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Field-normalized bibliometric evaluation of leading research institutions in chemistry in China and India

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Chemistry is the biggest area of research in which India publishes and it is the second biggest for China in recent years. Within this broad research area, the Council of Scientific and Industrial Research (CSIR) is India's biggest single academic research contributor, while the Chinese Academy of Sciences (CAS) is China's biggest player. In this communication, we use field-normalized bibliometric indicators from the latest (2013) release of SCImago Institutions Rankings World Reports to show that while the leading institutions from CSIR are showing a declining trend in the quality of research output, their counterparts from CAS are rapidly improving on both quality and quantity terms.

Keywords: Bibliometric indicators, chemistry, field-normalization, research institutions ranking.

THE Council of Scientific and Industrial Research (CSIR) and the Chinese Academy of Sciences (CAS) are the premier R&D agencies in India and China respectively. While the former has 38 constituent units (laboratories, centres, institutes, etc.), the latter has 124 institutions. In both agencies, institutes dedicated to research in the broad area of chemistry are prominent for their output and quality of research. In India, chemistry is the area in which the largest output is seen, while in China it is the second largest area of research (after engineering). Within the broad research area of chemistry, CSIR and CAS are the biggest single academic research contributors for India and China respectively.

Most bibliometric exercises are based on using publication counts and citation-based statistics which do not account for varying citation practices in different disciplines[1]. Schubert and Braun[1] pointed out that comparative assessment of scientometric indicators is greatly hindered by the different standards valid in different science fields and sub-fields. Indicators from different fields can be compared only after first gauging them against a properly chosen reference standard, and thereafter their relative standing can be estimated. This makes comparison and benchmarking of laboratories difficult unless some form of field-normalization is implemented. The SCImago Institutions Rankings (SIR) World Reports[2] (http://www.scimagoir.com/) present secondary bibliometric data in

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the form of indicators that enable field-normalization to be introduced into the comparative studies. Field-normalization can show up surprising and counter-intuitive results. One of the surprises that came up was that while the leading institutions in CSIR where significant research in chemistry is done are showing a noticeable decline in field-normalized quality indicators, their counterparts in CAS are showing that growth in quantitative terms can be accompanied by increasing quality indicators as well. This is the issue discussed in this communication.

The SIR World Reports evaluate the research performance of leading research institutions in the world, using bibliometric data from *Scopus* (www.scopus.com), an Elsevier product. The bibliometric analysis is based on indicators addressing issues like the scientific impact, thematic specialization, output size and international collaboration networks of the institutions. Typically a report for a year covers the output over a rolling window of five years previous to that year (e.g. the report for 2009 covers the period 2003–07). The institutions have been chosen on the basis of having published at least 100 scientific documents of any type, that is, articles, reviews, short reviews, letters, conference papers, etc. during the last year of the respective five-year window as collected by *Scopus*. This selection of institution accounts for nearly 80% of all research (according to the *Scopus* database). In the regenerated reports for 2009 to 2013, 24 subordinate institutions (out of 38) belonging to CSIR and 94 subordinate institutions (out of 124) belonging to CAS are separately listed.

Unlike other bibliometric exercises, the SIR methodology is based on bibliometric data that can be distinctly identified with quantity and quality attributes[2]. Radojicic and Jeremic[3] have recently pointed out that where multiple quality indicators are given along with the quantity dimension (usually the absolute number of published papers), it is possible to find an optimal distance measure that integrates these indicators. The statistical *I*-distance method they employed on the dataset presented by *SCImago* Institutions Rankings methodology led to the conclusion that quality indicators such as 'excellence rate' and 'normalized impact' are far more important than gross number of published papers. In the present study we shall use a simpler Euclidean distance measure to combine three quality indicators which are intrinsically field-normalized into a composite quality indicator and display this with the quantity indicator on a two-dimensional map. Over time, the academic progress of research institutions can be visualized in the form of performance trajectories[4].

The latest (2013) release of SIR World Reports has regenerated the reports from 2009 to 2013 into a single format. Each report now reflects the current state of the database while maintaining consistency between the reports and the *Scopus* database. This enables one to do longitudinal studies as well that can trace the evolution of progress over the recent past.

The report for 2013, for example, covers the output from 2007 to 2011. Thus by doing a longitudinal examination of the latest five reports, we are in effect covering the bibliometric indicators of the period from 2003 to 2011. The bibliometric indicators in the SIR are proxies chosen to cover the main quantity (output) and quality (scientific impact) dimensions of each in the research performance of each institution as well as additional proxies that measure attributes like thematic specialization and the international collaboration networks of the institutions. The count of scientific documents takes into account articles, reviews, short reviews, letters, conference papers, etc. as collected by one of the leading aggregators of bibliometric data, namely *Scopus*.

In the regenerated reports, eight bibliometric indicators are shown. Among these, we shall for the purpose of our present exercise use only four: one which can be identified with the quantity attribute and another three with quality attributes. Thus, the O (or output) indicator is a measure of the quantity or size of the publication output of an institution and is the total number of documents published in scholarly journals indexed in *Scopus*. The three which are proxies in various ways of the quality of academic research output are:

1. The NI (or normalized impact) which compares the average scientific impact of the institution with the world average impact (taken as 1). It is actually a ratio between the average scientific impact of an institution and the world average impact of papers published in the same time period and subject area (normalized impact). In this sense, it is a field-normalized indicator. Thus a score of 0.8 implies a 20% below average citation performance, while a score of 1.3 means the institution is cited 30% above average.
2. The Q1 (or high quality publications) which is the ratio of publications that the institution publishes in what the *SCImago* team takes as the most influential scholarly journals of the world; those ranked in the first quartile (25%) in their categories as ordered by *SCImago Journal Rank*. Since this is reported as a percentage, the ratio (Q1/25) is again another normalized proxy for quality of publication, with a value of 1 taken as the world average.
3. The ER (or excellence rate) which indicates the percentage of an institution's scientific output that is included into the set formed by 10% of the most cited papers in the respective scientific fields, and serves as a measure of the high quality output of research institutions. Again, the ratio ER/10, allows one to normalize this proxy so that the world average becomes 1. This is also a field-normalized indicator.

The important point to be stressed here is that these three 'quality' indicators intrinsically cover what is called the

Table 1. Ranking of leading CSIR and CAS institutions in chemistry appearing in SIR 2009 to 2013 according to various indicators

Agency	Organization	Output Q					q^2				
		2009	2010	2011	2012	2013	2009	2010	2011	2012	2013
CAS	Institute of Chemistry	4,022	4,187	4,422	4,589	4,571	4.29	4.79	4.90	5.06	5.20
	Changchun Institute of Applied Chemistry	2,921	3,365	3,751	3,941	4,297	3.65	4.12	4.38	4.78	5.20
	Dalian Institute of Chemical Physics	2,934	3,328	3,457	3,590	3,656	2.39	2.64	2.75	3.02	3.33
	Shanghai Institute of Organic Chemistry	2,198	2,240	2,405	2,501	2,661	3.46	3.96	4.33	4.73	5.18
	Lanzhou Institute of Chemical Physics	1,678	1,836	1,848	1,902	2,136	1.93	2.15	2.46	2.83	2.73
	Guangzhou Institute of Geochemistry	1,255	1,458	1,652	1,815	1,898	3.56	3.65	3.76	3.98	4.03
CSIR	Indian Institute of Chemical Technology	2,494	2,638	2,758	2,846	2,867	1.84	2.08	1.83	1.91	1.86
	National Chemical Laboratory	2,198	2,242	2,194	2,087	2,022	3.25	3.10	2.91	2.72	2.57
	National Institute for Interdisciplinary Science and Technology	611	760	861	942	999	4.01	4.35	3.98	4.06	3.71
	Central Electrochemical Research Institute	608	702	798	822	872	1.57	1.83	1.89	1.84	1.51
	Central Leather Research Institute	735	776	794	816	857	1.48	1.42	1.34	1.40	1.27
	Central Salt and Marine Chemicals Research Institute	442	526	602	709	804	4.79	4.19	3.94	3.15	2.83

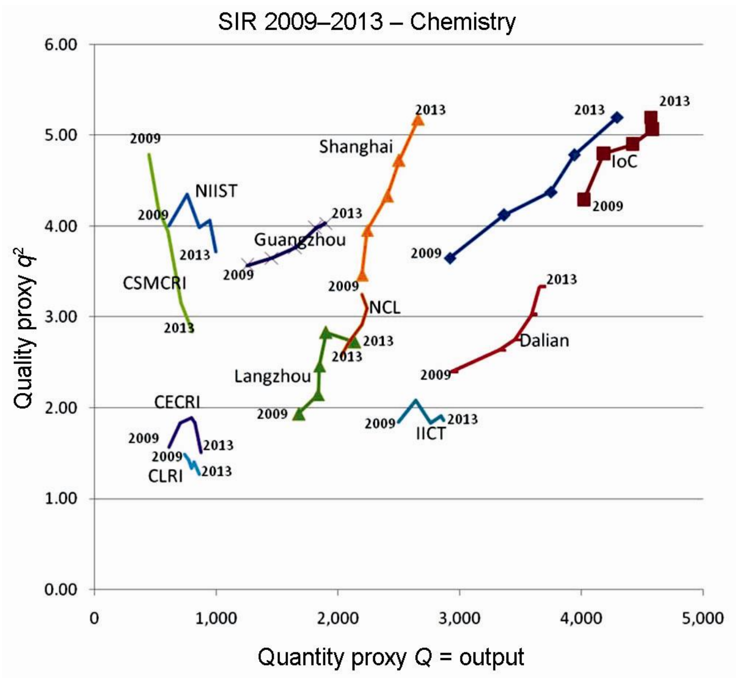

Figure 1. Performance trajectory of the premier CSIR and CAS laboratories in chemistry from 2009 to 2013 on a quality–quantity two-dimensional map.

field-normalization aspect[1], i.e. they account for the fact that the different publication and citation practices across disciplines lead to significantly different citation rates and that this can be normalized by adopting NI, Q1 and ER as bibliometric indicators. Default ranking using output as a single criterion is easy as it is a uni-dimensional indicator. However, as we have three quality indicators, ranking by quality needs these three to be combined into a single composite quality indicator. It is possible to use a Euclidean measure to combine these three quality proxies into a single one. We propose for this purpose, the q^2 proxy, where q^2 is defined as $((NI)^2 + (Q1/25)^2 + (ER/10)^2)/3$. This has the simplicity that it is a composite quality indicator with a value of 1 describing the world norm constituted from three indicators, namely NI, Q1/25 and ER/10, each of which defines a world norm with a value of 1. Thus we have in this analysis simplified the SIR Reports data to a quantity term ($Q = O$) and quality term (q^2). The single composite term, $X = q^2Q$, is that term which serves as the best proxy for total performance

Table 2. Differential progress of the quantity and quality indicators with respect to time

Agency	Organization	DQ/DT	1000 * Dq^2/DT	1000 * Dq^2/DQ
CAS	Institute of Chemistry	150.00	1.33	1.33
	Changchun Institute of Applied Chemistry	332.80	2.27	1.11
	Dalian Institute of Chemical Physics	170.60	1.33	1.15
	Shanghai Institute of Organic Chemistry	118.70	2.56	3.43
	Lanzhou Institute of Chemical Physics	98.20	1.52	1.79
	Guangzhou Institute of Geochemistry	164.30	0.79	0.75
CSIR	Indian Institute of Chemical Technology	95.40	–0.08	–0.08
	National Chemical Laboratory	–50.70	–1.07	–2.69*
	National Institute for Interdisciplinary Science and Technology	95.80	–0.45	–0.73
	Central Electrochemical Research Institute	64.80	0.10	0.15
	Central Leather Research Institute	28.40	–0.26	–1.61
	Central Salt and Marine Chemicals Research Institute	90.70	–3.04	–5.46

*Notation indicating negative trends in numerator and denominator.

in the research context. The best way in which progress can be displayed on a two-dimensional map is to plot the trajectories on a $q^2 - Q$ diagram[4].

In Table 1 we have prepared a league table showing the six leading institutions in each case from CSIR and CAS that are listed in SIR 2009 to 2013 and are prominent for their research in the area of chemistry. This is out of 38 and 124 constituent establishments in the CSIR and CAS families respectively. The table is organized in a manner that lets us see what happens longitudinally over the 2009–2013 period when field-normalized quality indicators are computed. With the exception of the National Chemical Laboratory (NCL), all the other five CSIR laboratories show an increase in output. All six CAS laboratories in the list show even more impressive increase in output during the period. Figure 1 captures the performance trajectories of the premier CSIR and CAS laboratories in the area of chemistry from 2009 to 2013 on a quality–quantity two-dimensional map.

To quantify the rates of progress (change), the following differential indicators are introduced based on the SLOPE function in Excel operating on the row data in Table 1

$$DQ/DT = \text{SLOPE}(Q, T),$$

$$1000 * Dq^2/DT = 1000 * \text{SLOPE}(q^2, T),$$

$$1000 * Dq^2/DQ = 1000 * \text{SLOPE}(q^2, Q).$$

The function SLOPE (known *y*s, known *x*s) returns the slope of the linear regression line through data points in known *y*s and known *x*s. It is the vertical distance divided by the horizontal distance between any two points on the line, which is the rate of change along the regression line. In the formulae above, *T* stands for the march of time. The results are displayed in Table 2. We see that the Chinese laboratories not only have significantly larger output than their counterparts in CSIR (Table 1), but these outputs are also increasing at a faster rate. All six CAS laboratories show an accompanying improvement in the quality parameters as reflected in the change in the composite quality parameter q^2 over time. Five of the six CSIR institutes show a decline in the normalized quality indicators and NCL is in a state of double distress – it has a shrinking output accompanied by a decline in quality.

We have taken a critical look at the academic research output in the area of chemistry of six premier institutes from CAS and CSIR using a field-normalization basis. This allows us to benchmark the performance of the institutions against a putative world norm. All the institutions in this elite category with the exception NCL have a reasonable to high growth rate in output. However, from the quality angle, we see that there is considerable variation. The laboratories in the CSIR family cluster show a discernible decline in the quality of publications. Particularly of concern is the fact that NCL, which was once the jewel in the crown of CSIR, is now in decline both on quantitative and qualitative terms when benchmarked against the world norm. The laboratories from China have shown an impressive improvement in the recent past on both quantitative and qualitative terms.

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