

### **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 absence 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<sup>1</sup> 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.

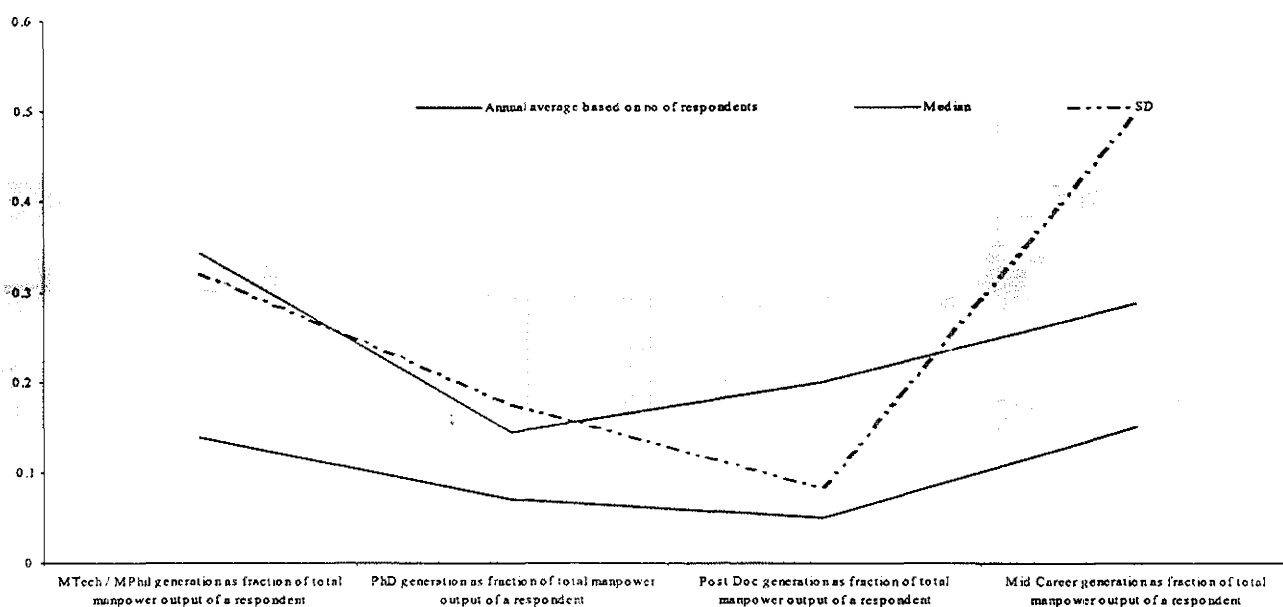
Our argument is supported by data. Our conclusion leads to suggesting possible policy initiatives.

**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.

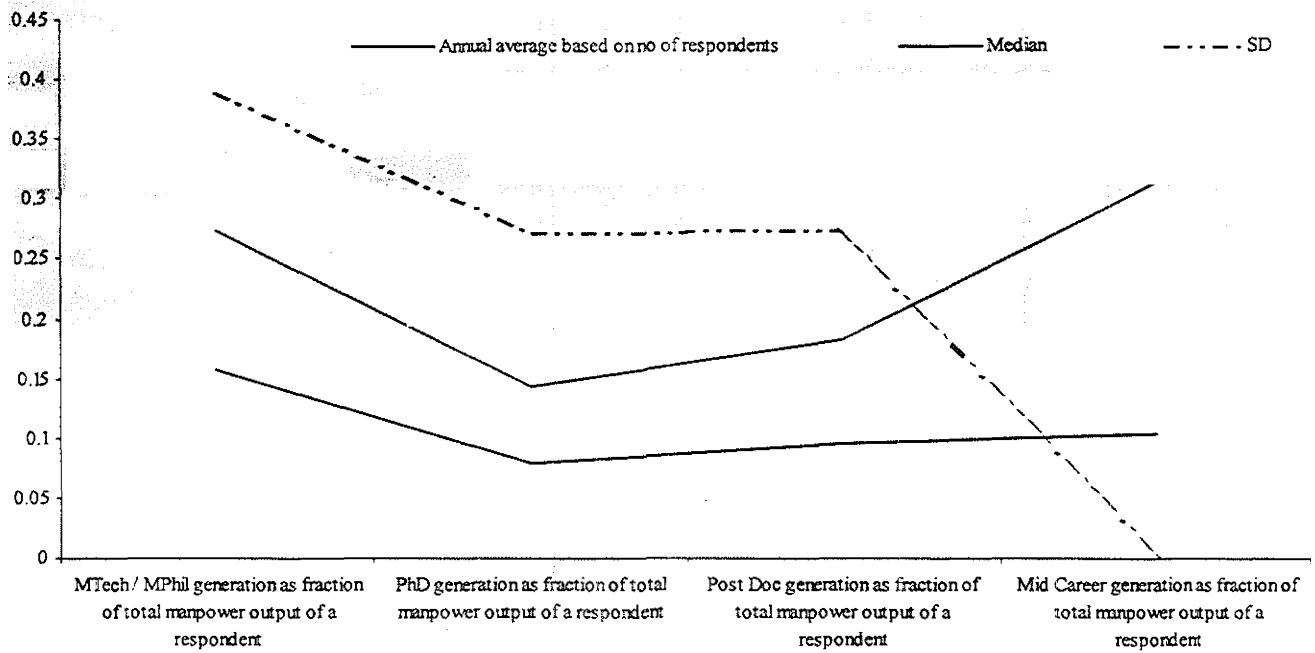
**Table-1: Manpower generation by biochemists of India**

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	Junior in orgn 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**

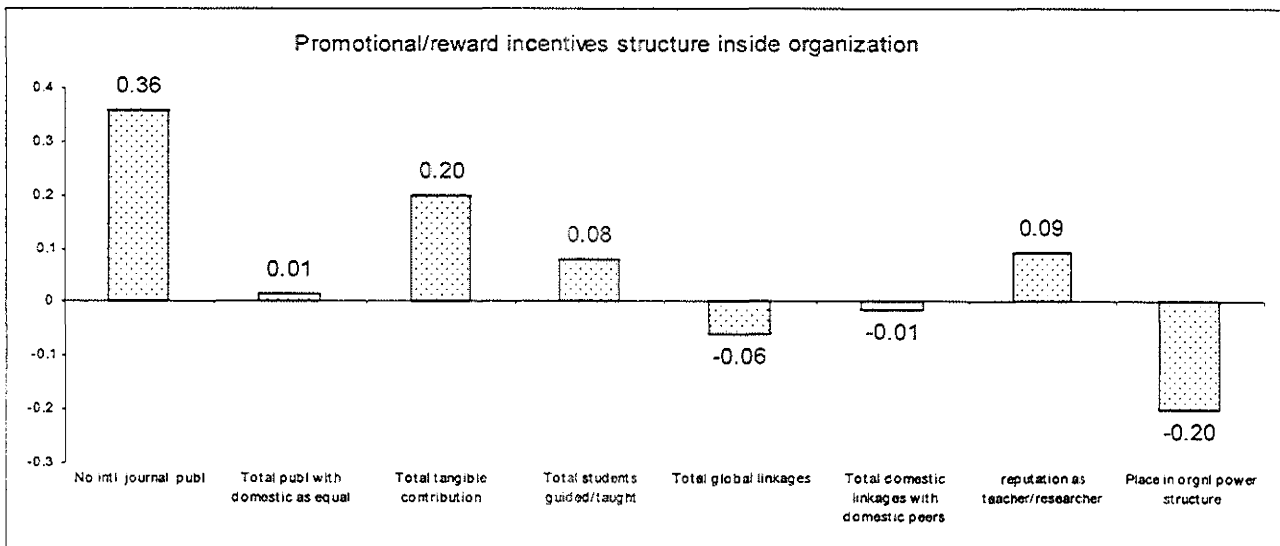
Data from 564 professionals from Survey of professionals in Univs/res orgns, 2003/4 ONLY GENETICS  
Group

	MTech/ MPhil students	PhD earned	Post- doctoral	Summer/Wi inter 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		

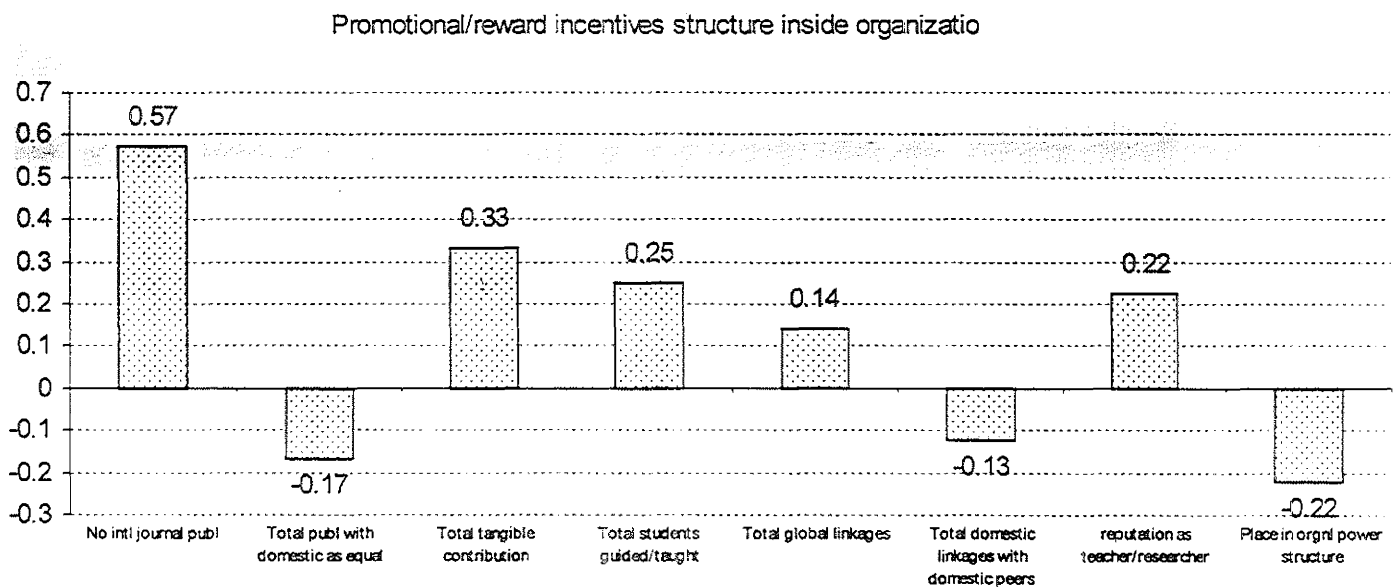


No less important is the existence of negative-list of incentives, or the absence of incentives. This applies to policies regarding publication in domestic journals, or policies on generating large number of good quality students. Survey respondents expressed their opinions on how their respective organizations 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).

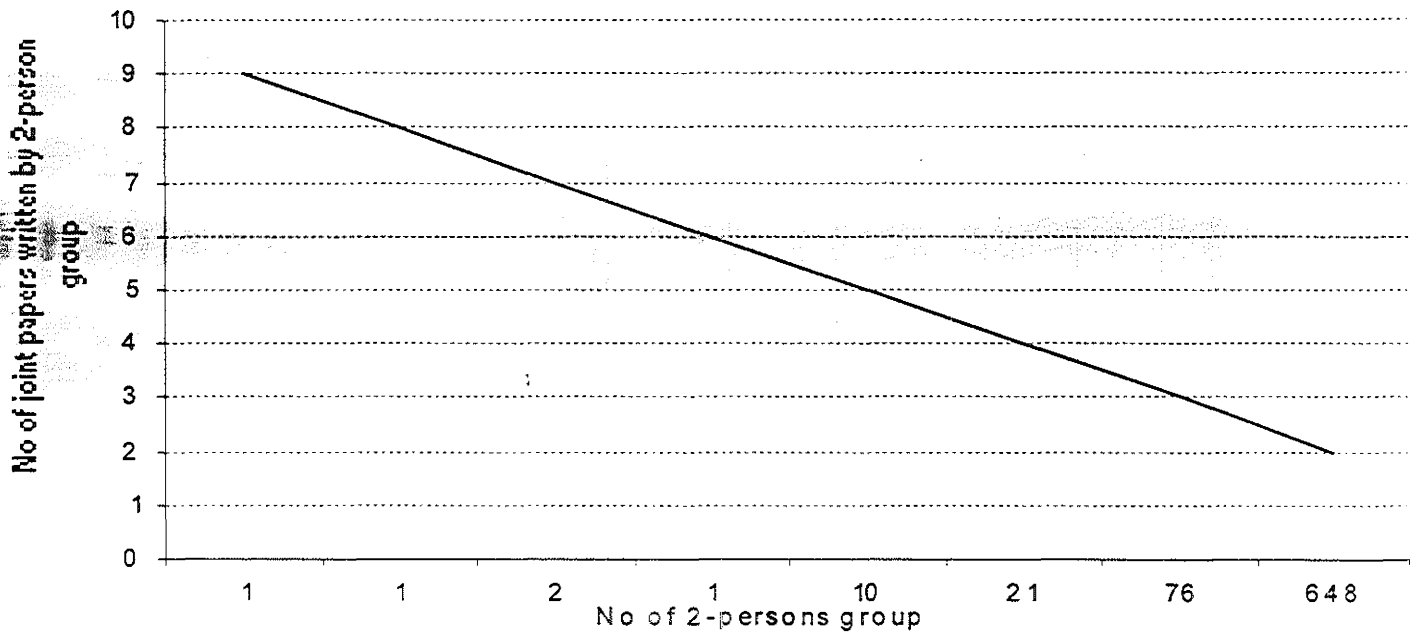
Low volume of manpower generation, low volume of quality-faculty, low volume of research publications and finally negative-incentives on publishing locally (contrary to publishing internationally) – all act synergistically to put a severe restraining curb on the primary resource, the manpower.

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**

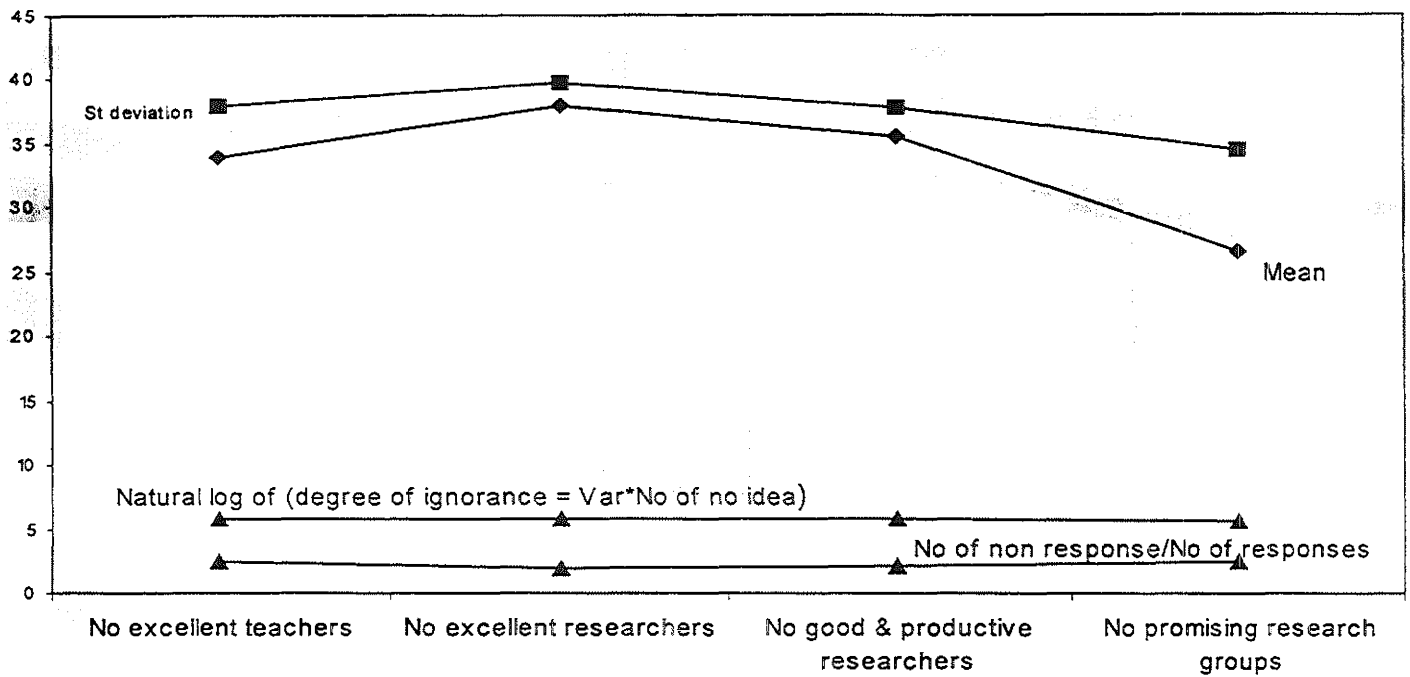
Strength of 2-person group-ties in India



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**

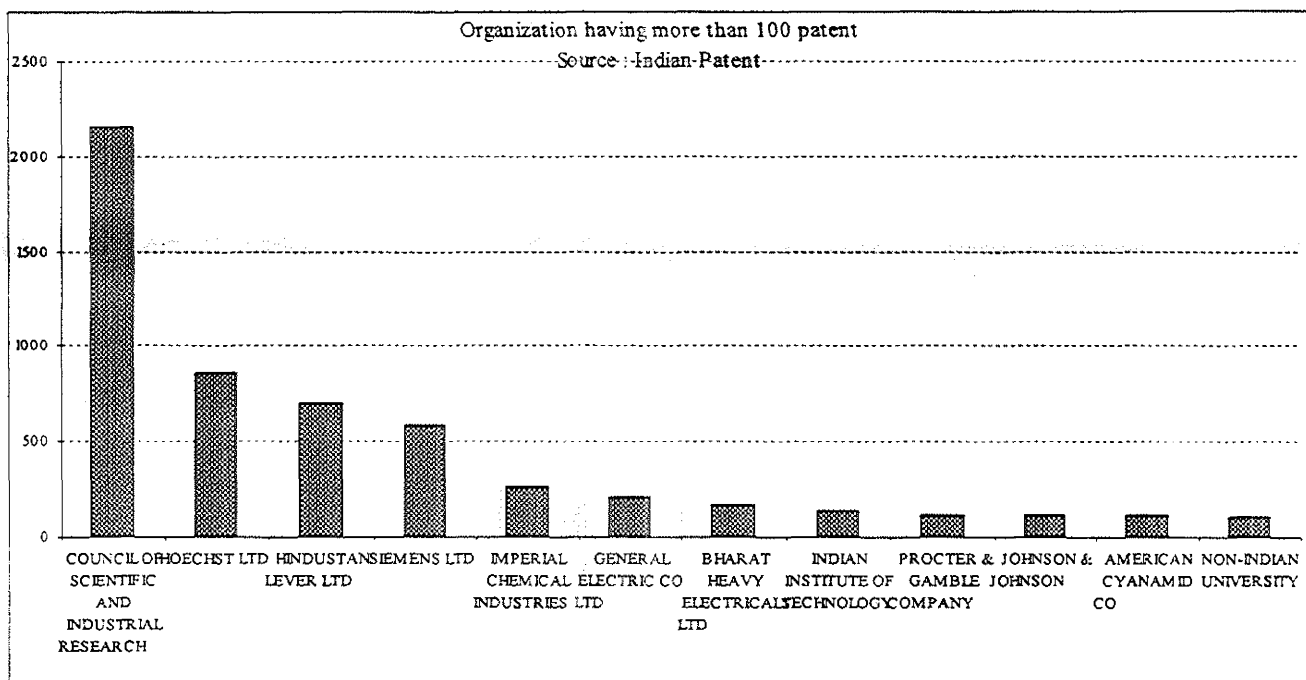
Estimate variations on the strength of national research strength



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.

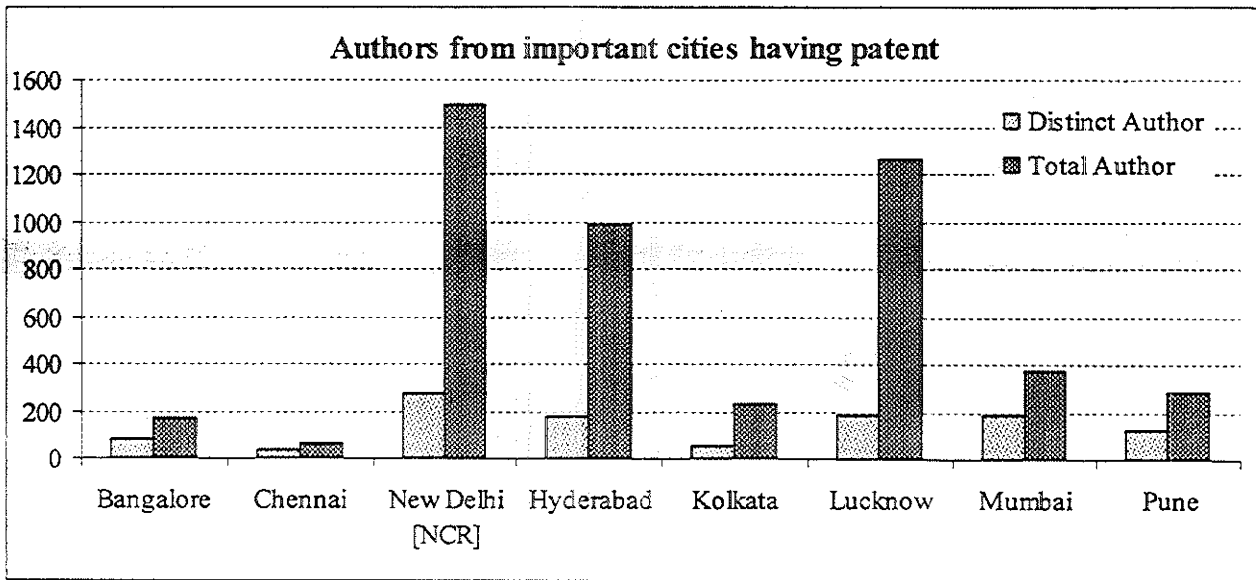
IPR related aspects have been looked at from two sources of data, first the Indian patents and second from US patents. Figure-7 brings out organizations who have been granted more than 100 patents by Indian Patents office.

**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.