appears to be high because most output appeared out of research undertaken at universities and research organizations. Practice oriented capability and consequently quality of output in Hyderabad appears to be poor.

Figure-5: Distribution of output over organizations in Hyderabad



We now look at two types of institutions – university and medical hospital.
University system is primarily for teaching; many universities have little wherewithal to undertake research.
Medical hospitals are overburdened with clinical practice, and the time still left over is used in teaching. There is nearly no time and practically no infrastructure to undertake research.
Given these – Figures-6 and 7 exhibit first minimal though but continuous growth in research output from medical systems of India through Figure-6; and then from Figure-7, we observe research output distribution over universities. Strangely, Varanasi, a city with much less grant-received than some of the peer-cities, produced maximum output. Several other cities with comparatively little grant produced more research output. Most importantly, all such universities produced numerous students during the same period.
These two Figures therefore speak of the type of capacity built up in India, and possibly the capacity to produce both research and students go together in many organizations. In all such cases, quality of manpower generated would in all likelihood be better than the average.

Figure-6: Research output growth from medical establishments

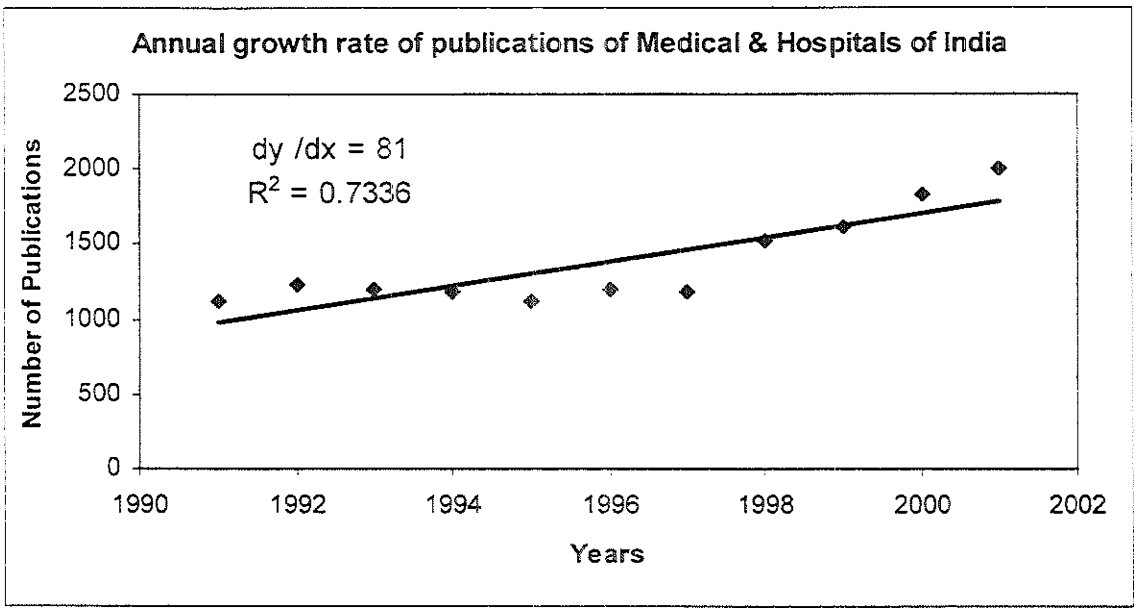
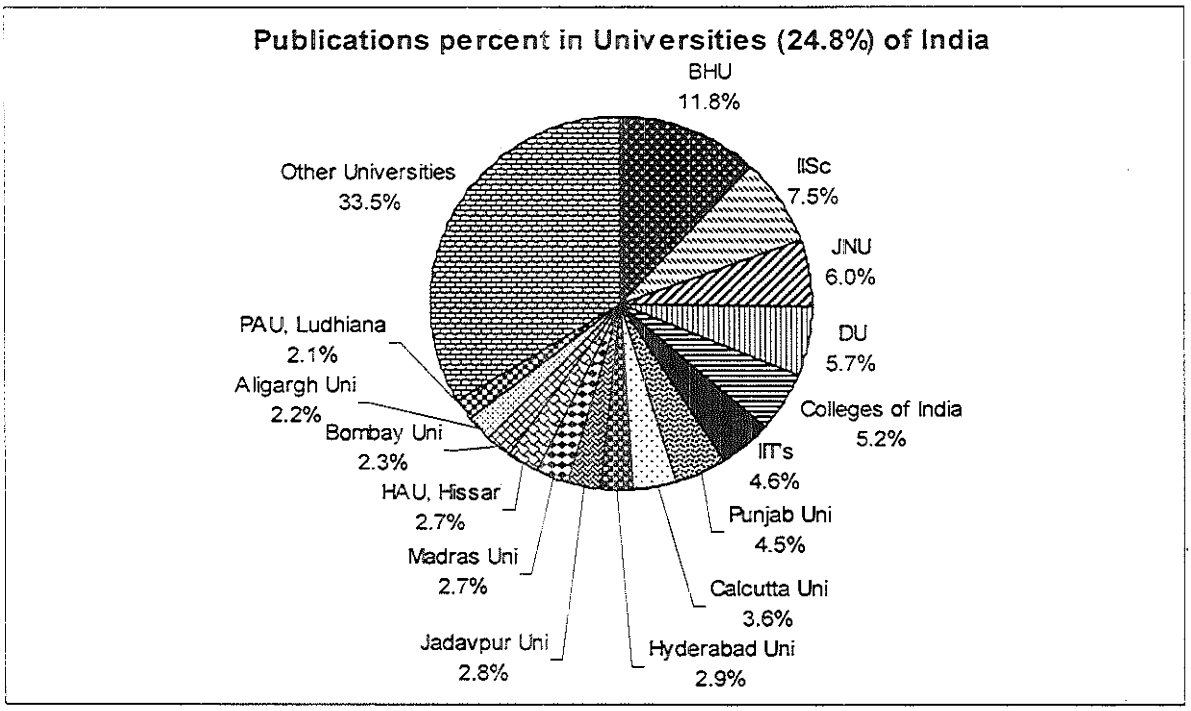


Figure-7: Research output distribution over university system



Chapter 8:

Training and degree education capacity

Capacity of domestic institutions can be appreciated if we look at the distribution of types, levels and numbers of courses on offer at several universities/IITs, etc., related to all areas of drugs and pharmaceuticals.

This chapter brings out formal degree, diploma/certificate, doctoral and post doctoral, other training, and similar other courses on offer at universities and IITS, IISc. However, the public sources do not divulge the quantum of intakes and outputs over years. Our sources have been Annual Reports, UGC, and websites.

Another important aspect could not be covered. This relates to training provided to medical students.

We could indicate only partially courses on offer for mid-career professionals. Most organizations do not carry out such programs. Moreover, public sources of data often fail to mention these courses and their quantum.

We present below a few summary Tables to indicate outturn of high-level manpower in areas related to drugs and pharmaceuticals. The data below indicates overall engineering outturn.

Number of Ph.D.s and M.E.s –

From India, 1990-200, Ph.D = 5088

M.E. = 81191

From IITs & IISc, 1990-200, Ph.D. = 3660

M.E. = 25698

Conversion of masters level manpower to doctoral level indicates capacity aspect of the system. The following data is indicative of that:

Table-1: Ratio of ME to PhD from IIT & IISc

Specialization	**India, 1990-2000**	**India, 1966-2000**	**IIT & IISc, 1990-2000**	**IIT & IISc, 1966-2000**
Biomedical engineering	14.8	11	2.7	2.6
Biotechnology	10.1	30.8	31.3	24.7
Chemical engineering	4.4	5.7	5.4	4.4
Computer science & engineering	22.4	24.2	9.6	13
Environmental engineering	50.3	55.4	9.3	11
Instrumentation engineering		230		347

Overall quantity in the select areas of engineering from all Indian organizations is presented below:

Table-2: Field-wise doctorates outturn from India

Field	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Biotechnology	1	2	1	2	1	2	4	4	1	4	22
Biochemical engineering	1		1		1		1	2	1	1	8
Biomedical engineering	1	1	1	1	1	1	1	3	2	2	14
Chemical engineering	44	53	44	53	44	53	49	49	52	61	502
Computer science & engineering	29	29	29	29	29	29	36	33	34	27	484
Environmental engineering	3	4	3	4	3	4	4	3	4	6	38
Polymer science1	1	2	1	2	1	2	3	3			15
Paints & plastic technology							1		1	2	4
Rubber technology	3	2	3	2	3	2	2	6	5	3	31
All engineering	385	433	385	433	385	433	467	542	522	525	4510

Here we present data on overall outturn and enrolment patterns in broad subject areas.

In the following pages we exhibit organization-wise types, levels, and numbers of courses up to the levels of doctorate and post-doctorate in areas related to drugs and pharmaceuticals.
Quantity of students enrolling and outgoing are not available.
Courses are of different types; hence no final table could be prepared. This Table can act as a database.

Table 3: Faculty-wise Number of Doctorate Degree awarded during 2000-2001 and 2001-2002

Faculty	No. of Doctorate Degree Awarded	
	2000-2001	2001-2002
Science	3727	4012
Engineering/Technology	778	747
Agriculture	889	781
Veterinary Science	110	90

Table 4: Stage wise enrolment

S. No.	Stage	Univ. Dept/ Univ. Collages	Affiliated Colleges	Total (% of Grand Total)	Percentage in Affiliated Colleges
1.	Graduate	812378	7415039	8227417 (89.16)	90.13
2.	Post-Graduate	285873	560683	846556 (9.17)	66.23
3.	Research	56455	5758	62213 (0.67)	9.25
4.	Diploma/Certificate	46442	45205	91647 (1.00)	49.33
	Grand Total	**1201148**	**8026685**	**9227833 (100.00)**	**86.98**

Table 5: Students enrolment : Faculty-wise 2002-2003

S.No.	Faculty	Total Enrolment	Percentage to Total enrolment in all faculty including arts, law and others
1.	Science	1834493	19.88
2.	Engineering/Technology	692087	7.50
3.	Medicine	300669	3.25
4.	Agriculture	55367	0.60
5.	Veterinary Science	14765	0.16