CHAPTER SEVEN

RESEARCH ENHANCEMENT

"Research is civilization and determines the economic, social and political development of a nation"

Sir CV Raman, NL
(1888-1970)

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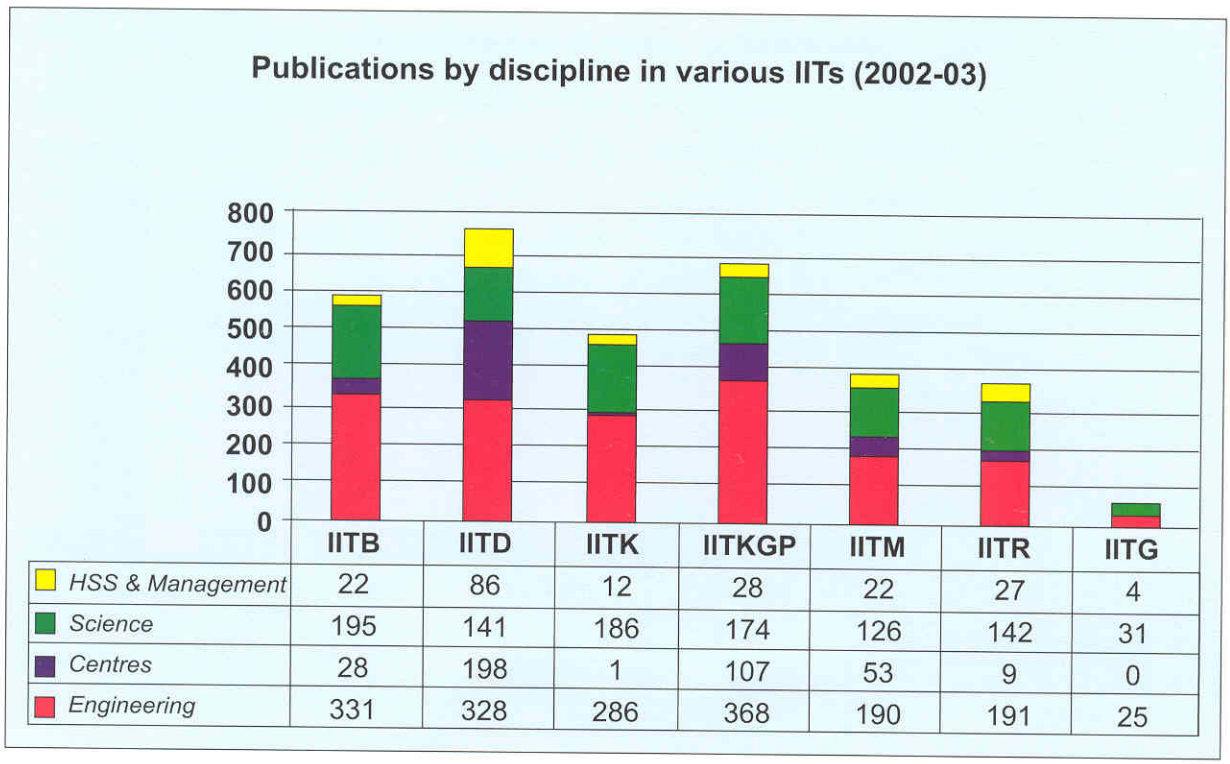
The tangible results of research at the IITs are typically in the form of Ph.D.s (Ph.D. theses), research publications, books, patents (discussed in a separate chapter) and knowledge-intensive products. Other parameters such as Government sponsored research, research grants resulting from the MoUs (alliances) with other institutions, performance of national facilities (located within IITs), and the conferences organized also provide insights into the research intensity of IITs. The presentation of the relevant data will be followed by several recommendations which are aimed at IITs achieving a higher level of research accomplishments.

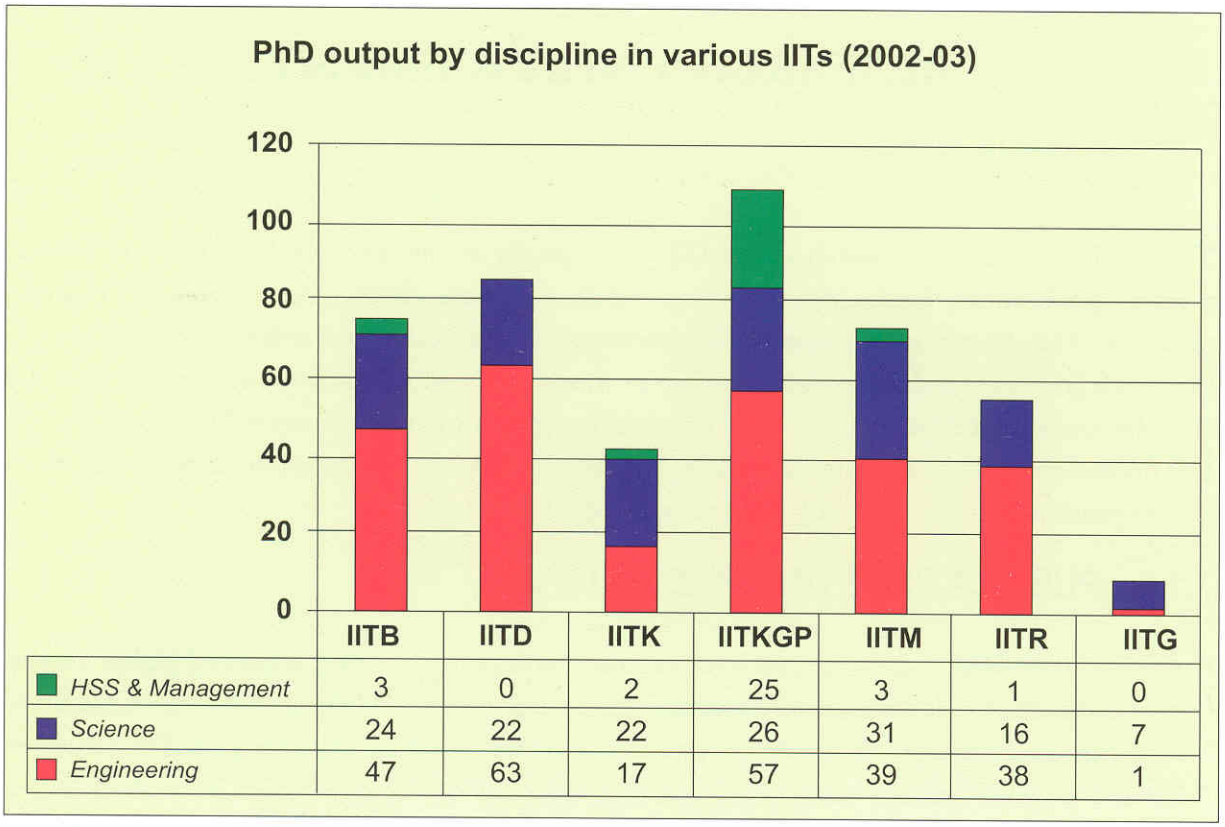
7.1 PUBLICATIONS AND Ph.D. OUTPUT

Figure 7.1 shows that, at an aggregate level, engineering departments have produced higher number of refereed publications than science departments, research centres and departments of Humanities/ Management. However, there are differences across IITs in terms of this break up. The centres of IITD and IITKGP publish more compared to the centres of the other IITs. Though IITK has several centres, the research output of the centres *per se* is not high. This points to probable differences in the role/interpretation of centres among IITs.



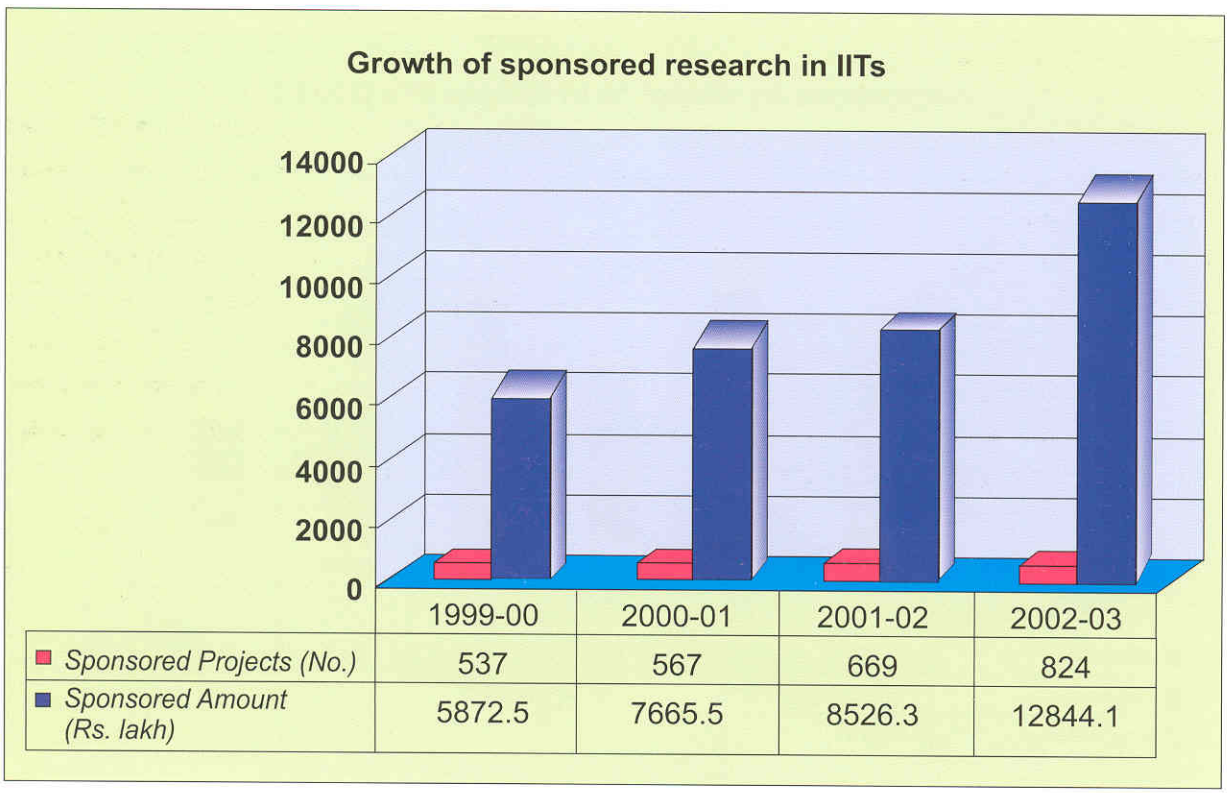
	IITB	IITD	IITK	IITKGP	IITM	IITR	IITG
HSS & Management	22	86	12	28	22	27	4
Science	195	141	186	174	126	142	31
Centres	28	198	1	107	53	9	0
Engineering	331	328	286	368	190	191	25

Figure 7.1: Publications by discipline in various IITs (2002-03)



	IITB	IITD	IITK	IITKGP	IITM	IITR	IITG
HSS & Management	3	0	2	25	3	1	0
Science	24	22	22	26	31	16	7
Engineering	47	63	17	57	39	38	1

Figure 7.2: Ph.D. output by discipline in various IITs (2002-03)



	1999-00	2000-01	2001-02	2002-03
Sponsored Projects (No.)	537	567	669	824
Sponsored Amount (Rs. lakh)	5872.5	7665.5	8526.3	12844.1

Figure 7.3: Growth of sponsored research in IITs

Figure 7.2 shows the Ph.D. output by discipline in the seven IITs.

- At an aggregate level, engineering Ph.D. output exceeds science and HSS output.
- However, IITK and IITG produce higher proportion of science Ph.D.s compared to the other IITs.
- IITKGP output of Ph.D.s in HSS & Management is more compared to the other IITs.

7.2 SPONSORED RESEARCH

The sponsored research in the IITs (mostly Government agency sponsored) has grown at about 40% p.a. over the past four years. The average size of sponsored projects increased from Rs. 10 lakh per project in 1999-00 to about Rs.15 lakh per project in 2002-03 (Figure 7.3).

However, the picture is not consistent across IITs (Figure 7.4).

7.3 INTERACTIONS WITH OTHER INSTITUTIONS

Another key stakeholder group of the IIT system is all the other educational/research institutions. IITs interact with other technological institutions within the country and abroad to exchange the best practices in education and research. These interactions are facilitated through alliances and conferences.

7.3.1 Alliances

Figure 7.5 shows that the number of active MOUs has gone up over the years. National MOUs have risen at a faster rate than the international MOUs. These alliances have yielded sponsored research projects in some cases. A strategy for the MOUs, in particular with eminent universities abroad, has to be thought through. It should be possible for each IIT to build close links with one or two leading universities overseas. The outstanding example of the University of Cambridge partnering with MIT, USA (there are several such partnerships emerging in the world) deserves to be emulated. It should also be possible to build into such alliances Ph.D. programme for students in the two partnering institutions, as is being attempted by the Department of Science and Technology in the Indo-German programme of collaboration in nanoscience and technology.

Table 7.1: Research grants obtained from MOUs

	1999-00	2000-01	2001-02	2002-03
Research grants from International MOUs (Rs. lakh)	558	571	897	667
Research grants from National MOUs (Rs. lakh)	2016	2310	3911	4562

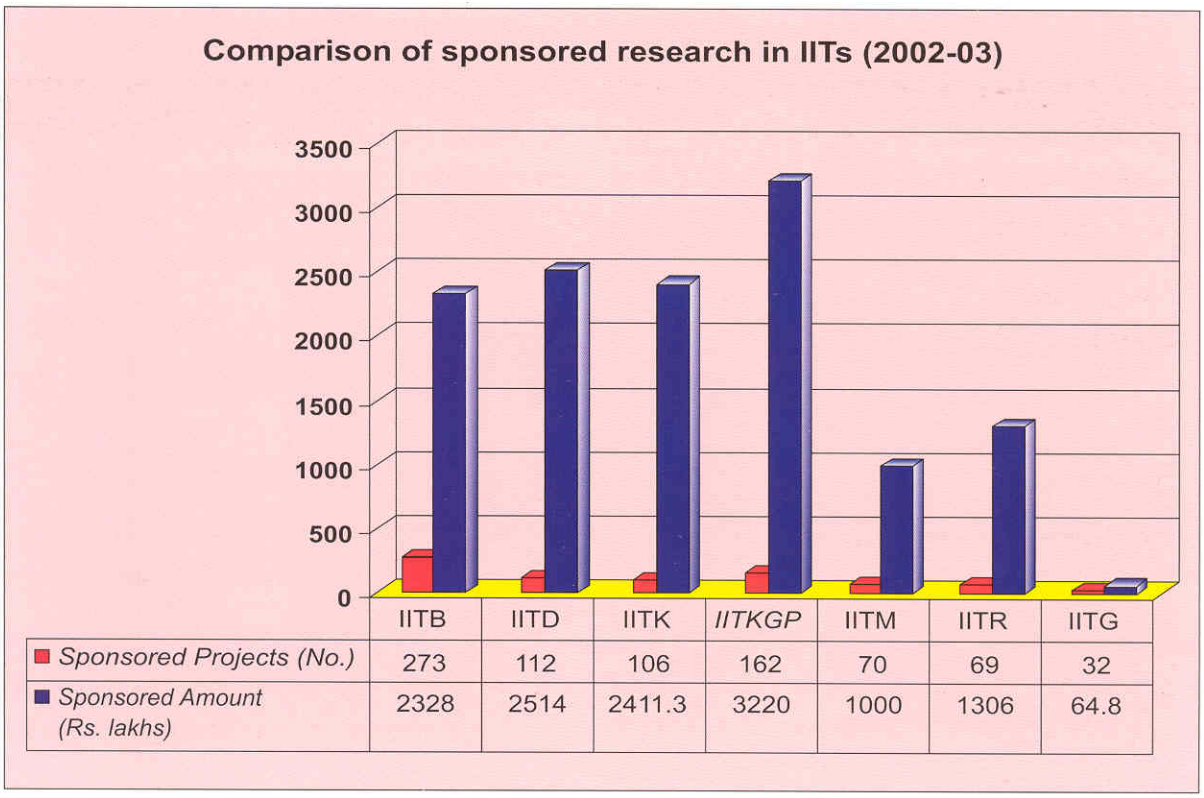
Table 7.1 shows the research grants acquired by IITs through MOUs. It is clear that most of the grants have come from the national MOUs. It implies that sponsored research in IITs may be directed towards national issues. However, the average project size of a national alliance is much lower (Rs. 6-8 lakh per project) than that of the international projects (between Rs. 15-20 lakh per project).

India has chains of national laboratories under various agencies, like CSIR, DRDO and DAE. Research funding is also provided by DST, DAE, DRDO, DOS, CSIR and MCIT *(please see page 151 for expanded form)*. IITs could consider working on developing carefully crafted MOUs with these agencies for undertaking major projects. There is much to be gained in terms of research promotion via alliances with these agencies.

IIT's will also benefit from inter-IIT alliances. Such alliances can be cast between departments and/or between disciplines among a pair or more of the IITs. Once a mechanism is in place for meaningful interfacing between departments/disciplines, cooperative endeavours in research as well as for improvements in curricula can be attempted. Through such inter-IIT collaborative endeavours, synergy and complimentarity in their academic programmes could result. Moreover, duplication of efforts, if any, could be minimised or altogether eliminated.

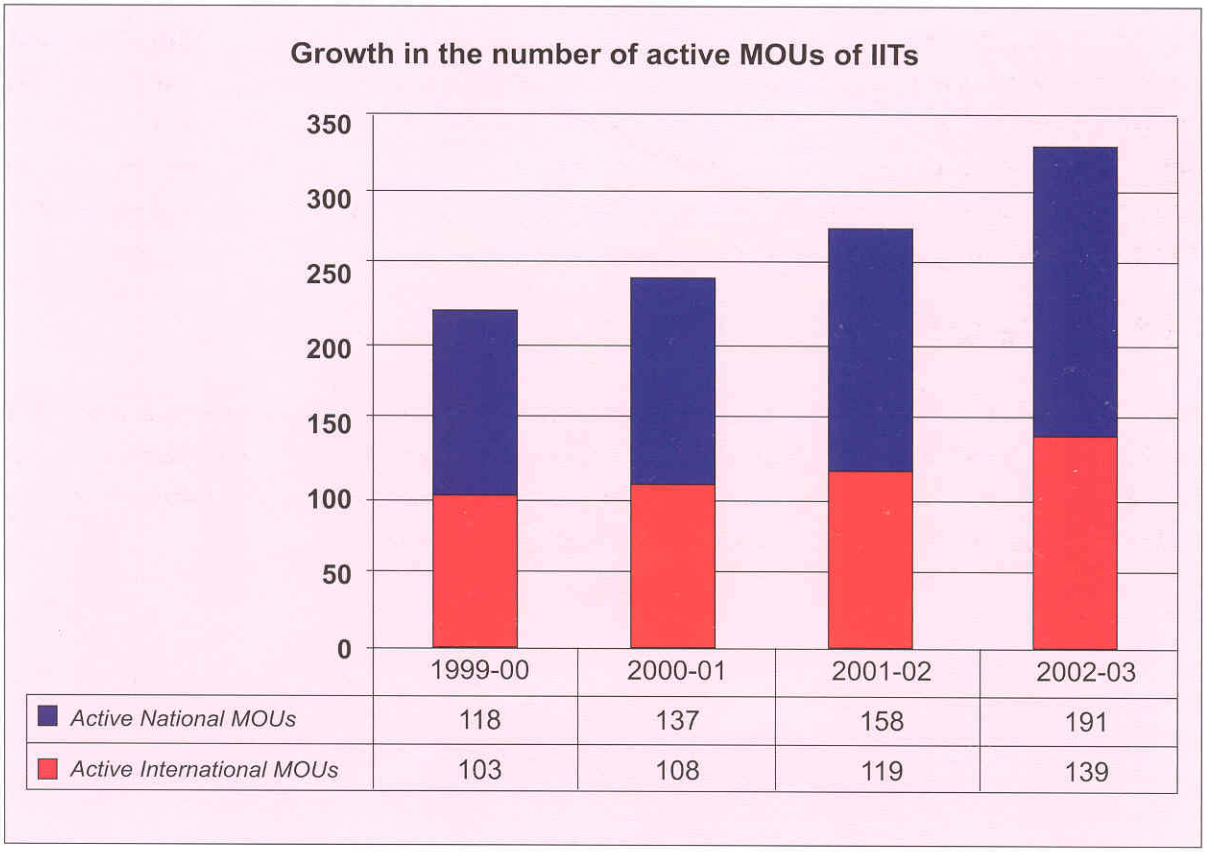
7.3.2 Conferences

Figure 7.6 shows that national conferences dominate the landscape of IITs. This suggests that IITs may be playing a critical role in facilitating knowledge dissemination within the country. However, there is inadequate data to comment on the quality of intellectual debate and networking fostered by these conferences. There is a need to think of appropriate metrics.



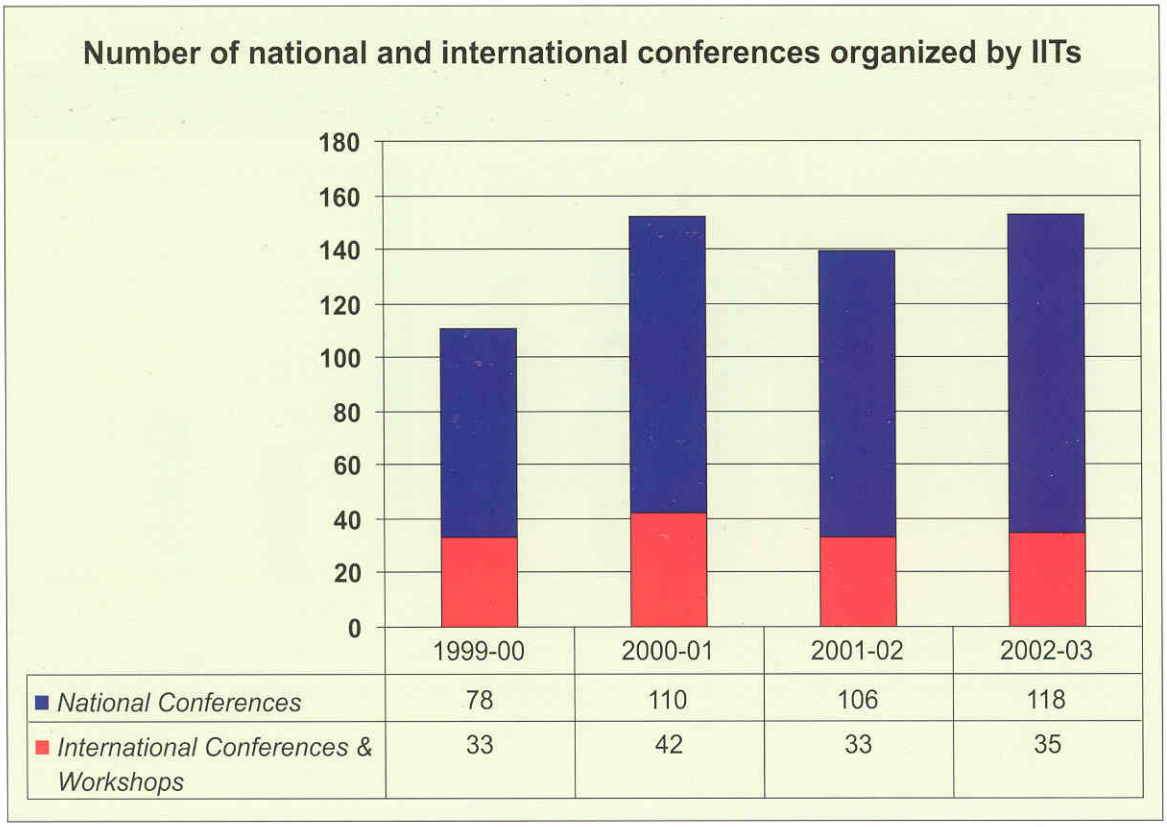
	IITB	IITD	IITK	*IITKGP*	IITM	IITR	IITG
Sponsored Projects (No.)	273	112	106	162	70	69	32
Sponsored Amount (Rs. lakhs)	2328	2514	2411.3	3220	1000	1306	64.8

Figure 7.4: Comparison of sponsored research in IITs (2002-03)



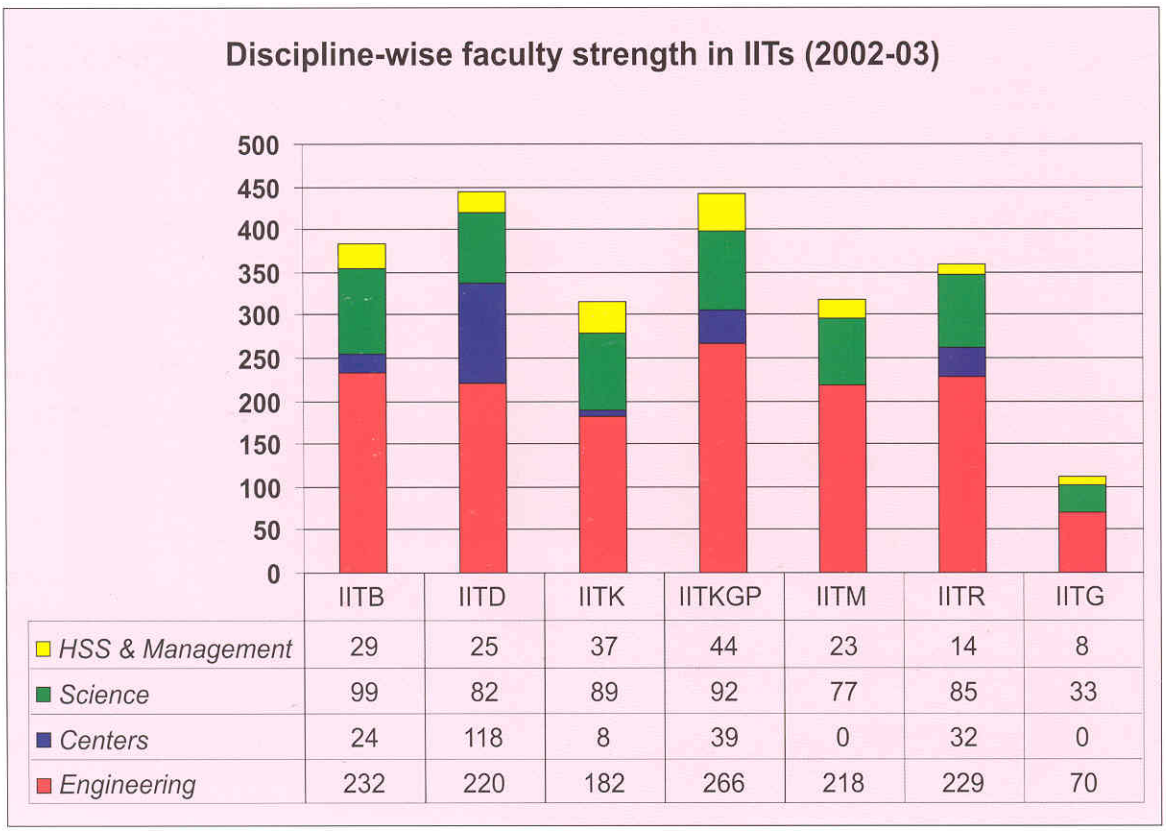
	1999-00	2000-01	2001-02	2002-03
Active National MOUs	118	137	158	191
Active International MOUs	103	108	119	139

Figure 7.5: Growth in the number of active MOUs of IITs



	1999-00	2000-01	2001-02	2002-03
National Conferences	78	110	106	118
International Conferences & Workshops	33	42	33	35

Figure 7.6: Number of national and international conferences organized by IITs



	IITB	IITD	IITK	IITKGP	IITM	IITR	IITG
HSS & Management	29	25	37	44	23	14	8
Science	99	82	89	92	77	85	33
Centers	24	118	8	39	0	32	0
Engineering	232	220	182	266	218	229	70

Figure 7.7: Discipline-wise faculty strength in IITs (2002-03)

Table 7.2: Conferences organized by individual IITs in 2002-03

	IITB	IITD	IITK	IITKGP	IITM	IITR	IITG
National Conferences	12	50	15	25	10	3	3
International Conferences	2	20	3	3	5	–	2

Table 7.2 shows the breakup of conferences by individual IITs. IITD hosts most conferences followed by IITKGP. It may be useful to understand the average number of participants per conference and the conferences per disciplinary area.

7.4 RECOMMENDATIONS

Principally, there are two key groups that can contribute to more and better research output from the IITs. These are A) the Faculty Community and B) the Ph.D. Student Community. These two groups are analysed further to identify possible ways of enhancing their performance. Accordingly, recommendations are made separately in respect of faculty and Ph.D. students.

7.4.1 Faculty Performance

The discipline-wise faculty strength in the 7 IITs is given in Figure 7.7.

- It is seen that the ratio of Science to Engineering faculty is 0.36 $\pm$ 0.1 in IITD, IITKGP, IITM and IITR while it is 0.48 $\pm$ 0.1 for IITB, IITG and IITK. The proportion of Science faculty is highest in IITK.

- While the ratio of HSS & Management to Engineering faculty is generally 0.11, it is 0.17 in IITKGP and 0.20 in IITK. The HSS/Management faculty is weakest in IITM, among the older IITs.

- The number of faculty members associated with the Centers varies widely. IITM & IITG have no faculty in the Centers. IITD has as much as 26.5% faculty in the Centers. The other IITs have between 0-9% of the total Faculty in the Centers.

While recruiting new faculty to fill in the substantial number of vacant positions, IITs may consider the balance between science, engineering and interdisciplinary faculty strength. Several frontier research areas fall into the category of science-intensive engineering fields. It has also been noticed that outstanding science capability has stimulated even more outstanding engineering research and development. It is, therefore, imperative that IITs look at the evolving situation worldwide in this respect, besides the developing needs in our country and accordingly plan fresh faculty induction.

At the present time, there is no system of offering rewards to outstanding performers among the faculty. IITs, like what the world's leading academic institutions have done, would do well to see what strategies will bring down the proportion of faculty members who are performing below the threshold of output set by the authorities. (There is one university, Harvard, in the World which claims that the number of Professors performing below international average is NIL!). **As an immediate measure, IITs should introduce a system of providing financial incentives to outstanding performers among the faculty which is further explained below.**

(i) Outstanding performance may be adjudged in terms of the following parameters;

a. Ph.D.'s produced by the Faculty member;

b. Sponsored projects earned by the Faculty member including their financial outlay;

c. Publications in citation-indexed journals;

d. Feedback on teaching performance from students and the Director and

e. Major awards like Fellowship of respected Academies, Bhatnagar Prize, International Awards and the like;

Let us consider (a) and (c) of the above, namely Ph.D.s produced and publications, since IITs need to expand their research base and gain prominence like the world's top ranking research universities. A high stature in research attracts high calibre (potential and demonstrated) researchers. This will enhance the quantum and quality of Ph.D.s and research publications. The Committee has the impression that this is indeed happening. This visible trend deserves to be encouraged, supported and built up. The IIT authorities have together the responsibility to ensure that the IIT system as a whole develops into a powerhouse of research and thereby makes an impact on the national and international plane. The ability of IITs to serve industry also stems from their research involvements.

- **At the present time, the IIT Ph.D. output works out to less than 0.2 per faculty. The BOG could set an appropriate target for each of the IITs, say to raise this by a factor of two (for the leading academic institutions in the world, the Ph.D. output would be 1 or more per faculty).**

  Just as a target like doubling the Ph.D. outturn may be a good target in the immediate term, so also doubling the number of journal publications would be a desirable goal.

- In regard to publications, presently the IITs do not report on citations (ie the number of references made to the IIT journal papers in the citation-indexed journals). If this is done, a useful parameter to assess the output, that is internationally used, is

$$\sqrt{\text{No. of publications per faculty per year X No. of citations per faculty per year}}$$

For the world's reputed universities, the index ranges from 5 to 10. The CSIR in our country have adopted the average impact factor as a measure of the basic research performance of their laboratories. **An average impact factor above 2.5 would place an institute high on the list of leading research institutions** in the country. IITs could adopt both the metrics, the first for comparison on an international scale (as the parameter is so accepted and has been indicated for top universities) and the second for a comparative assessment within the country (this parameter can be used for international comparison as well). Quantitative measures, like the ones indicated, help comparison with the best on a common basis. This is not to take the merit away from a few publications which are pathbreaking. They deserve always to be specially mentioned and recognised and this cannot be overemphasized.

- An assessment based on the above parameters i.e. Ph.D. per faculty and the publication index may be made by the HR Unit and placed before the Committee of Deans along with the material pertaining to (b) (d) and (e). The recommendations of the Dean's Committee are to be scrutinised and finalised by the Director who, in turn, will place the case of outstanding performers before the Board of Governors.

- The above suggestions have been made in order to have an accepted quantitative metric with which each BOG may look at their IIT research output in relation to the other IITs. If each IIT declares (as CSIR laboratories have been doing with positive results) one or both the indices, one can expect a healthy competition among the seven IITs. Each IIT would surely strive to come out better and better, in such a comparison, year after year.

(ii) The Committee suggests that the proceeds of the corpus amount with each of the IITs may be used for rewarding outstanding performances. Selection of outstanding performers and the quantum of the financial reward in a given year may be decided by the Board of Governors. If this were to become successful in yielding the desired results, the alumni, who have been generous all along, will no doubt gladly add to the corpus substantially to cater specifically for the purpose of rewarding outstanding performers.

(iii) The Committee further recommends that the Government institutes a new cadre of Distinguished Research Professors (DRP). Only Professors with an excellent track record of research would be eligible for DRPs. They will have no administrative responsibility and will devote their time wholly to teaching and research. They will carry higher emoluments, the salary of Secretary to Government of India. 50 such positions may be instituted for the 7 IITs as a whole. The proposed PAN-IIT Synergy Committee may recommend the basis on which the number of such positions is allocated to each IIT. These new positions could also be utilised to freshly induct star faculty for carrying out advanced research in the emerging interdisciplinary areas. Based on their present strengths, each IIT could discuss and determine which of the new frontiers would be within their grasp and accordingly propose additions to their present strength. The final selection may be made by a Special Committee of eminent experts to be recommended by the BOG for each IIT. Both internal and external candidates would be eligible for these positions. A special research grant of upto Rs.50 lakh, based on their research proposals, for a period of 5 years should be made available to each of the Distinguished Research Professors.

(iv) Similarly, each IIT should be supported for inviting outstanding scientists from anywhere, within and outside India. Each such visiting outstanding scientist could spend one year. Their emoluments (stipend) should be equivalent to that of a Professor, besides free furnished accommodation. There should also be a provision for a research grant to go with the stipend. A model for this is available in some advanced countries and may be studied for details.

(v) The Committee also recommends to the Government that each of the IITs be provided annually a sum of Rs. 2 crore for the following activities for which no financial resource is readily available:

- A faculty member could spend up to 3 months, and successively for upto 3 years, depending on the progress registered each year, at any leading institution abroad for joint work with a collaborating scientist/academic. Travel as well as *per diem* to be met out of the above grant. Decision on selection of faculty members is to be made by the Chairman, BOG in consultation with the Director.

- This grant can also be utilised to meet the cost of travel and stay up to 6 months by a Ph.D. scholar. The selection of the scholars is to be made by the Director in consultation with the Deans.

- Guidelines for utilisation of the needed amounts may be vetted and approved by the BOG.

(vi) As per the 2002 DST publication entitled "R&D Statistics", the country spent Rs.13,000 crore in 1999 on R&D. Less than 3% of this amount (i.e. about Rs.375 crore) was made available to higher education institutions i.e. Central, State, Deemed-to-be Universities, the IITs, the RECs (which are now NITs) etc. totaling as many as 300 entities. The national R&D expenditure currently is about Rs.25,000 crore. In relation to this amount, the quantum from the sponsored projects in all of the IITs put together in 2003 is only Rs.128 crore (most but not all of which is from governmental agencies), which amounts to less than 0.6% of the national R&D expenditure.

There has to be a radical improvement in the R&D funding of the IITs, considering that they account for about 60% of all Ph.D.s produced in engineering and that the Government has made substantial investment in the IIT infrastructure and that the IITs have highly qualified faculty. In this connection, each IIT, based on their respective strengths, should draw up a few grand challenge projects in interdisciplinary frontier areas and seek funding from one or the other science agency.

It has to be noted that India continues to be a target country for denial of certain technologies. Consequently, Indian experts will be barred from any manner of cooperation, including academic, with the advanced countries. IITs would do well to include such topics in their research portfolio. Funding for such projects can be expected to be forthcoming in a large measure. IIT Council could encourage IITs to identify a few PAN-IIT mega projects and thereby also promote inter-IIT collaboration.

(vii) It may also be noted that each IIT received Rs.100 to 120 crore per annum from the MHRD as non-plan and plan grants, but they do not have an annual R&D fund. Each IIT should, therefore, be encouraged to set up a Research Fund in their respective institutes. This is an urgent need. If each IIT adds annually up to an amount of Rs.10 crore from its own resources (earnings and donations) to the new Research Fund, the MHRD should match this amount with an annual allocation of Rs.10 crore. An annual research fund of Rs.20 crore, to start with, will empower the IITs to take up research projects autonomously without having to chase the funding agencies. Ready and speedy funding should make a big difference to the IIT research endeavour. Utilisation of the research fund by the faculty and the departments/centres should be determined via a competitive process. The Directors could set up a 3 - 4 member (one of which should be an outside expert) expert committee to evaluate the faculty research proposals to ensure judicious allocation as well as for the purpose of monitoring its utilisation.

7.4.2 Ph.D. Programmes

It is recognised the world over that the research output of an academic institution is significantly dependent on the number, quality and dedication of its Ph.D. research scholars who constitute the graduate research school. It is, therefore, important to review this aspect and propose ways to better the situation.

The Nayudamma IIT Review Committee submitted their report in the year 1986. This report contains statistics for the year 1984. The faculty strength in the then 5 IITs and the number of Ph.D.s produced by them in 1984 were respectively 1795 and 295. This works out to an output of 0.16 Ph.D. per faculty. In the year 2003, the faculty strength in the 7 IITs was 2375 and they together produced 444 Ph.D.s for an output per faculty of about 0.19 per faculty. Clearly, the growth in the Ph.D. output of the IITs in the last two decades has not been significant, notwithstanding the considerable expansion that has occurred during the period since the Nayudamma Review Committee. The small quantum of growth in the Ph.D. output may actually be a reflection of the engineering research scenario in the country. Ph.D. has not been hitherto a serious career goal of the engineering graduates. Securing employment immediately after the B.Tech. degree has almost become a cultural feature. Moreover, job opportunities for engineering graduates in general, and those of the IITs in particular, have been rising especially since the boom in the IT sector. The troubling trend has been that a candidate takes to Ph.D. only when other professional career prospects have been denied to him.

The above situation fortunately has changed in recent years. IITs have been able to take in far more number of Ph.D. students in the last 3 to 4 years (their strength in the IITs has gone up by more than 25% since 1995-2000). This trend must be strengthened. However, IITs too face what is a national problem, which is that highly talented youngsters are not attracted to research in science and engineering. A solution to this problem could lie in a new mechanism of career assurance. **The Committee would urge the Government seriously to consider this concept of assured career for promising researchers.**

In the quality improvement programme (QIP), MHRD supports and enables teachers in various engineering colleges including NITs to undertake Ph.D. research in the IITs. Between 1999-2001, under the QIP, 240 candidates obtained Ph.D. and 161 obtained M.Tech. degree from all the IITs put together. This has been a successful way of enhancing Ph.D. output as the teachers are invariably highly motivated researchers. The Committee recommends further enlargement of the QIP.

Although the Ph.D. intake has and can be increased substantially through direct intake or via the QIP, it is not clear if the calibre of those admitted is high enough. As of now, the IITs do not seem to have been able to attract their own undergraduate students to stay on for post-graduate and Ph.D. programmes. Now is the opportune time to take a close look at the quality of the intake as well as to render the Ph.D. degree an attractive career proposition for the bright IIT and other engineering graduates. Just as the JEE has proved to be an effective filter for screening in meritorious undergraduate students, it is important to institute a method for selecting the best possible Ph.D. scholars.

It is also necessary to introduce a structured pre - Ph.D. programme, not only to test their performance in selected courses related to their Ph.D. work but also to test their potential for original research. Clearing the pre - Ph.D. requirement should be made mandatory and, if a candidate is unable to do so in two chances, he should be advised to take to an alternative career-path. There is a system of a pre - Ph.D. process in the IITs but this needs to be examined afresh for making it more rigorous and for tightening it time-wise. We have the following further suggestions to improve doctoral and post-doctoral research at the IITs.

(i) It is recommended that MHRD institute 100 high value research fellowships. These Fellowships may be termed **IIT Golden Jubilee Research Fellowships and carry a monthly stipend of Rs. 20,000 (Rupees twenty thousand).** This works out to about 15 such fellowships in each of the 7 IITs.

The selection of the Golden Jubilee Fellows must be based on an interview to be conducted by a Committee to be set up by the IIT Directors for each of their institutes. The top rankers in B.Tech. and M.Tech. streams of the IITs, based on their performance at the B.Tech. final (or pre-final) and M.Tech. final (or prefinal) examinations, should be selected for the interview. With the introduction of a research project at the 2nd year stage and the one year project in the 2-year M.Tech. programme, the performance in these projects should receive due weightage in the final selection. For candidates from outside the IIT system, an entrance test may be conducted by each of the IITs, the best of whom are interviewed along with the selected toppers from the IITs, for final selection of the Golden Jubilee Fellows.

(ii) There is considerable merit in having a system whereby a candidate by the age of 25 years should be able to achieve a sound Ph.D. degree. The success of such a system will eliminate the deterrent that youngsters see in having to spend prolonged years for them to go through a Ph.D. programme. Encouraging the B.Tech. top rankers for admission to the Ph.D. programme provides the means for the brightest to get their Ph.D. by the age of 25. The Ph.D. research

monitoring and evaluation processes (including the time taken by the external examiners) should be rigorously managed by the Deans and Heads concerned to ensure that the duration that a meritorious scholar spends for his Ph.D. is not unduly stretched.

(iii) There is an unhealthy tendency in some of the Ph.D. research scholars to continue to stay on beyond 5 - years. This should be strongly curbed.

(iv) There is no system of Post-doctoral Associates in the IITs. Just as the Post-doctoral Associates have proved to be a useful cadre in the academic institutions elsewhere in the world, there is a need to have a Post-doctoral community in the IITs. The stipend for the Post-doctoral fellowship should be Rs. 25,000 and made tenable for a duration of 3 years with an annual increment of Rs. 1,000. Each IIT should have at least 25 such Post-doctoral Research Associates. These could also be assigned some teaching, laboratory and tutorial responsibilities, all of which put together not to exceed about 8 hours a week with the rest of the time available for advancing research in the respective fields.

(v) Currently, IITs have not been able to entertain scholars from overseas for their Ph.D. or M.Tech. programmes. IITs may be permitted to publicise abroad for attracting outstanding graduates for their M.Tech. and Ph.D. programmes. BOG's may set an upper limit for the number of such foreign students. This measure may prove to be a new way of augmenting the strength of high calibre students at the post-graduate and doctoral levels. Similarly post-doctoral associateships may also be made available to Ph.D.s from outside India to seek a place in the IITs. (In this connection, it needs to be stressed that foreign students are often deterred by the unfamiliar food available on campuses. Although a minor point, this aspect needs to be attended to while encouraging foreigners for Ph.D. as well as postdoctoral research at the IITs).

(vi) An excellent beginning has been made in formally interacting with overseas institutions and research leaders, on a mutual basis, in inter-country projects. The Department of Science and Technology, Government of India and the corresponding agency in Germany have agreed, through an MoU, on collaborative research in the area of nanotechnology. As part of the agreed arrangement, young scientists can register for Ph.D. in their respective countries. In advancing their research effort, they can spend a reasonable period in the other country (i.e. Indians in Germany and *vice-versa*). This enables access to advanced facilities and experienced research supervision on either side while providing for profitable collaboration at the student-and the supervisor-levels. This scheme deserves to be adopted on a wider scale. Figure 7.5 shows that, between the IITs, as many as 139 international MoUs are active. These MoUs may be revisited to examine if room for cooperative Ph.D. research can be provided in any of them.

(vii) Elsewhere (Chapter 8), a suggestion to introduce a credit-based research project from the 2nd year B.Tech. stage for the undergraduates has been made. The Departments may plan these B.Tech. projects in a way as to be part of the Ph.D. and post-doctoral research activities in the Department. This principle quite well applies to the one year M.Tech. thesis-based research

projects. The benefit of such a strategy is that the Ph.D. or the Post Doctoral scholar concerned can act as a mentor to the B.Tech. and M.Tech. students for their research projects.

(viii) There is a need to promote a wider employment base within the country, for candidates trained at the level of Ph.D. and experienced in post-doctoral research. **Though India boasts of a huge stock of S & T personnel, the number of researchers employed in the country is only about 160,000, a majority of whom are in the government laboratories.** As per the IMD World Competitiveness Year book 2004, total R&D personnel in business per 1000 people in India is 0.07 as against 0.35 in China, 0.38 in Brazil, 2.5 in UK, 3.7 in Germany, 4.4 in Japan and 7.3 in USA. The pharma and chemical industries have, in recent years, recruited doctorates for their R&D and the benefits are visible. The Committee is of the view that a new measure is required to expand the employment opportunities and recommends offering a tax-incentive. **We propose a tax-incentive directed to engaging R&D personnel by the industry in addition to an omnibus weighted tax deduction now available to outright donations for research in the industry. Once the principle is accepted, the details can be worked out.**

7.4.3. National Facilities

Figure 7.8 depicts national facilities allotted to IITs over the past 40 years (please refer to Table 3.1 for a list of these national facilities). It is clear that the frequency of allocation of national facilities to IITs has increased in the last 8-10 years.

A glance at the usage of national facilities points to a very positive feature (Figure 7.9). The aggregate performance of all the national facilities in IITs between 1999-2003 shows a strong positive correlation between the total annual expenditure (not counting the capital cost) and the percentage expenditure recovered (although with a limited data set). This builds a case for creation of additional national facilities in IITs, which will certainly help attract good quality researchers. The transformation in the research ambience in an academic institution brought about by the installation of a major experimental facility should be seen to be believed. For instance, a major computing facility came up in IIT Kanpur during this institute's early period and what an impact this has had on the computing culture not only in IITK but throughout the country! Advanced research tools have become even more expensive and some of these, like particle accelerators or synchrotron sources, can only be afforded by countries coming together. In this scenario, the major science agencies in the country can be approached by the IITs **jointly** to elicit funding for such major tools as high resolution microscopes and high performance computing facilities. It is a proven fact that ready availability of well-maintained research facilities have the power of attracting the talented to join the faculty, bright students to get into the system for research and eminent visitors to come and collaborate.

Microelectronics research and development did not take off in the country not because of lack of capability, but because of non-availability of foundries for access by the educational system. The same danger looms large in the emerging area of nanoelectronics for India to acquire nanodevice capabilities if institutions like the IITs cannot access nanofoundries. The same is true of electronic network research. Lack of dedicated networks has inhibited progress.

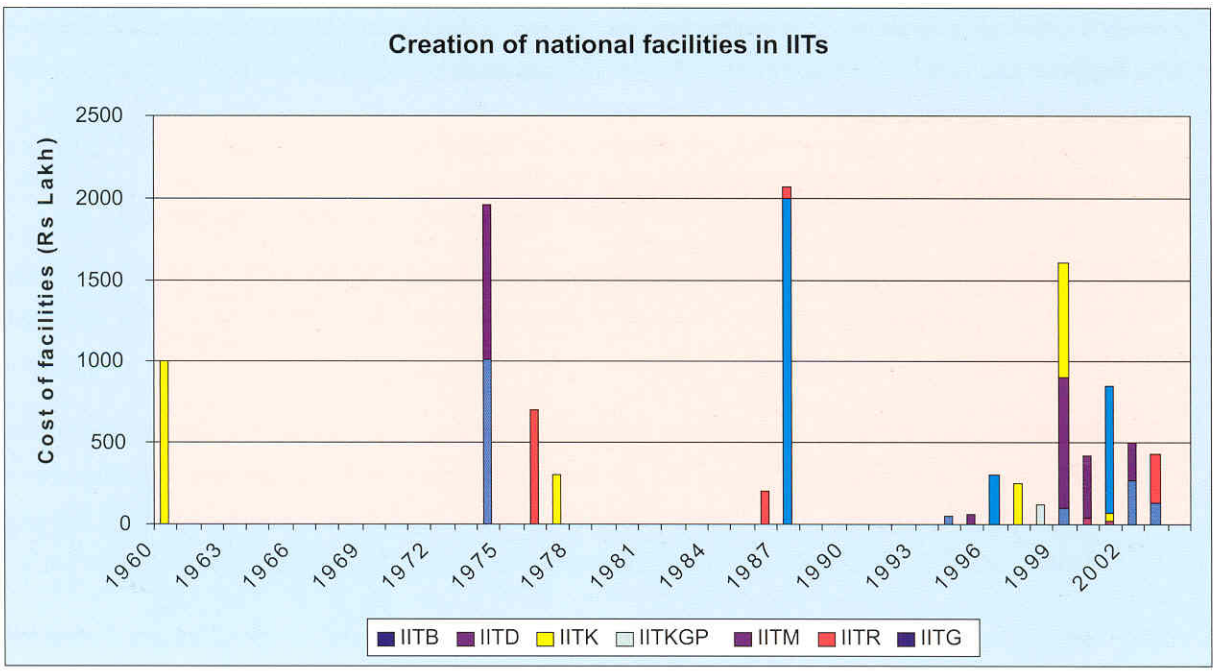


Figure 7.8: Creation of national facilities in IITs

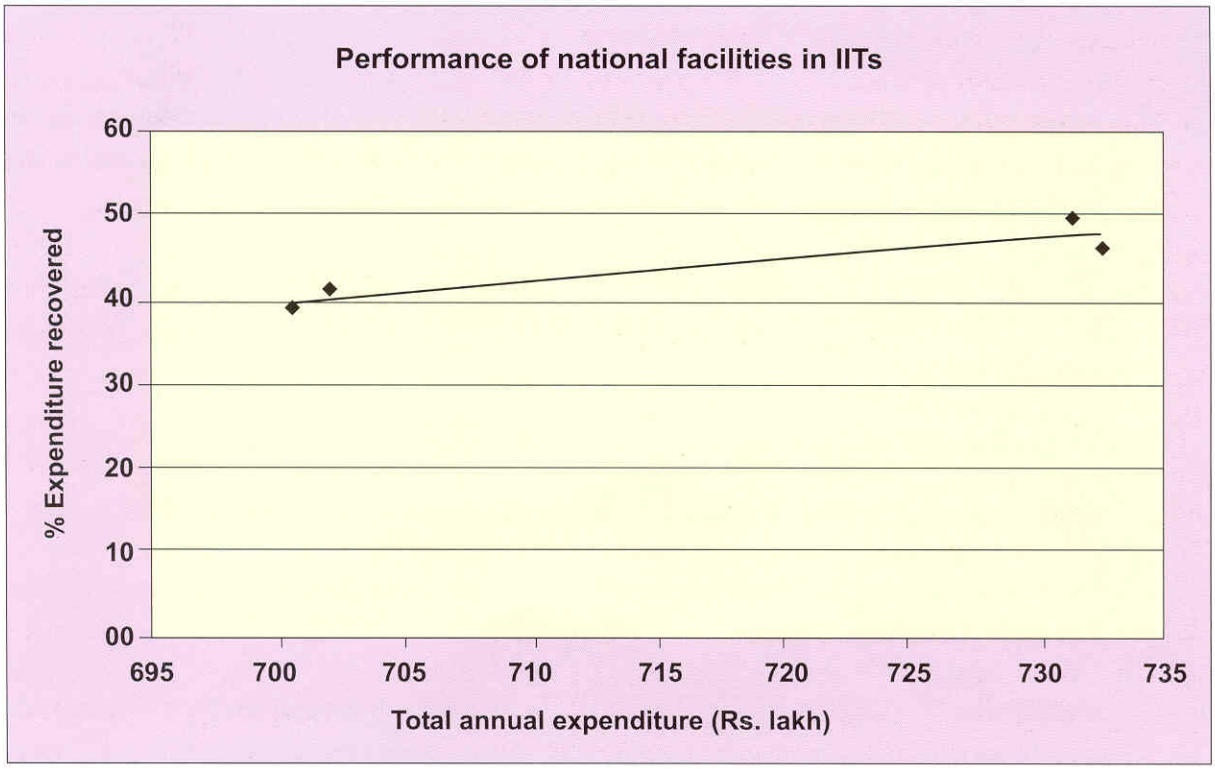


Figure 7.9: Performance of national facilities in IITs

Acquisition of major facilities, instituting systems for their management and creating a culture of shared facilities can surely be expected to raise the IIT research base and have a substantially salutary effect on the IIT research output.

7.5 SUMMARY OF RECOMMENDATIONS

1. While Section 7.4 contains the full set of recommendations, some are mentioned below. These are related to faculty (a and b), Ph.D. and Post-doctoral scholars (c to j) and research support (k to o).

   (a) Providing incentives to outstanding performers in research among the faculty members, with BOG determining criteria for performance evaluation, instituting Distinguished Research Professors and providing for financial support for adequate number of Visiting Professors and Visiting Outstanding Scientists from anywhere, within and outside India.

   (b) Budget for allowing faculty members (and their research scholars) to spend longer durations, up to 3 months, and successively for 3 years if necessary, for collaborative work abroad.

   (c) Efficient screening procedures for selecting Ph.D. students and rigorous pre-Ph.D. programme.

   (d) Assuring career to highly talented youngsters who choose to pursue research in the IITs. This will require a new mechanism to be considered by the Government.

   (e) Instituting, for 7 IITs put together, 100 Golden Jubilee Research Fellowships with a monthly stipend of Rs. 20,000/-.

   (f) Every effort to enable a bright candidate to complete Ph.D. degree requirements by the age of 25 (possible if bright B.Tech.s are taken into the Ph.D. programme). To enable this, introduce research project at the 2nd year stage for the B.Tech.s.

   (g) Build into alliances with foreign institutions a provision for Ph.D. work to be carried out as part of the collaborative project (e.g., DST's Indo-German Co-operative Project on nanotechnology).

   (h) Expanding QIP and ensuring quality at the same time.

   (i) Instituting Post-Doctoral Fellowships, 25 for each IIT (for all disciplines put together).

   (j) Permitting and attracting students for Ph.D. research from abroad, also as Post-Doctoral Research Associates.

   (k) Budget allocation separately for Research. IITs to use Rs.10 crore from their earnings and donations which is to be matched by MHRD with an equivalent allocation of Rs.10 crore exclusively for research.

(l) IITs to work out alliances with national laboratories and science funding agencies for research support.

(m) Identifying a few PAN-IIT grand challenge projects and promoting inter-IIT collaboration.

(n) Bid for more national experimental facilities to be installed in the IITs.

(o) Tax incentives to be provided to the Industry if they hire Ph.D. and research-trained post graduates.