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# Ranking of Indian Institutions Contributing to Computer Science Research, 1999-2008

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**ABSTRACT**

The present study undertakes the ranking of the most productive Indian institutions, viz., institutes of national importance, universities/ deemed universities, industrial enterprises, research institutes, Indian Institute(s) of Information Technology (IIIT(s)), select top engineering colleges, and regional engineering colleges (RECs)/National Institutes of Technology (NITs) in computer science research for their research output published during 1999-2008. The publications output of these productive institutions is judged on the basis of various quantitative indicators, such as the total number of raw papers and international collaborative papers and qualitative indicators, such as the average number of citations per paper and *h*-index value, and also in terms of a new composite indicator, which combines quantitative and qualitative aspects.

**Keywords:** Computer science, institutions, India, scientometrics, *h*-index, *p*-index

## 1. INTRODUCTION

Broadly, the term information technology (IT), as is now understood, refers to the computer and communication technology used to acquire, store, organise, manipulate, transport, and exchange information. The definition includes computer hardware and software, as well as telecommunication devices and computer-based networks that connect them. The IT as defined by the Information Technology Association of America (ITAA) is 'the study, design, development, implementation, support or management of computer-based systems, particular software applications and hardware'[1].

The information and communication technology (ICT) has been considered as one of the most important instrument in bringing about a wide ranging socio-economic transformations in India and other developing countries in 21st century. Many governments view the IT sector as an important engine of growth and taking measures to stimulate the sector output as a means of accelerating economic growth. The ICT sector in India spreads over both organised and unorganised segments of manufacturing and service sector. According to Department of IT of the Ministry of Communications and IT, the ICT sector is a fast growing sector of Indian industry, with a recorded production of Rs 1182.9 billion during 2003-04, which was estimated to have reached Rs 3682.2 billion during 2008-09, recording a growth of more than three tines during the last five years.

The software industry, which was worth Rs 744.9 billion in 2003-04 was estimated to achieve a production of Rs 2735.3 billion during 2008-09. The software exports have risen from US $ 17.7 billion in 2004-05 to an estimated figure of US $ 46.3 billion in 2008-09.The ICT sector GDP has increased to Rs 2530 billion in 2007-08 from Rs 656 billion in 2000-01, with a CAGR of 21.3 per cent. Within ICT sector, computer-related services grew at a rate of 27.23 per cent per annum, in contrast to manufacturing sector growing at 11.4 per cent per annum during 2000-01 and 2007-08. The share of ICT services sector to total Indian GDP was 5.52 per cent during 2007-08, which was only 3.05 per cent during 2000-01. The share of ICT manufacturing sector remained more or less constant with about 0.35 per cent share to GDP 2000-01 to 2007-08[2].

The education and training institutions in the field of computer science and technology may be grouped into formal and informal sector. The formal sector comprises institutions within the university system (university departments of computer science and colleges affiliated

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to universities), regional engineering colleges (RECs)/ national institutes of technology (NITs), and institutes of national importance (seven IITs; IISc, Bengaluru; and ISI, Kolkata). This sector also covers the institutions outside the university system, viz., training institutions recognised by the All India Council for Technical Education (AICTE), including the newly established Indian Institute of Information Technology (IIITs) in several states, and the DOEACC accredited training institutes. All these institutions belong to the formal sector in the sense that these all come under the regularity authority of the AICTE. These offer programmes at various hierarchical levels-Certificate, diploma, post-diploma, graduation, post-graduation, and doctorate level.

Some sort of equivalence has been established between the courses offered by the university system and those by the non-university system. For example, the DOEACC accredited 'B' level award is treated equivalent to Master of Computer Application (MCA) degree. The informal sector consists of a large number of private enterprises spread across the country, often refereed as 'training vendors', which offer a perplexity variety of courses. These include several organisations (more than 1500 centres), including NIIT and APTEC (both with more than 5000 centres), ECIL, ET&T, etc. These offer variety of short-term and long-term courses (ranging from 1 month to 3 years) in developer tools, RDBMS, web and internet, e-commerce, multimedia, programmes in IBM mainframes, ERP And AS/400, etc. and industry-certified courses of Global Infotech majors including Microsoft, Oracle, Cisco, IBM, etc. Some of the private vendors offer long-term degree-like programs and often collaborating with foreign universities to award degrees[3-5].

A large number of institutes from academic sector, R&D sector (government-sponsored) and private sector (industry-sponsored) involved in computer science research in India. These organisations are involved in a wide breadth of research problems under all major areas of computer science. Besides spending a considerable amount of money on infrastructure development and R&D activities on their own, these organisations are also getting enormous funds by way of extramural support from several Indian research agencies.

Computer science research in India is funded and promoted by several agencies-e.g., the Ministry of Human Resource Development (MHRD), AICTE, and University Grants Commission (UGC) primarily fund research in education sector, including in computer science. In addition, agencies and departments such as Department of Information Technology, Ministry of Communication & IT; Department of Electronics, Defence Research & Development Organisation; Department of Atomic Energy; Department of Space; Department of Science and Technology; and Council of Scientific & Industrial Research fund research as well as conduct research with institutions working in their areas to support their own research objectives. In addition, foreign and Indian firms support research projects in computer science in Indian academic and research institutions[6]

## 2. METHODOLOGY AND DATABASE

A total of 83 Indian institutions with comparative higher output of publications in computer science during 10 years (1999 to 2008) were identified. These 83 institutions had each published 35 or more papers during this period, as per the publication data downloaded from the Scopus, an international multidisciplinary bibliographical database. Together, they contributed 14375 papers, constituting 90.27 per cent papers to the total cumulative research output of India in computer science during 1999-2008.

The citations (c) received by papers of these institutes are considered for first three years (three year citation window) from the date of their publication (c). This allows the average number of citations per paper (*C*/*P*) to be computed for each of these institutes for the three-year citations window. h-indices for these institutions for the same period (i.e., 1999-2008) were also determined from the Scopus database. Similarly, the number of papers, which resulted from international collaboration, could also be determined (TICP) using appropriate search strategy and from this percentage share of papers from international collaboration to the total number of papers published ( per cent TICP) could be established.

Papers can be assessed for quality only when the impact in terms of the citations obtained over the period of the citation window is taken into account. This problem is complex, as there are several ways of ranking performance, e.g. the simplest and crudest being by quantity of output (papers – as shown in Table 1), impact (citations – not shown here), or by quality (mean citation rate = *C*/*P* as shown in Table 1), or by a performance index combining quantity and quality, e.g., the *h*-index (as shown in Table 1).

The insight emerging from some recent studies which have re-visited the problem of ranking research performance of any entity (from individuals to countries) as one belonging to the domain of random multiplicative processes, considers the best single indicator to be used for ranking using quality and quantity together, to be a geometric mean of *C* and C/*P* according to Prathap, However, by dimensional analysis, one can show that this has the dimensions of $h^{3/2}$. Indeed, a substitute or mock *h*-index defined as $h_m = (C^2P)^{1/3}$ is the best indicator for performance[7-9], having the correct dimensionality, that of *h* according to Prathap, henceforth being called as *p*-index. The ranking using this *p*-index is shown in Table 2.

**Table 1. Ranking using *p*-index**

| S. No. | Ranking using C/P | Ranking using *h*-index | Ranking using *p*-Index |
|---|---|---|---|
| 1. | Bell Labs Research Centre, India (3.11) | IISc, Banglore (35) | IISc, Banglore (17.39) |
| 2. | IIM Calcutta, Kolkata (2.5) | ISI, Kolkata (32) | ISI, Kolkata (16.78) |
| 3. | ISI, Kolkata (2.47) | IIT, Delhi (30) | IIT, Delhi (15.73) |
| 4. | IMS, Chennai (2.37) | IIT, Kharagpur (25) | IIT, Kanpur (13.75) |
| 5. | IISc, Bengaluru (2.06) | IIT, Bombay (23) | IBM, India (12.26) |
| 6. | IBM-India (2.02) | IIT, Kanpur (21) | IIT, Bombay (12.16) |
| 7. | IIT, Kanpur (1.95) | IIT, Madras (20) | IIT, Madras (11.72) |
| 8. | Bharathiar University (1.83) | IBM, India (19) | IIT, Kharagpur (11.45) |
| 9. | IIT Delhi (1.82) | Bell Labs Research Center, India (17) | Bell Labs Research Center, India (10.51) |
| 10. | Motorola, India (1.54) | Jadavpur University (16) | IIM, Kolkata (8.89) |
| 11. | NSIT, Delhi (1.50) | University of Calcutta (13) | IMS, Chennai (8.81) |
| 12. | University of Calcutta (1.46) | IMS-Chennai (13) | Jadavpur University (8.58) |
| 13. | DEI, Agra (1.43) | University of Delhi (11) | University of Calcutta (8.08) |
| 14. | Mepco Schlenk Engineering College (1.40) | IIT, Guwahati (11) | University of Delhi (7.24) |
| 15. | IIT Bombay (1.38) | University of Mysore (10) | IIIT, Hyderabad (6.49) |
| 16. | University of Mysore (1.36) | Anna University (9) | NSIT, Delhi (6.32) |
| 17. | Wipro Technologies (1.34) | IIM, Kolkata (9) | IIT, Guwahati (6.07) |
| 18. | Tezpur University (1.33) | University of Hyderabad (8) | Anna University (5.83) |
| 19. | University of Madras (1.32) | IIIT, Hyderabad (8) | University of Mysore (5.81) |
| 20. | IIT, Madras (1.31) | BITS, Pilani (8) | TIFR, Mumbai (5.76) |
| 21. | BARC, Mumbai (1.30) | TIFR, Mumbai (8) | IIT, Roorkee (5.51) |
| 22. | IIIT Bengaluru (1.30) | NSIT, Delhi (8) | Motorola, India (5.36) |
| 23. | Jadavpur University (1.29) | Tech Mahindra (8) | Bharathiar University (5.35) |
| 24. | TIFR, Mumbai (1.24) | IIT, Roorkee (7) | Microsoft, India (4.75) |
| 25. | IIT, Kharagpur (1.20) | Banaras Hindu University (7) | BARC, Mumbai (4.66) |
| 26. | IIIT, Hyderabad (1.16) | Bengal Engineering & Sci. University (7) | Bengal Engineering & Sci. University (4.66) |
| 27. | Jawaharlal Nehru University (1.11) | Infosys Technologies Ltd. (7) | University of Hyderabad (4.66) |
| 28. | Bengal Engineering & Sci. University (1.04) | Mepco Schlenk Engineering College (7) | Jawaharlal Nehru University (4.63) |
| 29. | University of Delhi (1.03) | PSG College of Technology, Coimbatore (6) | IIIT, Bangalore (4.57) |
| 30. | Manipal Institute of Technology (1.03) | Aligarh Muslim University (6) | DEI, Agra (4.56) |
| 31. | University of Pune (1.00) | Texas Instruments, India (6) | Mepco Schlenk Engineering College (4.53) |
| 32. | University of Kalyani (1.00) | Jawaharlal Nehru University (6) | BITS, Pilani (4.44) |
| 33. | Infosys Technologies Ltd., India (0.97) | Motorola, India (6) | Aligarh Muslim University (4.33) |
| 34. | Microsoft, India (0.91) | BARC, Mumbai (6) | Infosys Technologies Ltd. (4.22) |
| 35. | Aligarh Muslim University (0.90) | Institute of Tech, Banaras Hindu University (6) | Tezpur University (4.21) |
| 36. | Texas Instruments, India (0.89) | Bharathiar University (6) | Banaras Hindu University (4.17) |
| 37. | Cochin University of S&T (0.89) | University of Kalyani (6) | University of Madras (4.04) |
| 38. | IIT, Guwahati (0.88) | Microsoft, India (5) | Manipal Institute of Technology (4.00) |
| 39. | Tata Res Devel & Design Centre (0.87) | Pondicherry Engineering College (5) | Texas Instruments, India (4.0) |
| 40. | Guru Nanak Dev University (0.85) | Tata Consultancy Services, Pune (5) | Wipro Technologies (3.98) |
| 41. | Thapar University, Patiala (0.84) | Motilal Nehru NIT, Allahabad (5) | University of Pune (3.98) |
| 42. | Banaras Hindu University (0.82) | Cochin University of S&T (5) | Cochin University of S&T (3.85) |

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|---|---|---|---|
| 43. | BITS, Pilani (0.80) | University of Pune (5) | Thapar University, Patiala (3.40) |
| 44. | Hewlett-Packard, India (0.75) | Manipal Institute of Technology (5) | University of Kalyani (3.39) |
| 45. | IIT, Roorkee (0.72) | University of Madras (5) | Tata Res Develop & Design Centre (3.23) |
| 46. | Annamalai University (0.69) | Wipro Technologies (5) | PSG College of Tech., Coimbatore (3.18) |
| 47. | Indian School of Mines (0.68) | NIT, Tiruchirappalli (4) | Motilal Nehru NIT, Allahabad (3.13) |
| 48. | Tech Mahindra (0.67) | Osmania University (4) | Tata Consultancy Services, Pune (3.13) |
| 49. | Inst. of Tech, Banaras Hindu University (0.66) | NIT, Surathkal (4) | Hewlett-Packard, India (3.13) |
| 50. | C-DAC, Pune (0.66) | Thapar University, Patiala (4) | Guru Nanak Dev University (3.10) |
| 51. | Anna University (0.63) | Hewlett-Packard, India (4) | Tech Mahindra (2.99) |
| 52. | Manonmaniam Sundaranar University (0..63) | DEI, Agra (4) | Inst of Tech, Banaras Hindu Univ. (2.95) |
| 53. | University of Hyderabad (0.61) | Tata Res Dev & Design Centre, Pune (4) | NIT, Tiruchirappalli (2.88) |
| 54. | Motilal Nehru NIT, Allahabad (0.59) | Manonmaniam Sundaranar University (4) | Indian School of Mines, Dhanbad (2.79) |
| 55. | Tata Consultancy Services, Pune (0.53) | Maduarai Kamraj University (4) | C-DAC, Pune (2.67) |
| 56. | NIT, Surathkal (0.51) | Thiagarajar College of Engineering (3) | NIT, Surathkal (2.67) |
| 57. | NIT, Tiruchirappalli (0.50) | Dhirubhai Ambani Institute of Information & Communication Technology (3) | Pondicherry Engineering College (2.66) |
| 58. | Andhra University (0.48) | Honeywell International-India Pvt. Ltd. (3) | Manonmaniam Sundaranar Univ. (2.55) |
| 59. | PSG Coll of Technology, Coimbatore (0.45) | West Bengal University of Technology (3) | Annamalai University (2.54) |
| 60. | Gulbarga University (0.44) | IIIT, Bangalore (3) | Osmania University (2.23) |
| 61. | College of Engn., Thiruvananthapuram (0.42) | IIIT, Allahabad (3) | Andhra University (2.19) |
| 62. | Pondicherry Engineering College (0.41) | Indian School of Mines, Dhanbad (3) | Honeywell International-India Pvt. Ltd. (2.05) |
| 63. | Atal Bihari Vajpayee IIIT, Gwalior (0.38) | Andhra University (3) | Gulbarga University (1.95) |
| 64. | Honeywell International-India Pvt. Ltd. (0.36) | Atal Bihari Vajpayee IIIT, Gwalior (3) | West Bengal Univ. of Tech. (1.94) |
| 65. | Osmania University (0.35) | Guru Nanak Dev University (3) | IIIT, Allahabad (1.88) |
| 66. | West Bengal University of Technology (0.35) | Gulbarga University (3) | Atal Bihari Vajpayee IIIT, Gwalior (1.86) |
| 67. | IIIT, Allahabad (0.35) | B.S. Abdur Rahman Crescent Engn Coll (3) | Coll. of Engn., Thiruvananthapuram (1.84) |
| 68. | Malaviya NIT, Jaipur (0.34) | Coll of Engineering, Thiruvananthapuram (3) | NIT, Kurukshetra (1.67) |
| 69. | NIT, Kurukshetra (0.33) | Annamalai University (3) | Dhirubhai Ambani Inst of Information & Communication Technology (1.65) |
| 70. | BITS, Mesra (0.31) | NIT, Rourkela (2) | Malaviya NIT, Jaipur (1.60) |
| 71. | Satyam Computer Services Ltd. (0.28) | Sri Venkateswara Coll of Engn (2) | Satyam Computer Services Ltd. (1.58) |
| 72. | Panjab University, Chandigarh (0.27) | Satyam Computer Services Ltd. (2) | BITS, Mesra (1.51) |
| 73. | Maduarai Kamraj University (0.26). | C-DAC, Pune (2) | NIT, Rourkela (1.45) |
| 74. | Dhirubhai Ambani Institute of Information & Communication Technoogy (0.25) | University of Kerala (2) | Panjab University, Chandigarh (1.39) |
| 75. | NIT, Rourkela (0.18) | Tezpur University (2) | Maduarai Kamraj University (1.32). |
| 76. | Thiagarajar College of Engineering (0.16) | JNTU College of Engineering, Hyderabad (2) | Thiagarajar College of Engineering (1.25) |
| 77. | Govt College of Engineering, Pune (0.16) | NIT, Kurukshetra (2) | Govt College of Engineering, Pune (1.04) |
| 78. | B.S. Abdur Rahman Crescent Engineering College (0.16) | Panjab University, Chnadigarh (2) | B.S. Abdur Rahman Crescent Engineering College (0.99) |
| 79. | Vellore Institute of Technology (0.14) | BITS, Mesra (2) | Vellore Institute of Technology (0.94) |
| 80. | NIT, Warangal (0.13) | Malaviya NIT, Jaipur (2) | NIT, Warangal (0.93) |
| 81. | Sri Venkateswara College of Engn. (0.09) | NIT, Warangal (1) | Sri Venkateswara College of Engn. (0.86) |
| 82. | University of Kerala (0.07) | Vellore Institute of Technology (1) | JNTU College of Engineering, (0.60) |
| 83. | JNTU College of Engineering (0.07) | Govt College of Engineering, Pune (1) | University of Kerala (0.59) |

**Table 2. Scientometric data for top 83 institutions contributing to computer science based on papers published during 1999-2008, arranged according to *p* values**

| S. No. | Name | P | C | C/P | *h*-index | ICP | % ICP | *p* |
|---|---|---|---|---|---|---|---|---|
| 1. | Indian Institute of Science (IISc), Bangalore | 1241 | 2554 | 2.06 | 35 | 256 | 20.6 | 17.39 |
| 2. | Indian Institute of Technology (IIT), New Delhi | 1175 | 2139 | 1.82 | 30 | 272 | 23.1 | 15.73 |
| 3. | Indian Institute of Technology (IIT), Kharagpur | 1050 | 1256 | 1.20 | 25 | 179 | 17.0 | 11.45 |
| 4. | Indian Institute of Technology (IIT), Mumbai | 944 | 1303 | 1.38 | 23 | 231 | 24.5 | 12.16 |
| 5. | Indian Institute of Technology (IIT), Chennai | 938 | 1229 | 1.31 | 20 | 186 | 19.8 | 11.72 |
| 6. | Indian Statistical Institute (ISI), Kolkata | 772 | 1910 | 2.47 | 32 | 177 | 22.9 | 16.78 |
| 7. | Indian Institute of Technology (IIT), Kanpur | 683 | 1333 | 1.95 | 21 | 182 | 26.6 | 13.75 |
| 8. | Anna University, Chennai | 502 | 315 | 0.63 | 9 | 38 | 7.57 | 5.83 |
| 9. | International Business Machines (IBM), Bangalore | 454 | 915 | 2.02 | 19 | 195 | 42.95 | 12.26 |
| 10. | Jadavpur University, Kolkata | 380 | 490 | 1.29 | 16 | 72 | 18.95 | 8.58 |
| 11. | University of Delhi, Delhi | 359 | 369 | 1.03 | 11 | 53 | 14.76 | 7.24 |
| 12. | Indian Institute of Technology (IIT), Roorkee | 327 | 234 | 0.72 | 7 | 44 | 13.5 | 5.51 |
| 13. | Indian Institute of Technology (IIT), Guwahati | 291 | 255 | 0.88 | 11 | 43 | 14.8 | 6.07 |
| 14. | University of Hyderabad, Hyderabad | 273 | 166 | 0.61 | 8 | 39 | 14.29 | 4.66 |
| 15. | University of Calcutta, Kolkata | 248 | 362 | 1.46 | 13 | 40 | 16.13 | 8.08 |
| 16. | International Institute of Information Technology (IIIT), Hyderabad | 204 | 236 | 1.16 | 8 | 48 | 23.5 | 6.49 |
| 17. | PSG College of Technology, Coimbatore | 157 | 71 | 0.45 | 6 | 5 | 3.18 | 3.18 |
| 18. | Birla Institute of Technology and Science (BITS), Pilani | 136 | 109 | 0.80 | 8 | 24 | 17.6 | 4.44 |
| 19. | Microsoft, India | 128 | 117 | 0.91 | 5 | 44 | 34.38 | 4.75 |
| 20. | Tata Institute of Fundamental Research (TIFR), Mumbai | 124 | 154 | 1.24 | 8 | 68 | 54.8 | 5.76 |
| 21. | Institute of Mathematical Sciences (IMS), Chennai | 122 | 289 | 2.37 | 13 | 53 | 43.4 | 8.81 |
| 22. | Bell Labs Research Center, India | 120 | 373 | 3.11 | 17 | 82 | 68.33 | 10.51 |
| 23. | Netaji Subhash Institute of Technology (NSIT), Delhi | 113 | 169 | 1.5 | 8 | 9 | 7.96 | 6.32 |
| 24. | Pondicherry Engineering College | 113 | 46 | 0.41 | 5 | 3 | 2.65 | 2.66 |
| 25. | Indian Institute of Management (IIM), Kolkata | 113 | 282 | 2.5 | 9 | 43 | 38.05 | 8.89 |
| 26. | Tata Consultancy Services (TCS), Pune | 110 | 58 | 0.53 | 5 | 19 | 17.27 | 3.13 |
| 27. | University of Mysore | 107 | 145 | 1.36 | 10 | 15 | 14.02 | 5.81 |
| 28. | Banaras Hindu University, Varanasi | 107 | 88 | 0.82 | 7 | 11 | 10.28 | 4.17 |
| 29. | Aligarh Muslim University | 100 | 90 | 0.90 | 6 | 32 | 32 | 4.33 |
| 30. | National Institute of Technology (NIT), Tiruchirappalli | 96 | 48 | 0.50 | 4 | 8 | 8.33 | 2.88 |
| 31. | National Institute of Technology (NIT), Rourkela | 95 | 17 | 0.18 | 2 | 4 | 4.21 | 1.45 |
| 32. | Bengal Engineering and Science University, Howrah | 93 | 97 | 1.04 | 7 | 8 | 8.6 | 4.66 |
| 33. | Osmania University, Hyderabad | 92 | 32 | 0.35 | 4 | 13 | 14.13 | 2.23 |
| 34. | Motilal Nehru National Institute of Technology, Allahabad | 88 | 52 | 0.59 | 5 | 9 | 10.2 | 3.13 |
| 35. | Texas Instruments | 81 | 72 | 0.89 | 6 | 26 | 32.1 | 4.00 |
| 36. | Jawaharlal Nehru University, New Delhi | 80 | 89 | 1.11 | 6 | 10 | 12.5 | 4.63 |
| 37. | Infosys Technologies Limited, Bangalore | 79 | 77 | 0.97 | 7 | 14 | 17.72 | 4.22 |
| 38. | Sri Venkateswara College of Engineering, Tirupati | 76 | 7 | 0.09 | 2 | 12 | 15.8 | 0.86 |
| 39. | Thiagarajar College of Engineering | 74 | 12 | 0.16 | 3 | 4 | 5.41 | 1.25 |
| 40. | Cochin University | 72 | 64 | 0.89 | 5 | 14 | 19.44 | 3.85 |
| 41. | Dhirubhai Ambani Institute of Information and Communication Technology | 72 | 18 | 0.25 | 3 | 17 | 23.6 | 1.65 |

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|---|---|---|---|---|---|---|---|---|
| 42. | National Institute of Technology (NIT), Surathkal | 72 | 37 | 0.51 | 4 | 4 | 5.56 | 2.67 |
| 43. | Honeywell International India Pvt. Ltd. | 67 | 24 | 0.36 | 3 | 9 | 13.43 | 2.05 |
| 44. | Motorola | 65 | 100 | 1.54 | 6 | 21 | 32.31 | 5.36 |
| 45. | University of Pune | 63 | 63 | 1 | 5 | 15 | 23.81 | 3.98 |
| 46. | West Bengal University of Technology | 60 | 21 | 0.35 | 3 | 5 | 8.333 | 1.94 |
| 47. | Tech Mahindra | 60 | 40 | 0.67 | 8 | 4 | 6.667 | 2.99 |
| 48. | Manipal Institute of Technology | 60 | 62 | 1.03 | 5 | 10 | 16.7 | 4.00 |
| 49. | Bhabha Atomic Research Centre | 60 | 78 | 1.3 | 6 | 10 | 16.7 | 4.66 |
| 50. | Institute of Technology, Banaras Hindu University | 59 | 39 | 0.66 | 6 | 8 | 13.6 | 2.95 |
| 51. | Thapar University, Patiala | 56 | 47 | 0.84 | 4 | 2 | 3.57 | 3.40 |
| 52. | International Institute of Information Technology, Bangalore | 56 | 73 | 1.30 | 3 | 7 | 12.5 | 4.57 |
| 53. | Hewlett-Packard | 55 | 41 | 0.75 | 4 | 11 | 20 | 3.13 |
| 54. | Indian Institute of Information Technology, Allahabad | 54 | 19 | 0.35 | 3 | 8 | 5.56 | 1.88 |
| 55. | Satyam Computer Services Ltd., India | 50 | 14 | 0.28 | 2 | 2 | 4 | 1.58 |
| 56. | Indian School of Mines University | 47 | 32 | 0.68 | 3 | 4 | 8.51 | 2.79 |
| 57. | Mepco Schlenk Engineering College | 47 | 66 | 1.40 | 7 | 1 | 2.13 | 4.53 |
| 58. | Bharathiar University | 46 | 84 | 1.83 | 6 | 4 | 8.70 | 5.35 |
| 59. | Dayalbagh Educational Institute, India | 46 | 66 | 1.43 | 4 | 1 | 2.17 | 4.56 |
| 60. | Andhra University | 46 | 22 | 0.48 | 3 | 7 | 15.22 | 2.19 |
| 61. | Tata Research Development and Design Centre | 45 | 39 | 0.87 | 4 | 12 | 26.67 | 3.23 |
| 62. | National Institute of Technology, Warangal | 45 | 6 | 0.13 | 1 | 2 | 4.44 | 0.93 |
| 63. | Atal Bihari Vajpayee Indian Institute of Information Technology and Management | 45 | 17 | 0.38 | 3 | 2 | 4.44 | 1.86 |
| 64. | Centre for Development of Advanced Computing India | 44 | 29 | 0.66 | 2 | 4 | 9.09 | 2.67 |
| 65. | Vellore Institute of Technology | 43 | 6 | 0.14 | 1 | 7 | 16.3 | 0.94 |
| 66. | University of Kerala | 43 | 3 | 0.07 | 2 | 21 | 48.84 | 0.59 |
| 67. | Government College of Engineering, Pune | 43 | 7 | 0.16 | 1 | 4 | 9.3 | 1.04 |
| 68. | Tezpur University | 42 | 56 | 1.33 | 2 | 5 | 11.9 | 4.21 |
| 69. | JNTU College of Engineering, Hyderabad | 42 | 3 | 0.07 | 2 | 2 | 4.76 | 0.60 |
| 70. | National Institute of Technology, Kurukshetra | 42 | 14 | 0.33 | 2 | 0 | 0 | 1.67 |
| 71. | Guru Nanak Dev University | 41 | 35 | 0.85 | 3 | 1 | 2.44 | 3.10 |
| 72. | Manonmaniam Sundaranar University | 41 | 26 | 0.63 | 4 | 0 | 0 | 2.55 |
| 73. | University of Kalyani | 39 | 39 | 1 | 6 | 4 | 10.26 | 3.39 |
| 74. | Gulbarga University | 39 | 17 | 0.44 | 3 | 1 | 2.56 | 1.95 |
| 75. | University of Madras | 38 | 50 | 1.32 | 5 | 18 | 47.37 | 4.04 |
| 76. | Panjab University | 37 | 10 | 0.27 | 2 | 2 | 5.41 | 1.39 |
| 77. | B.S. Abdur Rahman Crescent Engineering College | 37 | 6 | 0.16 | 3 | 3 | 8.11 | 0.99 |
| 78. | College of Engineering, Thiruvananthapuram | 36 | 15 | 0.42 | 3 | 1 | 2.78 | 1.84 |
| 79. | Annamalai University | 35 | 24 | 0.69 | 3 | 3 | 8.57 | 2.54 |
| 80. | Birla Institute of Technology, Mesra | 35 | 11 | 0.31 | 2 | 5 | 14.3 | 1.51 |
| 81. | Maduarai Kamraj University | 35 | 9 | 0.26 | 4 | 8 | 22.86 | 1.32 |
| 82. | Wipro Technologies | 35 | 47 | 1.34 | 5 | 9 | 25.71 | 3.98 |
| 83. | Malaviya National Institute of Technology | 35 | 12 | 0.34 | 2 | 2 | 8.57 | 1.60 |
| | Total | 14375 | 19051 | 1.32 | 7.21 | 2851 | 19.83 | |

## 3. ANALYSIS AND RANKING

Table 2 shows the raw scientometric data for top 83 institutes contributing to computer science research output, i.e., the number of papers published (*P*), the citations obtained during the citation window (*C*), the average number of citations per paper (*C/P*), the number of papers resulting from international collaboration (ICP) and the percentage thereof (% ICP). Also shown in Table 2 are the *h*-index and the newly proposed composite performance index (*p*).

Some old insights are reinforced and some new insights emerge from Table 1 and 2. It is not surprising that by number (quantity) or by performance (quality and quantity combined), the Institute of National Importance (INI) (including IISc, Bangaluru; ISI, Kolkata; and IITs) lead among all engineering and technological institutes in the country.

Among the INIs, IISc, Bengaluru continue to hold the first rank in performance in terms of *p*-value, productivity (*P*) and *h*-index, but 5th rank in average citation per paper. Similarly, ISI, Kolkata improved its ranking to 2nd place in terms of *p*-value and in *h*-index, in spite of 3rd rank in average citation per paper and 5th in productivity. Similarly IIT, Kanpur has also improved its performance ranking to 4th place terms of *p*-value, in spite of 6th rank in *h*-index and 7th each in productivity and average citations per paper. The IIM, Kolkata has also improved its performance ranking to 2nd rank in average citations per paper, in spite of 17th in *h*-index, 19th place in *p*-value and 25th in publication productivity.

Among the four IIITs (having also the status of deemed university), two have improved in terms of performance ranking as measured by *p*-value, compared to their productivity ranking. For example, the IIIT, Hyderabad, has improved its performance index ranking to 15th rank in terms of *p*-value (in spite of 19th rank in terms of *h*-index, 26th rank in terms of average citation per paper and 16th rank in terms of publication productivity) and IIIT, Bengaluru to 29th rank in terms of *p*-value (in spite of 22nd rank in average citation per paper, 60th rank in terms of *h*-index and 52nd rank in terms of publication productivity).

Although the NITs have been around for a long time (earlier known as RECs), and have been upgraded to deemed university, their research performance is still very dismal. Except for two institutions, the performance has gone down in terms of *p*-value compared to their productivity. For example, the NIT, Kurukshetra, has improved its performance index to 67th rank in terms of *p*-value (in spite of 76th rank in terms of *h*-index, 68th rank in terms of average citation per paper and 70th rank in terms of publication productivity) and Malaviya NIT, Jaipur to 69th rank in terms of *p*-value (in spite of 67th rank in average citation per paper, 79th rank in terms of *h*-index and 83th rank in terms of publication productivity).

Among the select engineering colleges, only three institutions have improved in terms of performance ranking as measured by *p*-value, compared to their productivity ranking. For example, the Mepco Schlenk Engineering College has improved its performance index ranking to 31th rank in terms of *p*-value (in spite of 28th rank in terms of *h*-index, 14th rank in terms of average citation per paper and 57h rank in terms of publication productivity), Manipal Institute of Technology to 38th rank in terms of *p*-value (in spite of 30th rank in average citation per paper, 44th rank in terms of *h*-index and 60th rank in terms of publication productivity), and College of Engineering, Thiruvantapuram to 66th rank in terms of *p*-value (in spite of 61th rank in terms of average citation per paper, 67th rank in terms of *h*-index and 78th rank in terms of publication productivity).

Among the universities'/deemed universities' status engineering colleges, more than 50 per cent have improved their performance in terms of *p*-values compared to their productivity. For example, the University of Calcutta has improved its performance index to 13th rank in terms of *p*-value (in spite of 11th in *h*-index, 12th rank in average citation per paper and 15th in publication productivity), Netaji Subhash Institute of Technology, Delhi to 16th rank in terms of *p*-value (in spite of 11th rank in average citation per paper, 22th rank in *h*-index and 23th in publication productivity), Bengal Engineering and Science University, Howrah to 26th rank in terms of *p*-value (in spite of 26th rank in *h*-index, 28th rank in average citation per paper and 32th in publication productivity), Bharathiar University to 26th rank in terms of *p*-value (in spite of 8th rank in average citations per paper, 36th rank in *h*-index and 58th rank in publication productivity), Dayalbagh Educational Institute, Agra to 30th rank in terms of *p*-value (in spite of 13th rank in *h*-index, 52nd rank in average citations per paper and 59th rank in publication productivity), Tezpur University to 35th rank in terms of *p*-value (in spite of 18th rank in average citations per paper, 74th rank in *h*-index and 68th rank in publication productivity and University of Madras to 37th rank in terms of *p*-value (in spite of 19th rank in average citations per paper, 45th rank in *h*-index and 75th rank in publication productivity.

In the industry, again more than 50 per cent enterprises have improved their performance in terms of *p*-values compared to their productivity. For example, the IBM-India office has improved its performance index to 5th rank in terms of *p*-value (in spite of 8th rank in *h*-index, 6th rank in terms of average citation per paper and 9th rank in publication productivity), Bell Lab Research Centre, India to 9th rank in terms of *p*-value (in spite of 1st rank in average citation per paper, 9th rank in terms of *h*-index and 22th rank in terms of publication productivity), Motorola, India to 22th rank in terms of *p*-value (in spite of 10th rank in terms of average citation per paper, 33th rank in terms of *h*-index and 44th in terms of publication productivity) and Wipro

Technologies to 40th rank in terms of *p*-value (in spite of 17th rank in terms of average citations per paper, 46th rank in terms of *h*-index and 82th rank in publication productivity).

Among the four research institutes, three have improved their performance compared to their productivity. For example, the IMS, Chennai has improved its performance index to 11th rank in terms of *p*-value (in spite of 13th rank in terms of *h*-index, 4th rank in terms of average citation per paper and 21th rank in terms of publication productivity), BARC, Mumbai to 25th rank in terms of *p*-value (in spite of 21th rank in average citation per paper, 34th rank in terms of *h*-index and 49th rank in terms of publication productivity) and C-DAC, Pune to 55th rank in terms of *p*-value (in spite of 50th rank in terms of average citation per paper, 72th rank in terms of *h*-index and 64th rank in terms of publication productivity).

Table 3 reveals the performance of the Indian engineering and technological institutions (measured in terms of *p* values) when they are grouped into various categories. It is seen that the institutes of national importance as group leads in terms of research performance among these seven groups, followed by universities/deemed university, industry, research institutes, IIITs, select engineering colleges, and NITs/RECs.

The ranking of the various institutions within each group defined above according to the *p*-index also give an indication of how each category performs within its peer group. These 83 institutions consists of 10 INI, 4 IIITs, 8 NIT/RECs, 4 research institute (RI), 11 select engineering colleges (SEC), 33 university/deemed university (Univ/DU) and 13 industry enterprises.

For example, among the 10 INI, the best performance in terms of *p*-index values (17.39) is shown by IISc, Bangalore, followed by ISI, Kolkata (16.78), IIT, New Delhi (15.73), IIT, Kanpur (13.75), IIT, Bombay (12.16), IIT, Madras (11.72), IIT, Kharagpur (11.45), IIM, Kolkata (8.89), IIT, Guwahati (6.07) and IIT, Roorkee (5.51).

Similarly, among the 32 universities, the best performance in terms of *p*-index values (8.58) is shown by Jadavpur University, Kolkata, followed by University of Calcutta (8.08), University of Delhi (7.24); Anna University (5.83); University of Mysore (5.81); Bharathiar University (5.35); Bengal Engineering & Science University (4.66); University of Hyderabad (4.66); Jawaharlal Nehru University (4.63); Dayalbagh Educational Institute (4.56); Birla Institute of Technology & Science, Pilani (4.44); Aligarh Muslim University (4.33); Tezpur University (4.21), Banaras Hindu University (4.17); University of Madras (4.04); University of Pune (3.98); Cochin University of Science & Technology (3.85); Thaper University (3.40); University of Kalyani (3.39); Guru Nanak Dev University (3.10); Indian School of Mines (2.79); Manonmaniam Sundaranar University (2.55); Annamalai University (2.54); Osmania University (2.23); Andhra University (2.19); Gulbarga University (1.95); West Bengal University of Technology (1.94); Birla Institute of Technology, Mesra (1.51); Panjab University, Chandigarh (1.39); Madurai Kamraj University (1.32), Vellore Institute of Technology (0.94); and University of Kerala (0.59).

Similarly among the four IIITs, the best performance in terms of *p*-index values (6.49) is shown by IIIT, Hyderabad, followed by IIIT, Bangalore (4.57); IIIT, Allahabad (1.88); and Atal Bihari Vajpayee IIITM, Gwalior (1.86). Among the 10 NITs, the best performance in terms of *p*-values (3.13) is shown by Motilal Nehru NIT, followed by Institute of Technology; Banaras Hindu University (2.95); NIT, Tiruchirappalli (2.88); NIT, Surathkal (2.67); NIT, Kurukshetra (1.67); Malaviya NIT (1.60); NIT, Rourkela; (1.45); and NIT Warangal (0.93).

Among the 12 select engineering colleges, the best performance in terms of *p*-index values (6.32) is shown by NSIT, Delhi, followed by Mepco Schlenk Engineering College (4.53); Manipal Institute of Technology (4.0); PSG College of Technology, Coimbatore (3.18); Pondicherry Engineering College (2.66); College of Engineering, Thiruvananthapuram (1.84); Dhirubhai Ambani Institute of Information and Communication Technology (1.65);

**Table 3. Ranking of Indian institutes groups using the performance index *p* during 1999-2008 according to the SCOPUS database**

| S. No. | Institute/Category | *P* | *C* | *C/P* | *h*-index | ICP | % ICP | *p* |
|---|---|---|---|---|---|---|---|---|
| 1. | Institutes of National Importance (10) | 7534 | 17495 | 1.66 | 21.3 | 1613 | 21.41 | 27.47 |
| 2. | University/Deemed Universities (33) | 3381 | 3037 | 0.9 | 5.47 | 482 | 14.26 | 13.97 |
| 3. | Industrial Enterprises (13) | 1349 | 1917 | 1.42 | 7 | 448 | 33.21 | 13.97 |
| 4. | Research Institutes (4) | 350 | 550 | 1.57 | 7.2 | 135 | 38.57 | 9.53 |
| 5. | IIITs (4) | 359 | 322 | 0.9 | 3.5 | 59 | 16.43 | 6.61 |
| 6. | Select Top Engineering Colleges (12) | 870 | 482 | 0.55 | 4.08 | 71 | 8.16 | 6.44 |
| 7. | NITs/RECs (8) | 532 | 225 | 0.42 | 3.25 | 37 | 6.95 | 4.82 |
| | Total (83) | | | | | | | |

Thiagarajan College of Engineering (1.25); Government College of Engineering, Pune (1.04); B.S. Abdur Rahman Crescent Engineering College (0.99); Sri Venkateswara College of Engineering (0.86); and JNTU College of Engineering, Hyderabad (0.60).

Among the 4 research institutes, the best performance in terms of *p*-index values (8.81) is shown by Institute of Mathematical Sciences, Chennai, followed by Tata Institute of Fundamental Research (5.76); Bhabha Atomic Research Centre, Mumbai (4.66); and Centre for Development of Advanced Computing, Pune (2.67).

Among the 13 industrial firms, the best performance in terms of *p*-index values (12.26) is shown by IBM-India, followed by Bell Labs Research Centre, India (10.51); Motorola, India (5.36); Microsoft India (4.75); Infosys Technologies Limited (4.22); Texas Instruments-India (4.00); Wipro Technologies (3.98); Tata Research Development and Design Centre (3.23); Tata Consultancy Services, India (3.13); Hewlett-Packard-India (3.13); Tech Mahindra (2.99); Honeywell International India Pvt. Ltd. (2.05); and Satyam Computer Services Ltd. (1.58).

## 4. CONCLUSIONS

In this paper, a very rational procedure for ranking the research performance of Indian institutions contributing to computer science research in the country is used. The overall ranking of top 83 Indian institutions and ranking of individual institutions among the seven groups of institutions give an indicative, if not nearly comprehensive, assessment of how the institutions of higher education are performing as generators of new knowledge in computer science.

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