Research competitiveness of Indian institutes of science education and research

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This article describes our effort to measure the research competitiveness of Indian Institutes of Science Education and Research (IISERs) through a scientometric analysis of their research output during the last five years (2010–14). The research output indexed in Web of Science of the five recently established IISERs has been obtained and analysed computationally to identify growth trends, per capita output, authorship and collaboration patterns, citation impact, average citation per paper, etc. The research performance of IISERs is also compared with the Indian Institute of Science, Bengaluru and the Indian Institute of Technology system to obtain an assessment of their research potential. Thus the article presents a useful and detailed analytical account of research potential and competitiveness of IISERs.

Keywords: Authorship and collaboration pattern, citation analysis, research competitiveness, scientometrics.

THE Indian Institutes of Science Education and Research (IISERs) have been established during the last decade as public-funded institutions to promote higher scientific learning and research and scientific exploration at the undergraduate (UG) and postgraduate (PG) levels. The mission and vision statement of IISER, Kolkata (http://www.iiserkol.ac.in/about-us/mission-and-vision) clarifies the objectives as, 'The basic idea of IISER is to create research Universities of the highest caliber in which teaching and education will be totally integrated with the state of the art research'. These institutions are autonomous in nature and are devoted to UG and PG teaching and research in the sciences. Taking into account this specific and important mandate, they have been declared as institutions of national importance (http://mhrd.gov.in/institutions-national-importance). IISERs are designed to become science institutions of the highest calibre and reach the prestigious position and global setting that the Indian Institute of Science (IISc), Bengaluru, the Indian Institute of Technology (IITs) and the Indian Institutes of Management (IIMs) currently enjoy (https://en.wikipedia.org/wiki/Indian_Institute_of_Science_Education_and_Research,_Kolkata). As of now, five IISERs are operational across the country, namely IISER, Kolkata in West Bengal (established in 2006), IISER Pune in Maharashtra (also 2006), IISER Mohali in Punjab (2007), IISER Bhopal in Madhya Pradesh (2008) and IISER Thiruvananthapu-

ram, Kerala (also 2008). The Central Government in its 2015 budget (http://indiabudget.nic.in/ub2015-16/bs/bs.doc) announced the establishment of two more IISERs, one at Berhampur in Odisha and the other in Nagaland. However, these new IISERs are not yet operational. Taking into account the mandate and specialized nature of these institutions, we analyse the research performance of the five operational IISERs during the last five years (2010–14). All these IISERs are operational for at least last 6–7 years and now have noticeable presence in terms of research output as well as faculty strength. We present here outcomes of a detailed analysis of the research output from these institutions published in journals and conferences of repute.

Data collection and methodology

We have collected research output data of the five IISERs, published during the period 2010–14, and indexed in the *Web of Science* (*WoS*) (http://www.webofknowledge.com). We used search queries with substrings of the type: (OG = 'Indian Institute of Science Education and Research (IISER) Pune') for the purpose of data collection for different IISERS. As on 3 May 2015, we found a total of 2340 unique publication records contributed by IISERs during this period, with individual outputs being 275 for IISER Bhopal, 871 for IISER Kolkata, 516 for IISER Mohali, 673 for IISER Pune and 232 for IISER Thiruvananthapuram. This set contains some collaborated research output as well and hence unique records are less than the sum of individual institution outputs. The downloaded records in the data are of several types, namely articles (2178), reviews (50), conference

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papers (12), editorial material (31), book chapters (5), letters (10), meeting abstracts (43), biographical item (1), book review (1), corrections (7), and news items (2). Each record consists of different meta-data of the documents, including authors, title, year of publication, abstract, keywords, references, citation counts, etc. The entire data downloaded are analysed using by R language programs. The csv format results obtained from programs are processed using spreadsheet package to generate plots of results.

We have followed standard scientometric methodology for analysis and computed well-known parameters like total papers (TP), total citations (TC), cited versus uncited papers, average citation per paper (ACPP), international collaborative papers (ICP), highly cited papers (HiCP), h-index[1], g-index[2], hg-index[3], p-index[4], etc. The HiCP is calculated with respect to research output of India (i.e. relative to India and not the whole world) during the period. Top 5% most cited papers from India constitute the HiCP set for the country and the percentage contribution of IISERs to this set is the value of HiCP for IISERs. We have also identified authorship patterns for IISERs. The faculty strength data for IISERs are obtained from their websites to generate a research output–faculty size plot. The research output data indexed in the *WoS* for the given period for the whole of India, IISc, and the IIT system are also obtained for a comparative assessment of the research potential of ISERs.

Research output

In Figure 1, we have plotted the year-wise research output for all the five IISERs (and also IISc). Table 1 gives the values for different indicators. We observe that there is a noticeable increase in the total research output (from 219 in 2010 to 728 in 2014) of the IISERs. Taking into account the fact that these are new institutions with small faculty size and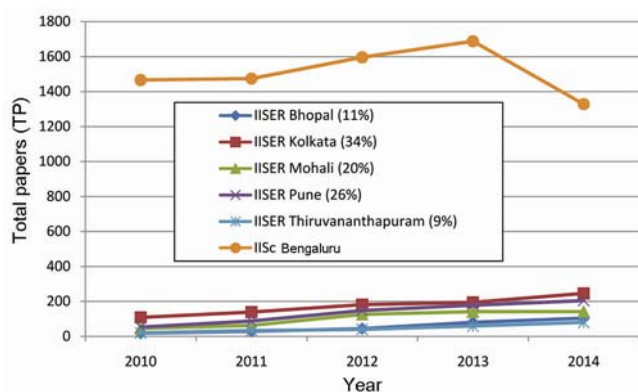 limited infrastructure during the initial phase, the research output produced is noticeable. We have also measured percentage contribution of IISERs to total Indian research output and found that it increased from 0.46 in 2010 to 1.25 in 2014. This is no doubt a noticeable contribution in a short period. Table 1 shows that the older IISERs have higher research output. This may be an indication that as the faculty size of these institutions increase and required infrastructure becomes available; the research output will increase substantially. In terms of research output distribution within IISERs, IISER Kolkata has a highest percentage share (~34), followed by IISER Pune (~26) and IISER Mohali (~20).

In Figure 2 we have plotted the research output versus faculty strength for all five IISERs. Here the bubble size for an IISER is proportional to the total citations its output attracts. We see that IISER Kolkata is best placed in the figure in terms of faculty productivity and citation pattern of its research output. Further, IISER Mohali has higher productivity level than IISER Bhopal, which has comparatively more faculty members. Table 1 also
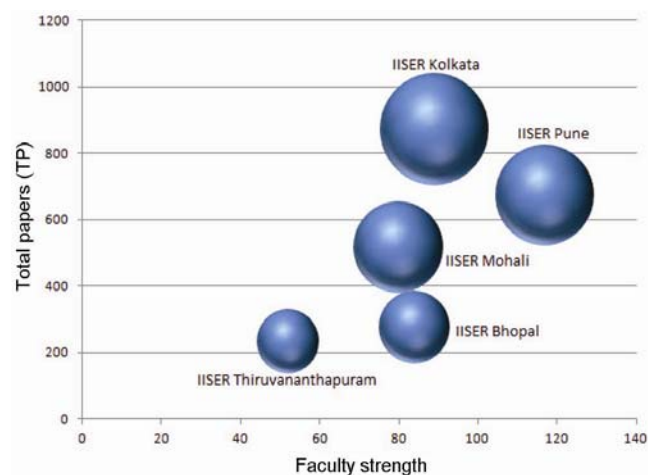

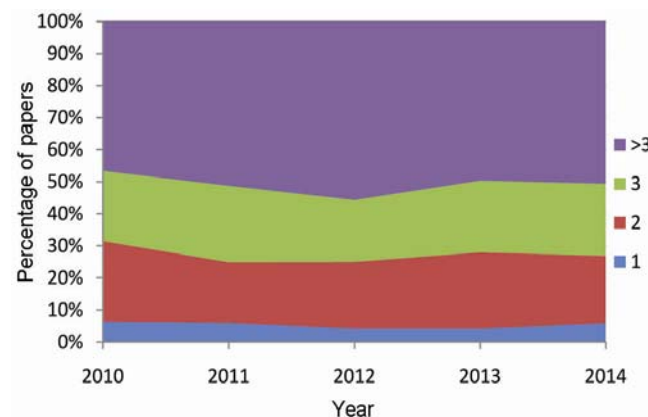**Figure 2.** Research output–faculty strength plot (2010–14).

Figure 1. Total research output of all the Indian Institutes of Science Educational Research (IISERs) and the Indian Institute of Science (IISc), Bengaluru (2010–14).

Figure 3. Authorship pattern for research output of all IISERs (year-wise).

Table 1. Scientometric indicator values for the Indian Institute of Science Education and Research (IISERs) (2010–14)

Institution	Year of establishment	TP	Faculty strength*	TP per capita	TC	ACPP	HiCP	ICP	*h*-index
IISER Kolkata	2006	871	89	9.79	5063	5.81	38	313	28
IISER Pune	2006	673	117	5.75	4161	6.18	33	197	26
IISER Mohali	2007	516	80	6.45	3447	6.68	25	163	26
IISER Bhopal	2008	275	84	3.27	2153	7.83	20	67	20
IISER Thiruvananthapuram	2008	232	52	4.46	1643	7.08	14	91	21

*As on 7 May 2015. TC, Total citations; ACPP, Average citations per paper; HiCP, High cited papers; ICP, Internationally collaborated papers.

Table 2. Scientometric indicator values to compare IISERs, the Indian Institute of Science (IISc) Bengaluru and the Indian Institute of Technology (IIT) system (2010–14)

Parameter	IISER Kolkata (oldest institute)	Average of IISERs	IISc	Average of IITs
TP	871	513	7,552	2021
TP per capita	9.79	5.94	12.18	5.51
TC	5,063	3,293	41,940	12,551
ACPP	5.81	6.71	5.55	5.51
HiCP	38 (4.3%)	26 (5.1%)	737 (9.8%)	421 (20.8%)
ICP	313 (35.9%)	152 (34.5%)	2049 (27.1%)	527 (26.5%)
h-Index	28	24	59	29
g-Index	42	38	88	44
hg-Index	34.3	30.3	72.1	35.8
p-index	30.8	27.4	61.5	33.8

presents some related results. We can see that IISER Kolkata has highest research output (TP) per capita (9.79) followed by IISER Mohali (6.45). However, in terms of average citations per paper, IISER Bhopal performs better, though IISER Kolkata has the highest citations received. IISER Kolkata also takes the top position in terms of ICP instances and *h*-index value. It is worth mentioning that ICP instances and *h*-index values are relatively good for most of the IISERs in such a short time of existence.

Authorship and collaboration pattern

We have analysed authorship and collaboration patterns observed in research output from the IISERs. First we identified how many research papers from each of the II-SERs in a particular year are single-authored and how many are multi-authored (2, 3 or more). Figure 3 shows the authorship pattern year-wise for all the IISERs taken together. We can see that the number of papers with more than three authors is the most significant. In general, there is a clear trend towards multi-authored papers in IISER research output data. Next, we identified how much of the output involves collaboration at the international scale. We analysed the research records and extracted the country information for each collaborated record. Those having at least two authors from different countries are counted as ICP instances. We observed that on an average 34.5% of the research output from IISERs

is internationally collaborated. We further observed that the ICP instances in the total output of IISER system increased from 39.73% in 2010 to 40.63% in 2011, but then declined to 26.32% in 2014. When we compare the ICP instances of IISERs with other institutions, as shown in Table 2, we find that IISERs have substantially more ICP output compared to the IIT system and IISc. The IISER system thus has been able to achieve substantial amount of international collaboration in a short period of time. This indicates the international outlook of the IISERs and the intention to be on forefront of research in science.

Citation analysis

Though IISERs are new and their research output is yet to get an adequate time window for visibility and citations, we, nevertheless, looked at the citation patterns of their research output. First of all, we measured (year-wise) what percentage of research output of IISERs is cited and what percentage is not yet cited. Figure 4 shows the cited percentage (percentage of research output in a year which is cited by at least one paper published later) plot for the IISER research output from 2010 to 2014. The plot also shows the cited percentage curves for the whole of India and IISc. It is interesting to observe that cited percentage of IISERs is higher than IISc, though the cited percentage of IISERs appears congruent in trend to IISc and the whole of India. Next we obtained/computed TC, ACPP and HiCP parameter values for IISERs and compared

them with the whole of India and IISc (Table 2). The IISER average ACPP is 6.71, which is little higher than IISc and the whole of India. However, this may not be sufficient enough to conclude that IISERs will have higher ACPP than other institutions in future, as ACPP tends to be on the higher side when the output is low. We have also computed HiCP for IISERs and found average HiCP percentage of IISERs to be 5.1 compared to 9.8 of IISc and average value of 20.8 for the IIT system. This seems obvious due to lesser output of IISER and shorter time window for citation visibility in addition to the institutions being new and small. Table 2 also shows h, g, hg and p-index values for IISER, IISc and the IIT system. We can see that values for IISERs are quite close to average values of the IIT system. In Figure 5, we plot TP (measuring productivity) versus TC (measuring impact) for all the five IISERs. We can see that IISER Kolkata is on the higher side of the productivity–impact plot followed by IISER Pune and IISER Mohali. The two

Figure 4. Cited percentage of research output of IISERs, IISc and India (year-wise).

Figure 5. Total papers (TP) versus total citations (TC) plot for IISERs (2010–14).

relatively newer IISERs at Bhopal and Thiruvananthapuram have yet to achieve comparable levels.

Conclusion

This article presents a scientometric assessment of research potential and competitiveness of IISERs. With IISERs being specialized, designed and projected as flagship institutions of scientific research and education in India, we obtained a scientometric overview of their research output and also compared them with a benchmark Indian institution (IISc). With IISERs being new institutions and currently in the process of attracting faculty and setting up infrastructure, it may not be proper to do a full-scale comparison with other Indian or world institutions. This has also not been our objective. On the other hand, we tried to analyse the research output of IISERs to make an initial assessment of their research potential and obtain an informed view on their future research prospects. It is interesting to observe that despite being young and small institutions, IISERs have performed well in terms of research. The quantity of research output (measured per capita) and quality of research output of IISERs is congruent and comparable to research output from well-established and premier Indian institutions in scientific research. The future of IISERs in terms of their contribution to scientific research in India looks promising. Further analysis of other relevant data for a longer time period, such as patents obtained, university–industry–government collaboration[5] and innovations, would be useful to make a detailed assessment of the research competitiveness of IISERs.
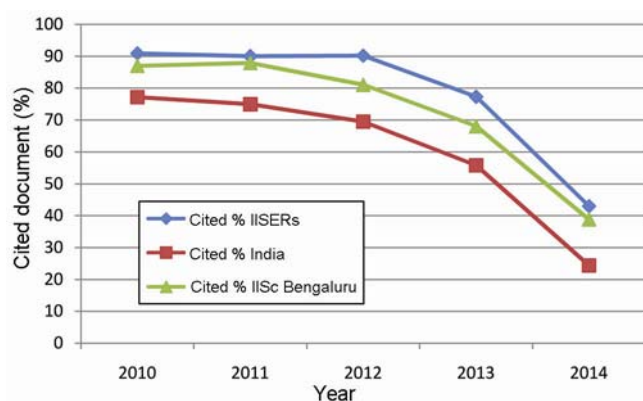
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