Chemistry research in India: A bright future ahead

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Introduction

Chemistry is the most preferred research area among Indian scientists for quite some time in terms of total number of publication, global share, visibility and citation impact are concerned. Growth rate of India in chemistry research area is more than that of global growth rate as evidenced from the data covered in Web of Science database (WoS). The trend of research output in chemistry clearly indicates that India is steadily putting stiff challenge to traditionally established countries like Japan and Germany and even surpassed them in 2014 to acquire 3rd position in global ranking. From this study we predict that India will grow further in chemistry research area and even can put challenge to USA and China in long run.

The output and trend of science & technology (S&T) research in India are of considerable interest to scientometricians from all over the world for quite some time. Gupta and Dhawan (2009), Glänzel and Gupta (2008) and Gunasekaran, Batcha and Sivaraman (2006) have studied different aspects of S&T research in India.

Methodology

Data sources and processing

All bibliometric data have been extracted from WoS Core Collection of Thomson Reuters till April 30, 2015. The period for publication activity has been taken for six years (2009-2014) as findings till 2008 are available in literature.

Results and Discussions

In chemistry research area a total 1,045,343 number of papers has been published during the period 2009-2014. USA and China are leaders in this field in terms of number of publications with global share of 22.502% and 20.792% respectively. India is at 5th position with global share of 5.767%. Chemistry research output of ten most productive countries excluding USA and China in terms of global share has been shown in Figure 1. India's growth is very steady during this period and acquired 3rd position in 2014 followed by USA and China, with global share of 6.456%. India has published maximum number of research papers in Chemistry compared to other research areas and its global share in chemistry research has been increased steadily during 2009 to 2014.

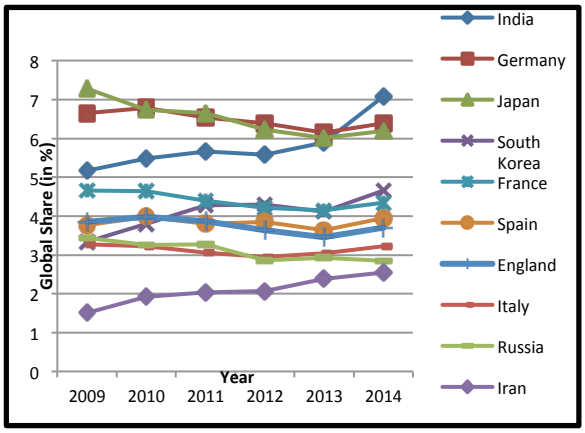

Figure 1. Global share of countries in chemistry.

It is evident from Figure 1 that global share of Japan has been decreased during 2009-2014 and its positions in global ranking have been fallen from 3rd position in 2009 to 5th position in 2014. Global share of Germany in Chemistry research has been decreased slightly during this period but Germany has managed to keep its position at 4th during the entire period. South Korea and Iran have increased their research output in chemistry steadily in terms of global share during this period. Research output of other countries (France, England, Spain, Italy and Russia) shown in this Figure are comparable to each other in chemistry and they are placed in between 7th to 11th positions during this period.

Table 1 shows India's ranking in major research areas covered in WoS during 2009-2014. In terms of number of publications and global share, India's performance is the best in Chemistry.

In Table 2 we have shown the h-index and average citation per article in chemistry during 2009-2012. We see that h-index and average citation per article are comparable with that of Japan and Germany.

Table 1. India's Position in major research areas in terms of global share.

Research Areas	2009	2010	2011	2012	2013	2014
Physics	10	9	8	8	7	**7**
Chemistry	5	5	5	5	5	**3**
Materials Science	7	6	6	6	**5**	6
Engineering	11	12	11	6	**4**	6
Computer Science	12	12	9	**3**	4	11
Biochemistry Molecular Biology	12	11	11	11	10	**9**
Neuroscience Neurology	18	17	17	16	**16**	17

Table 2. Comparison of citation and h-index of chemistry publications during 2009-2012.

Countries	2009		2010		2011		2012	
	h- index	Avg Citation	h- index	Avg Citation	h- index	Avg Citation	h- index	Avg Citation
India	83	11.54	78	10.39	66	8.41	57	6.49
Japan	106	15.83	97	13.81	89	11.63	66	7.94
Germany	118	19.86	125	19.29	95	14.04	74	9.94

Conclusions

This study clearly indicates the trends in chemistry research during 2009-2014 for most productive countries in terms of number of publications and global share. It is evident from the results that India has done remarkable progress in chemistry research area during this period. One of the reasons for this progress is that quite a few key persons in science policy makers in India are having chemistry background. Indian scientists working in the field of chemistry are more focused and recognized worldwide as many of them have been awarded TWAS prize and fellowship, FRS, and other distinguished international fellowships and medals. Strong collaboration between India and other countries in chemistry research is worth mentioning as 10,941 numbers of papers out of total 60,285 are published in collaboration. As a traditional subject, most of the Indian universities teach chemistry and around 40% of total publications is contributed by the universities. Research laboratories also get a steady flow of trained students with chemistry background from universities. Looking at the distribution of the publications to the institutes we see that CSIR laboratories publish most (11,037) followed by IITs (7,382) in chemistry. Some of the most productive laboratories in chemistry research in India are BARC (2,394), IICT (2,210), IISc (2,065), IACS (1580) and NCL (1,508). Prominent universities in chemistry research are JU (1,262), DU (1,182) and BHU (1,136). We see that there is almost no role of industries as per the funding of research is concerned in the field of chemistry in India. CSIR, DST and UGC are the major sponsors in chemistry research in India. As per the topic or subject category is concerned where Indian scientists publish more, we see Physical chemistry is the most focused (29%) followed by Organic (20%), Inorganic (11%), Analytical (10%), Applied (7%), Nanoscience (6%) and Atomic-Molecular (5%) respectively. The bright side of chemistry research in India is also reflected in the number of patents granted in this subject area. From Derwent Innovations Index of WoS, we see that out of total 462 numbers of patents granted to Indian innovators during 2009-2014, 330 numbers i.e. 71% are in the field of chemistry. Interestingly, DRDO, India holds most (79%) of the patents. The picture is not much different in Indian patent database (http://ipindiaservices.gov.in/publicsearch/), where we see 4,801 numbers of patents (i.e. 37%) have been granted in chemistry research area out of total 12,982 patents granted in all fields during 2009-14. India has a large consumer base. As a result chemical industries in different sectors like fertilizer, pesticide, plastic, paint, petro-chemical, medicine, cosmetics and health care products are thriving in India. So career as research scientist in chemistry is attractive for better placement in the R&D labs of those industries. India's contribution in chemistry research has been recognized by ACS and designated IACS, Kolkata on 15/12/1998 as International Historic Chemical Landmark for C V Raman and the Raman Effect.

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Main Institutional Sectors in the Publication Landscape of Spain: The Role of Non-profit Entities

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Introduction

The study of national efforts in R&D by institutional sector is a matter of great concern because sectors differ in their main activities, accounting systems, orientation towards research and type of R&D (OECD, 2003). However, bibliometric analyses at the level of institutional sectors are not very common because the assignation of centres to sectors is not free of difficulties and the resulting sectors may entail a certain degree of heterogeneity. The role of institutional sectors in the scientific activity of countries, either for the total country (Godin & Gingras, 2000; Moya et al., 2013) or in a given field (Lander, 2013), has been analysed in the literature, although studies dealing with specific sectors such as universities or companies are much more frequent.

In most countries, main institutional sectors in publications include universities, hospitals and public research centres, while papers from non-profit entities (NPE) are usually scarce. Although this applies in Spain, an impressive increase in papers from NPE has been observed in the last fifteen years. This paper aims to analyse the research performance of non-profit entities in Spain with regard to activity, impact and collaboration; to locate them in the national context; and to identify main types of active organisations.

Methods

Spanish publications (original articles and reviews), hereafter papers, covered by Web of Science (WoS, 2000-2011), search strategy CU=Spain and PY=2000-2011, are analysed. Six institutional sectors are identified in all addresses through a semi-automatic process (Morillo et al., 2013) followed by a manual revision to assess validity: companies, health sector, non-profit entities, public administration, public research centres and university. A full counting method is used.

The impact of publications is analysed through the percentage of papers in first quartile journals within each field (%Q1), normalised position (NP) (Bordons & Barrigón, 1992), relative impact factor (RIF), % non-cited papers and citations relative to country average (RC) (three-year citation window). The orientation of sectors towards collaborative research is explored through the number of authors per paper, number of institutions per paper and collaborative pattern (percentage of papers with a single institution, percentage of papers with national collaboration, percentage of papers with international collaboration). An in-depth analysis of NPE is carried out. The NPE's activity index (AI) in ten broad thematic areas is obtained to gain insight into the specialisation profile of these entities as compared to Spain.

Results

Main institutional sectors in Spanish papers in WoS (2000–2011) include university (66%), public research organisations (22%) and the health sector (18%). Non–profit entities amount to 10% of the papers, and show the highest increase during the period (3% of the country output in 2000 vs. 18% in 2011). This sector shows high specialization in Biomedicine (AI=1.59) and Clinical Medicine (AI=1.67). Collaboration in NPE is above the country average in terms of team size (11 vs. 8), number of institutions per paper (5 vs. 3) and share of collaborative papers (91% vs. 68%). NPE show also the highest shares of both nationally and internationally co-authored papers (75% vs. 41% and 45% vs. 40%, respectively). NPE display the highest percentage of papers in high-quality journals and the highest impact through relative citations (Table 1).

From the inspection and categorization of the NPE, the following organisational types emerge: foundations (50.3%), research networks (24.6%), consortia (16.0%), research management entities (12.2%), associations (6.5%), and scientific parks (1.0%). The highest increase during the period corresponds to research management entities and research

networks. Research management entities stand out because of their high figures in both the percentage papers in high impact factor journals and relative citations (Table 2).

Research management entities show the lowest proportion of papers with a single institution (2%), a high share of papers with national (89%) and international collaboration (68%), and the highest average team size. The highest share of papers in Q1 journals is observed for co-authored activity between national and foreign partners for all sectors except associations and research networks.

The specialization of NPE varies according to the organisational type: Biomedicine and Clinical Medicine for networks, consortia and foundations; Physics for research management entities; Biomedicine and Chemistry for scientific parks; and Engineering for associations.

Conclusions

The in-depth analysis of the NPE in Spain shows the rising trend of different organisational types which differ according to the field and respond to specific strategic procedures to manage research (creation of foundations in the context of medicine, networks for clinical research, scientific parks to link basic and applied research in the university context, etc.). Interestingly, some of these organisational types (research networks, consortia, parks) include cross-sector and cross-discipline collaboration which is supposed to lead to major discoveries in science and even to radical innovation. Collaboration in the context of the structured and stable framework provided by these organisational forms is more effectively enhanced than through occasional collaborative projects. Our data indicate the success of these emerging organisations in supporting/conducting high impact research.

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Table 1. Number of papers and impact indicators by institutional sector in Spain (WoS 2000-2011)

	No. Papers	NP	%Q1	%Non cited papers	RC	RIF
Universities	271399	0.66	47.93	23.45	0.85	0.89
Public Research Centres	91095	0.74	62.41	12.94	1.31	1.24
Health sector	74337	0.59	39.66	21.32	1.20	1.16
NPE	41605	0.74	62.59	10.56	1.75	1.57
Public Administration	17238	0.66	49.04	20.65	1.01	0.96
Companies	15682	0.63	43.72	22.15	0.81	0.84

Table 2. Number of papers and impact indicators of the NPE by organisational type (WoS 2000-2011)

	No. Papers	NP	%Q1	%Non cited papers	RC	RIF
Foundations	20934	0.76	65.50	9.71	1.82	1.67
Research Networks	10249	0.75	63.16	7.18	1.83	1.74
Consortia	6651	0.73	60.83	9.88	1.69	1.55
Research Management Entities	5074	0.81	76.47	6.42	2.71	1.96
Associations	2692	0.66	47.73	20.84	0.90	0.94
Scientific Parks	310	0.76	66.11	8.71	1.21	1.55
Other NPE	1204	0.60	35.35	27.99	0.75	0.76