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Foreign MNC R&D Centers in India: A Study of their Publications, 2003-12

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ABSTRACT

The paper analysed 3040 publications of 21 most productive foreign multinational companies (MNCs) R&D centers in India during 2003-12, with a focus on the extent of their research output and citation impact, distribution of their publications by various subject fields, international collaborative publications, and national collaborating linkages with different type of Indian organisations. The data for the study has been derived from Scopus international multidisciplinary bibliographical database. The study found that the publications of these foreign R&D centers grew at an annual growth rate of 23.56 %, registered a citation impact of 2.29 and involved international collaboration in 46.02 % of its publications. The major areas of interest of these foreign R&D centers are computer science and engineering, followed by mathematics, materials science, physics, biochemistry, genetics & molecular biology, etc. The national collaborative linkages of foreign R&D centers are predominately with institutes of national importance.

Keywords: Multinational companies, R&D centers, scientometrics, citation impact

1. INTRODUCTION

The top 1000 R&D spenders (multinational companies) had increased their spending from $549 billion in 2008-09 to $582 billion in 2010-11. These multinational companies (MNCs) play an important role in economy and R&D activities of host countries, particularly the developing countries. At present, more than one third of the top 1000 global spenders (MNCs) have set up R&D centers in India[1].

India is estimated to have the eighth largest annual R&D investments worldwide in FY 2011. Its share in global annual R&D spending has increased from 2.6 % in FY 2010 to 2.8 % in FY 2011. In fact, India's share in global R&D spending has increased over the last five years[2]. Foreign investment in R&D in India has grown significantly over the years. The R&D expenditure through foreign direct investments (FDI) has increased in India from INR 286 crores in 2002-03 to INR 2883 crores in 2009-10. The share of foreign companies in overall Indian R&D has risen to about 20 % by 2009-10[3].

According to a Zinnov report[4], India currently hosts 1031 MNC R&D centers till the end of 2013, growing at 4 % a year, with an employment base of 244000 growing at 11 % per year. Texas Instruments was the first major MNC which established an R&D center in Bangalore in 1985[2]. Since then, a number of MNCs from different countries (though predominantly from USA) have set up R&D centers in India. Twenty five global MNCs have established R&D centers in India since the beginning of 2012 alone[5].

Mrinalini[6], *et al*. (from NISTADS) with the financial support of DST-TAIFAC carried out one of the largest and most comprehensive survey of foreign investment in R&D in India during 2003-09. According to this survey, the total number of FDIs in R&D in India was 964 from 706 MNCs originating from 23 countries and they together brought $29 billion as FDI in R&D in India during 2003-09. Country-wise number of FDI investments in R&D indicates that USA had largest number of investments (591), followed by UK (51), Germany (49), France (31), Japan (27), Switzerland (21) and 17 other countries (127). Bangalore, Hyderabad, Chennai, Mumbai/Pune and Delhi/NCR account for 88 % of the inflow of FDI in R&D in India during this period. In terms of sectoral share of total FDI in R&D, the largest share (50.36 %) was in IT & Software, followed by aerospace (12.52 %), pharmaceuticals & biotechnology (9.72 %), automobiles (9.27 %), machinery & equipments (3.01 %), services (2.62 %), electronic components (2.56 %), chemicals (1.25 %), etc. These 706 MNCs created 247000 jobs through R&D investments in India over the past decade and also obtained 1166 patents during 2003-09.

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The presence of these multinational companies in India is slowly leading to its rapid integration into the global research system. India is fast emerging as a major destination for high-end R&D projects for MNCs across the globe[7]. India is being benefited from these foreign R&D centers in terms of employment, as sizable number of PhDs, Master and Bachelor degree holders in science and engineering, and technicians, etc., are working on future technologies, working with sophisticated equipment/machinery and getting opportunities for specialised education and training abroad. Indian R&D organisations, universities and industry are also gaining by working with these foreign R&D centers through contract research, collaborative research, training programmes and courses being conducted by some of them. Many of these foreign R&D centers have established collaborated linkages with institutes of national importance, government departments, national research laboratories, engineering colleges, etc[8]. The research and technology output of foreign R&D centers in India comes both in the form of patents and research papers. The present paper analyses the publication output of only 21 most productive foreign MNC R&D centers in India.

2. OBJECTIVES

The main objectives of this paper is to analyse the publication output of most productive 21 foreign MNC R&D centers in India publishing 50 or more papers during 2003-2012. The specific objectives are to:

- Analyse the overall publication growth and citation quality of their publication output;
- Analyse the share of international collaboration papers, the share of various collaborating countries and the study of major collaborating linkages between foreign R&D centers and Indian organisations;
- Analyse subject-wise scatter of their publications; and
- Study the productivity and citation impact of individual 21 foreign R&D centers in India.

3. METHODOLOGY AND DATABASE

The study is based on publication data, derived from international multidisciplinary Scopus database (http://www.scopus.com) for 10 years from 2003 to 2012. The Scopus is one the world's largest abstract and citation database of peer-reviewed literature.

The study has used two types of search strategies. The first search strategy was focussed on individual 21 foreign MNC R&D centres. The individual R&D centre name was searched under "Affiliation" tag along with India "Country" tag and period from 2003-12 under "Date Range" tag. This search strategy was further restricted to: (i) Citation count and citation window of three years and information on *h*-index by ticking 'Citation' tag and (ii) information on international collaborative papers by ticking the 'Country' tag. Such a search strategy was run individually for all 21 foreign R&D centres to get information on their total papers, total citations (on three year citation window), average citation per paper, *h*-index and international collaborative papers. The second search strategy combined the search strategies of all individual 21 foreign R&D centres. This combined search strategy was further restricted to 'Country' tag to get information on collaborative countries and their publication output, 'Affiliation' tag to get information on different type of national collaborative institutions and their output and 'Subject' tag to get information on different subject fields and their publications output and citation impact data.

For analysing the average citation per paper, the citation data for three years, two years and one year citation windows have been used for all articles published during 2003-10, 2011, and 2012.

((AF-ID("Texas Instruments India Ltd" 60036281))) OR ((AF-ID("GE Global Research India" 60048593))) OR ((AF-ID("GE John F. Welch Technology Centre" 60003296))) OR ((AF-ID("Microsoft Research India" 60098465))) OR ((AF-ID("Samsung Electronics India Software Operations Ltd." 60079429))) OR ((AF-ID("Intel Technology India Pvt Ltd."60097645))) OR ((AF-ID("General Electric Company India" 60094574))) OR ((AF-ID("Bell Labs Research Center India" 60081331))) OR ((AF-ID("ABB Corporate Research India"60076028))) OR ((AF-ID("Accenture Services Pvt Ltd. India" 60099706))) OR ((AFFIL(yahoo*) AND AFFIL(india))) OR ((AFFIL(hewlett*) AND AFFIL(bangalore))) OR ((AFFIL(astrazeneca*) AND AFFIL(bangalore))) OR ((AFFIL(cisco*) AND AFFIL(india))) OR ((AFFIL(general AND motors) AND AFFIL(bangalore))) OR ((AF-ID("IBM India Research Laboratory New Delhi"60003329))) OR ((AF-ID("Honeywell International India Pvt. Ltd." 60080087))) OR ((AF-ID("Philips Electronics India Limited" 60079587))) OR ((AFFIL(stmicroelectronics) ANDAFFIL(india))).

4. ANALYSIS

4.1 Publication Output, Citation Impact and International Collaborative Papers

The cumulative publication output of 21 foreign MNC R&D centers in India consisted of 3040 papers during 2003-12, which increased from 82 papers in 2003 to 429 papers in 2012, witnessing an annual average growth rate of 23.56 %. Of the total papers of these 21 foreign R&D centers in India, 64.25 % appeared as conference papers, 31.72 % as articles, 1.81 % as reviews, 1.42 % as editorial and others as article in press, notes, letter, short survey, book

and erratum. The average citation impact per paper registered by these 21 foreign R&D centers in India was 2.29 during 2003-12 (Table 1).

Table 1. Publication output, citation impact and international collaboration share of foreign R&D centers in India, 2003-12

Period	Total papers	Total citations	Average citations per paper	International collaborative papers (%)
2003	82	217	2.65	49 (59.76)
2004	153	456	2.98	69 (45.1)
2005	196	368	1.88	85 (43.37)
2006	273	683	2.50	135 (49.45)
2007	375	1186	3.16	174 (46.4)
2008	422	1485	3.52	166 (39.34)
2009	334	1231	3.69	153 (45.81)
2010	336	802	2.39	168 (50)
2011	440	474	1.08	199 (45.23)
2012	429	75	0.17	201 (46.85)
Total	**3040**	**6977**	**2.29**	**1399 (46.02)**

4.2 Share of International Collaborative Papers

The average international collaborative publication share of these 21 foreign MNC R&D centers in India was 46.02 % during 2003-12 (Table 1). The largest share (67.26 %) of international collaborative publications of foreign R&D centers in India was registered by United States during 2003-12, followed by behind by U.K (5.50 %), Canada (4.15 %), France, Germany, Australia, Singapore, Italy and China (between 3.15 % to 3.93 %), Japan, Switzerland, Netherlands and Sweden (between 2.00 % to 2.36 %), Spain, South Korea, Israel and Taiwan (between 1.22 % to 1.57 %), etc. The largest share of international collaborative publications of USA was mainly because most of the foreign R&D centers in India having their parent offices in USA (Table 2).

4.3 National Collaborative Linkages

On analysing the national collaborating linkages of the 21 foreign R&D centers in India during 2003-12, it was observed that their highest number of collaborative linkages (222) was with Indian Institute of Science, Bangalore, followed by Indian Institute of Technology (IIT), Delhi (85), IIT-Kharagpur (75), IIT-Madras (57), IIT-Bombay (52), IIT-Kanpur (33), Indian Statistical Institute–Kolkata (20), Indian Institute of Information Technology, Bangalore (15), Indian Institute of Information Technology, Hyderabad (13), Tata Institute of Fundamental Research, Mumbai (11), IIT-Roorkee (9), Sri Sathya Sai University, Anantpur (9), Jawarharlal Nehru Centre for Advanced Scientific Research, Bangalore (8), Indian Institute of Science, Education and Research, Kolkata (8),

Table 2. Share of international collaborative papers of collaborating counties of foreign R&D centers in India, 2003-12

Collaborating country	International collaborative papers (% ICP)
USA	941 (67.26)
UK	77 (5.5)
Canada	58 (4.15)
France	55 (3.93)
Germany	52 (3.72)
Australia	44 (3.15)
Singapore	44 (3.15)
Italy	44 (3.15)
China	44 (3.15)
Japan	33 (2.36)
Switzerland	31 (2.22)
Netherlands	31 (2.22)
Sweden	28 (2.0)
Spain	22 (1.57)
South Korea	22 (1.57)
Israel	19 (1.36)
Taiwan	17 (1.22)
Finland	11 (0.79)
Romania	11 (0.79)
Greece	9 (0.64)
Austria	8 (0.57)
Iran	8 (0.57)
Russia Federation	8 (0.57)
Belgium	7 (0.5)
Brazil	7 (0.5)
Czech Republic	7 (0.5)
Malaysia	7 (0.5)
Denmark	6 (0.43)
Mexico	6 (0.43)
Hungary	5 (0.36)
Poland	5 (0.36)
Total	**1399**

Bengal Engineering & Science University, Howrah (7), Jadavpur University, Kolkata (7), Birla Institute of Technology & Science, Pilani (6), IIT-Guwahati (6), J.N. Technological University, Hyderabad (6), Vellore Institute of Technology (5), Manipal Hospital (5), National Aerospace Laboratories, Bangalore (5), Jawaharlal Nehru University, Delhi (5), Infosys Technologies Ltd., Bangalore (4), Chennai Mathematical Institute (4), Anna University, Chennai (4), PSG College of Technology, Coimbatore (4), Birla Institute of Tehnology, Mesra (4), etc.

4.4 Individual Bilateral Collaborative Linkages

In terms of individual bilateral collaborative linkages of 21 foreign R&D centers in India with national organisations during 2003-12, the highest (39) was between Texas Instruments India Ltd., Bangalore and Indian Institute of Science, Bangalore, followed by IBM India Research Lab, New Delhi and Indian Institute of Technology, Delhi (29), Honeywell International India Pvt. Ltd., Bangalore and Indian Institute of Science, Bangalore (23), Texas Instruments India Ltd., Bangalore and Indian Institute of Technology, Madras (17), Microsoft Research India and Indian Institute of Science, Bangalore (13), Philips Electronics India Ltd. and Indian Institute of Science, Bangalore (13), Yahoo Research Lab and Indian Institute of Science, Bangalore (13), Honeywell International India Pvt. Ltd., Bangalore and Indian Statistical Institute, Kolkata (12), GE John Welch Technology Center and Indian Institute of Science, Bangalore (9), Intel Technology India Pvt. Ltd. and Indian Institute of Technology, Bombay (9), etc. From the above, it is clear that the major portion of national collaborative linkages of foreign R&D centers in India are with institutes of national importance in India.

4.5 Subject-wise Distribution of Publications

Looking at the subject-wise distribution of publications of 21 foreign MNC R&D centers in India during 2003-12, it was observed that the largest contribution is from computer science with 48.55 % share, followed by engineering (45.72 %), mathematics (11.81 %), materials science (10.43 %), physics & astronomy (7.83 %), biochemistry, genetics & molecular biology (5.07 %), chemistry (3.55 %), medicine (3.39 %), chemical engineering (3.19 %), etc. In terms of citation impact of publications of 21 foreign R&D centers in India as measured by average citation per paper over three year citation window, the highest (4.10) citation impact was registered by medicine, followed by chemistry (3.44), pharmacology, toxicology & pharmaceutics (3.19), physics & astronomy (2.56), chemical engineering (2.47), materials science (2.46), biochemistry, genetics & molecular biology (2.38), computer science (2.23), engineering (2.14), etc. (Table 3).

4.6 Most Productive MNC R&D Centers

The top 21 most productive foreign MNC R&D centers in India involved in research have published 50 to 364 papers each during 2003-12. These 21 foreign R&D centers together have published 3052 papers (which includes 3040 plus 12 collaborative papers among 21 MNCs) with a average productivity per center of 145.33 during 2003-12. The publication profile of these 21 foreign R&D centers in India along with their research output, citations, *h*-index and ICP values are presented in Table 4. Only seven foreign R&D centers have registered higher output than the group average productivity of 145.33. These are IBM Research Lab, New Delhi with 364 papers, followed by Texas Instruments India Ltd., Bangalore (293 papers), GE Global Research, Bangalore (286 papers), General Motors India, Bangalore (272 papers), Honewell International India Pvt Ltd., New Delhi (181 papers), Microsoft Research India, Bangalore (171 papers), and GE John Welch Technology Centre, Bangalore (154 papers).

The average citation per paper registered by the total papers of these 21 foreign R&D centers was 2.29 during 2003-12 and eight R&D centers have registered higher citation impact than their group

Table 3. Subject-wise distribution of publications of 21 foreign R&D centers in India, 2003-12

S. No.	Sub-field	TP	TC	ACPP	% TP
1.	Computer Science	1476	3294	2.23	48.55
2.	Engineering	1390	2972	2.14	45.72
3.	Mathematics	359	705	1.96	11.81
4.	Materials Science	317	779	2.46	10.43
5.	Physics & Astronomy	238	609	2.56	7.83
6.	Biochemistry, Genetics & Molecular Biology	154	367	2.38	5.07
7.	Chemistry	108	372	3.44	3.55
8.	Medicine	103	422	4.10	3.39
9.	Chemical Engineering	97	240	2.47	3.19
10.	Energy	68	130	1.91	2.24
11.	Pharmacology, Toxicology & Pharmaceutics	59	188	3.19	1.94
12.	Environment Science	51	48	0.94	1.68
	Total of 21 Foreign R&D centers in India	**3040**			

TP=Total papers; TC=Total citations; CPP=Average citations per paper

Note: There is some overlapping of literature under different sub-fields. As a result, the combined output of 21 R&D centers in India under 12 sub-fields listed above will be more than its actual total output

Table 4. Productivity and research impact profile of foreign R&D centers in India, 2003-12

Name of R&D center	TP	TC	ACPP	*h*-Index	ICP	% ICP
IBM Research Lab, New Delhi	364	870	2.39	20	188	51.65
Texas Instruments India Ltd., Bangalore	293	420	1.43	13	79	26.96
GE Global Research, Bangalore	286	554	1.94	15	172	60.14
General Motors India, Bangalore	272	759	2.79	18	123	45.22
Honewell International India Pvt..Ltd., New Delhi	181	246	1.36	10	45	24.86
Microsoft Research India, Bangalore	171	546	3.19	11	93	54.39
GE John Welch Technology Centre, Bangalore	154	542	3.52	17	80	51.95
Yahoo Labs, Bangalore	143	381	2.66	12	78	54.55
Samsung Electronics India Software Operational Ltd., Bangalore	136	97	0.71	7	28	20.59
Intel Technology India Ltd., Bangalore	128	594	4.64	14	70	54.69
Hewlett Packard Labs, Bangalore	139	236	1.70	11	42	30.22
Philips Electronics India Ltd., Mumbai	122	117	0.96	7	28	22.95
GE India Technology Center, Bangalore	105	258	2.46	15	53	50.48
Bell Labs Research Centre India, Bangalore	90	353	3.92	13	56	62.22
Astra Zeneca India, Bangalore	82	501	6.11	15	42	51.22
STMicroelectronics Pvt. Ltd., Greater Noida	77	106	1.38	6	45	58.44
ABB Corporate Research India, Bangalore	71	61	0.86	6	35	49.30
CISCO Systems, Bangalore	65	92	1.42	7	34	52.31
Motorola India Pvt. Ltd., Gurgaon	65	97	1.49	6	17	26.15
Synopsys India Pvt. Ltd., Noida	58	94	1.62	6	25	43.10
Accenture Services Pvt, Ltd., Bangalore	50	59	1.18	5	7	14.00
Total	**3052***	**6983**	**2.29**	**11.14**	**1340**	**43.91**

TP = Total papers; TC = Total citations; CPP = Average citations per paper; CP = International collaborative papers

*On adding the individual papers of 21 MNCs, their sum comes to 3052 papers (which includes 3040 papers plus 12 collaborative papers among these 21 foreign MNCs)

average. They are Astra Zeneca India, Bangalore with citation impact per paper of 6.11, followed by Intel Technology India Ltd., Bangalore (4.64), Bell Labs Research Centre India, Bangalore (3.92), GE John Welch Technology Centre, Bangalore (3.52), Microsoft Research India, Bangalore (3.19), General Motors India, Bangalore (2.79), Yahoo Labs, Bangalore (2.66) and IBM Research Lab, New Delhi (2.39).

The average *h*-index value of these 21 most productive foreign R&D centers in India was 11.14 and 10 centers have achieved higher *h*-index value than the group's average. These are IBM Research Lab, New Delhi with *h*-index of 20, followed by General Motors India, Bangalore (18), GE John Welch Technology Centre, Bangalore (17), GE Global Research, Bangalore (15), GE India Technology Center, Bangalore (15), Astra Zeneca India, Bangalore (15), Intel Technology India Ltd., Bangalore (14), Texas Instruments India Ltd., Bangalore (13), Bell Labs Research Centre India, Bangalore (13) and Yahoo Labs, Bangalore (12) (Table 4).

5. CONCLUSIONS

The 21 MNCs foreign R&D centers in India contributed 3040 papers, increasing annually from 82 to 429 from 2003 to 2012, and witnessing an annual average growth rate of 23.56 %. These 21 foreign R&D centers have registered an average citation impact per paper of 2.29 and 46.02 % of their papers involve foreign collaboration, predominately with their parent companies country of affiliation. USA accounted for 67.26 % share in international collaborative papers of these centers, followed by UK (5.5 %), Canada (4.15 %), France (3.93 %), Germany (3.72 %), Australia (3.15 %), etc. A significant large share of national collaborative linkages of these 21 foreign R&D centers are with Indian institutes of national importance, but also involves R&D laboratories, engineering colleges, universities, hospitals, etc. Computer science and engineering accounts for the largest share (48.55 % and 45.72 %) of output of foreign R&D centers, followed by mathematics (11.81 %), materials science (10.43 %), physics & astronomy (7.83 %),

biochemistry, genetics & molecular biology (5.07 %), chemistry (3.55 %), medicine (3.39 %), chemical engineering (3.19 %), etc.

The analysis of the publication output of foreign R&D centers in India presented throws some light on the quantum of their research output and research impact, nature of research activities in terms of various subject fields and the type of collaborative linkages with different type of Indian organisations (including identification of key collaborating partners) and with different countries. Such an analysis will be helpful for Indian policy makers to gauge the usefulness of such activities on Indian R&D and its impact on Indian economy.

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