



Confederation of Indian Industry

An abstract graphic featuring flowing, overlapping lines in shades of orange and green, with dashed lines following the curves, set against a white background.

# Indian Science *Ascending*

A Nature Index analysis

natureINDEX

Larissa Kogleck  
Subhra Priyadarshini  
Stephen Pincock  
Antoine Bocquet  
Chris Gilloch  
- Springer Nature

**SPRINGER NATURE**

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## natureINDEX



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Nature Publishing Group (NPG) is a publisher of high-impact scientific information in print and online. NPG publishes journals, online databases and services across the life, physical, chemical and applied sciences.

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### NATURE INDEX

The Nature Index ([www.natureindex.com](http://www.natureindex.com)) tracks the affiliations of research articles published in an independently selected group of 68 high-quality science journals, and charts publication productivity for institutions and countries. Article count (AC) includes the total number of affiliated articles. Weighted fractional count (WFC) accounts for the relative contribution of each author to an article and applies a weighting to correct imbalances in the Index's subject coverage towards astrophysics. Weighted collaboration scores are based on the WFCs from bilateral collaborations, and are thus cumulative in case of multilateral collaborations. This report draws on Nature Index data derived from articles published in calendar year 2014. WFC is used throughout as the primary metric.

### CONFEDERATION OF INDIAN INDUSTRY

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, playing a proactive role in India's development process. Founded in 1895, India's premier business association has around 8000 members, from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 200,000 enterprises from around 240 national and regional sectoral industry bodies.

CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes. Partnerships with civil society organizations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, healthcare, education, livelihood, diversity management, skill development, empowerment of women, and water, to name a few.

In its 120th year of service to the nation, the CII theme of **Build India - Invest in Development: A Shared Responsibility**, reiterates Industry's role and responsibility as a partner in national development. The focus is on four key enablers: Facilitating Growth and Competitiveness, Promoting Infrastructure Investments, Developing Human Capital, and Encouraging Social Development.

With 66 offices, including 9 Centres of Excellence, in India, and 8 overseas offices in Australia, Bahrain, China, Egypt, France, Singapore, UK, and USA, as well as institutional partnerships with 312 counterpart organizations in 106 countries, CII serves as a reference point for Indian industry and the international business community.

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*Indian Science*  
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# Foreword



Welcome to this first Nature Index report on science in India. In the following pages you will find a revealing snapshot of the high-quality research being produced by institutions in India as seen through the lens of the Nature Index, a database that tracks the affiliations of research articles published in an independently selected group of 68 superior science journals.

In this report, we have used the index to put India's output in the context of other countries with broadly similar economic conditions. A marked growth in the output of top-quality science and a particular strength in the broad discipline of chemistry are among the interesting findings described here.

This report also reveals the patterns of international collaboration that connect Indian institutions to the global scientific community. Within the journals covered by the index, Indian academic institutions co-author more papers with international companies than with domestic firms.

Since its launch in 2014, the Nature Index has provided a new way to look at the scientific literature and the research organizations that contribute to it. By focusing on articles in a small group of journals favoured by the scientific community as a place to publish their best research, it provides a level of analysis that is more targeted and hence more malleable.

The Nature Index is a product of Springer Nature, a major new force in scientific, scholarly, professional and educational publishing created through the combination of Nature Publishing Group, Palgrave Macmillan, Macmillan Education and Springer Science+Business Media in May 2015.

By harnessing its combined expertise, scale and the reach of its brands, the company aims to serve academic researchers, students, teachers, institutions, professionals and the wider public. As such, we are pleased to present this report in partnership with the Confederation of Indian Industry.

## **Antoine Bocquet**

Vice President Sales Japan, India, Southeast Asia and Oceania  
Managing Director, Nature Japan K.K./Springer Japan K.K.

# Foreword



This report begins with a chapter titled “India’s ascent towards world class science” which sums up in six simple words India’s standing in the world of science. The picture that it presents is also refreshingly different from the common perception about Indian scientific output. This perception – of India failing to produce anything of significant scientific value despite a huge young and capable population -- is largely based on media interest. Positive stories rarely attract the attention they deserve. Hopefully, this maiden CII – Nature Index report will change perceptions.

It shows India at the 13th position globally on an index of world-class scientific journals. A good strategy, which this report adopts, is of comparing India with economically similar regions / countries. At the same time it presents concerns as they are – stagnant funding for R&D as a percentage of GDP, red tape, government indifference and “unfair appointments”.

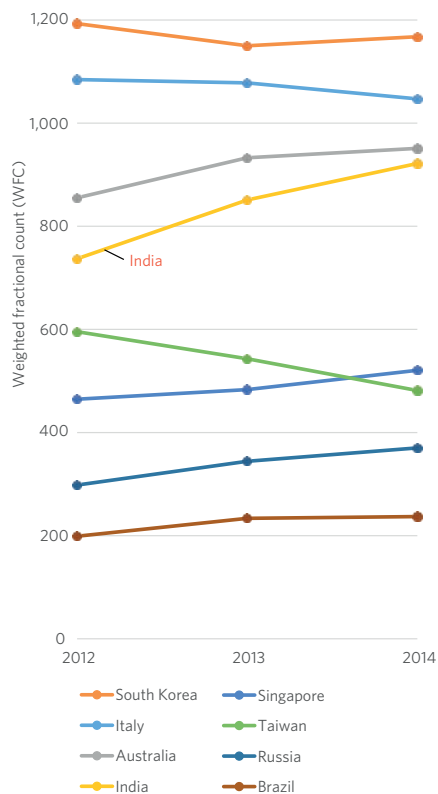
With Prime Minister Narendra Modi recently launching a single-window mechanism, called “Imprint”, for release of funds for R&D to academic institutions, along with a corpus of Rs 1 billion (Rs 1,000 crore), the required correction at government and policy level has begun. Hopefully soon then, our “historic love affair with chemistry”, as this report aptly highlights, will be replicated in other areas of science too.

I hope this report, jointly produced by CII and Nature Index, will become more robust and expansive in years to come.

**Dr Naushad Forbes**

President Designate, CII & Director, Forbes Marshall

# India's ascent towards world-class science



**FIGURE 1** India's ascent | India has steadily increased its contribution in the Nature Index compared to other nations with a similar output and broadly similar economic backgrounds.

Transitioning from a developing country to an emerging economic superpower, India is experiencing an attendant surge in its share of the world's high-quality scientific publications. This rise is clearly indicated in the Nature Index, a database that tracks the affiliations of research articles published in an independently selected group of 68 high-quality science journals.

Since 2012, the country's weighted fractional count (see box: Nature Index on page A) has increased by 185 (Fig. 1). As a result of this growth, India ranked 13th globally in the index in 2014, sandwiched between Australia and the Netherlands, with a weighted fractional count of 921.8 and an article count of 1,484 (Fig. 2).

To place the patterns of India's Nature Index output in an international context, this report compares the country to groups of other nations in the Asia-Pacific, Europe and South America that have similar volumes of index output in 2014 and broadly similar economic backgrounds.

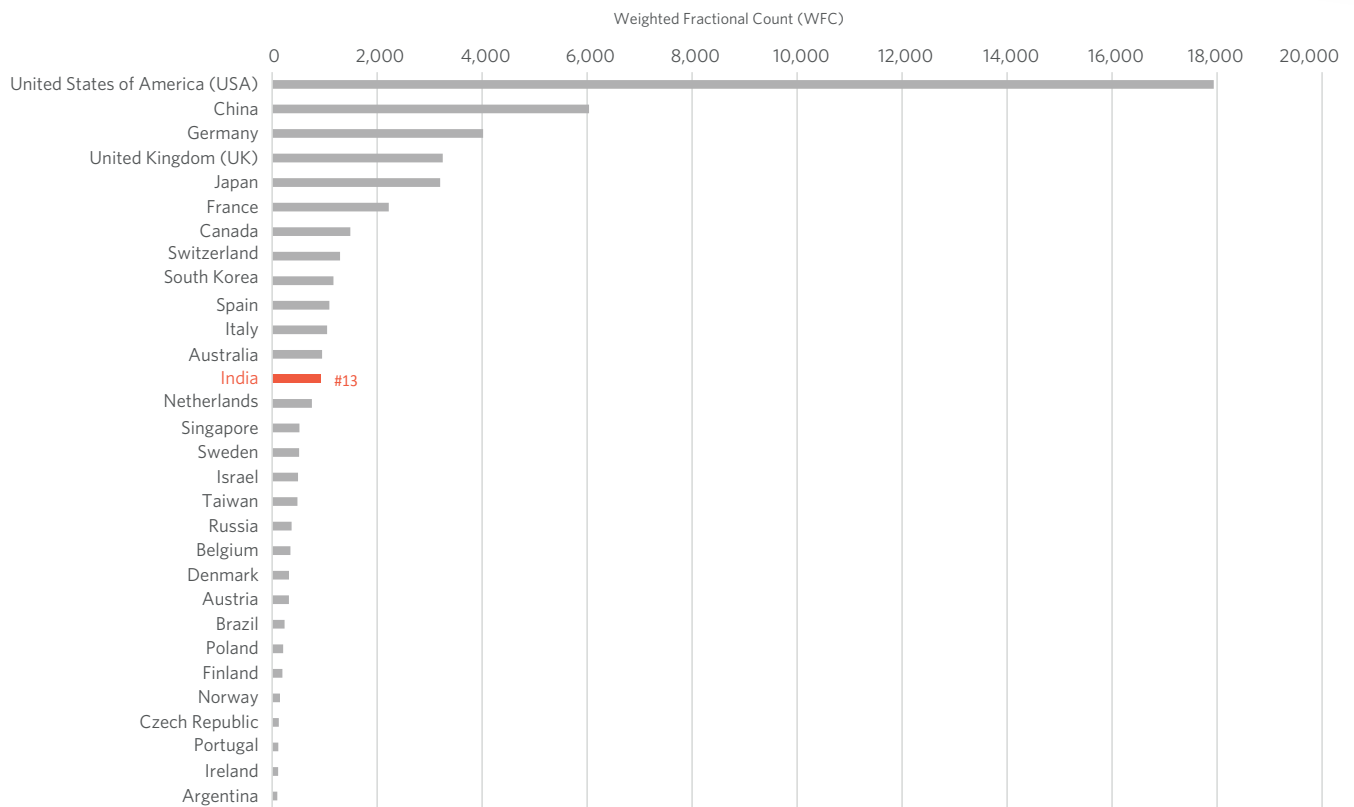
The growth in Indian output in the index has been achieved despite a stagnation in spending. The country invests less than other comparator countries in this analysis as measured by research and development funding, committing

less than 1 per cent of its gross domestic product to research (source: UNESCO data from 2011). Indeed, funding for science and technology has hovered at around this level for the past two decades.

While Russia, Brazil and Italy spent at similar levels (between 1 and 1.5 per cent of their gross domestic products), among the group of comparators considered here only Italy achieved a weighted fractional count higher than India's. And while Australia, Singapore and South Korea spend higher proportions of their gross domestic products on science, India's weighted fractional count in 2014 far surpasses that of Singapore, draws level with Australia and is closing the gap with South Korea.

India's current government, led by Narendra Modi, has not yet offered much to science and technology. The past two budgets were disappointing: the 2014 budget with a below-inflation increase in funding followed by the 2015 budget that remained rather flat, and actually nose-dived for some key government departments.

The 2014 annual budget set aside 362.69 billion rupees (US\$6 billion) for research being carried out under the science and technology ministry and seven other ministries — agriculture, defence, earth



**FIGURE 2 Global Top 30 in the Nature Index 2014** | India's position at number 13 in the world puts it among the global leaders in producing high-quality science.

sciences, health, renewable energy, space and atomic energy. In 2015, this allocation was marginally higher at 419 billion rupees (US\$6.4 billion).

Despite the funding stagnation, the new government has taken some steps in a positive direction, including establishing tax incentives for research and development that are among the best in the world. These have helped to boost research investment by a few industries, but have yet to drive widespread innovation. Problems such as bureaucracy, government indifference, unfair appointments (or appointments not based on experience), and lack of resources also continue to dampen enthusiasm.

However, despite limited resources and complexities, the international science community is still hopeful for Indian science. These past couple of years have seen international attention focused on the country's ambitious space voyages,

the Mars Orbiter Mission and India's first dedicated multiwavelength space observatory Astrosat. In another area, Indian biologists also made a mark in international proteomics research by mapping the human proteome and making it to the cover of *Nature* in 2014<sup>1</sup>.

India's biggest strengths are the quality of its most elite scientific institutions, a healthy growth in the biotechnology sector and commitment by researchers to address India's social and economic challenges. Indeed, the country, soon to be the world's most populous nation, is sitting at the nexus of some grand challenges in building scientific capacity to tackle pressing issues in energy, water, food and pollution.

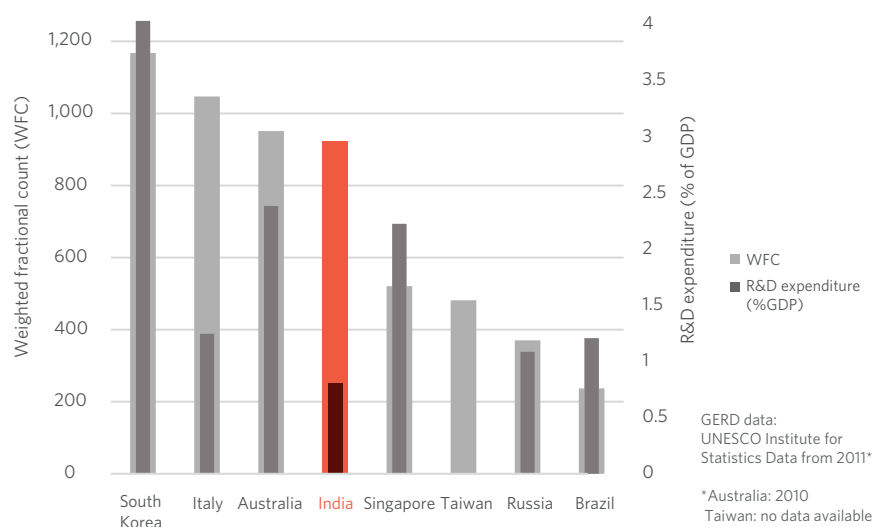
In this context, the art of *jugaad* – the characteristically Indian technique of frugal innovation – and youthful enthusiasm in abundance are things that shine through. ■

1. Kim, M. S. *et al.* A draft map of the human proteome. *Nature* 509, 575–581 (2014).

# India's high-quality research output in a global context

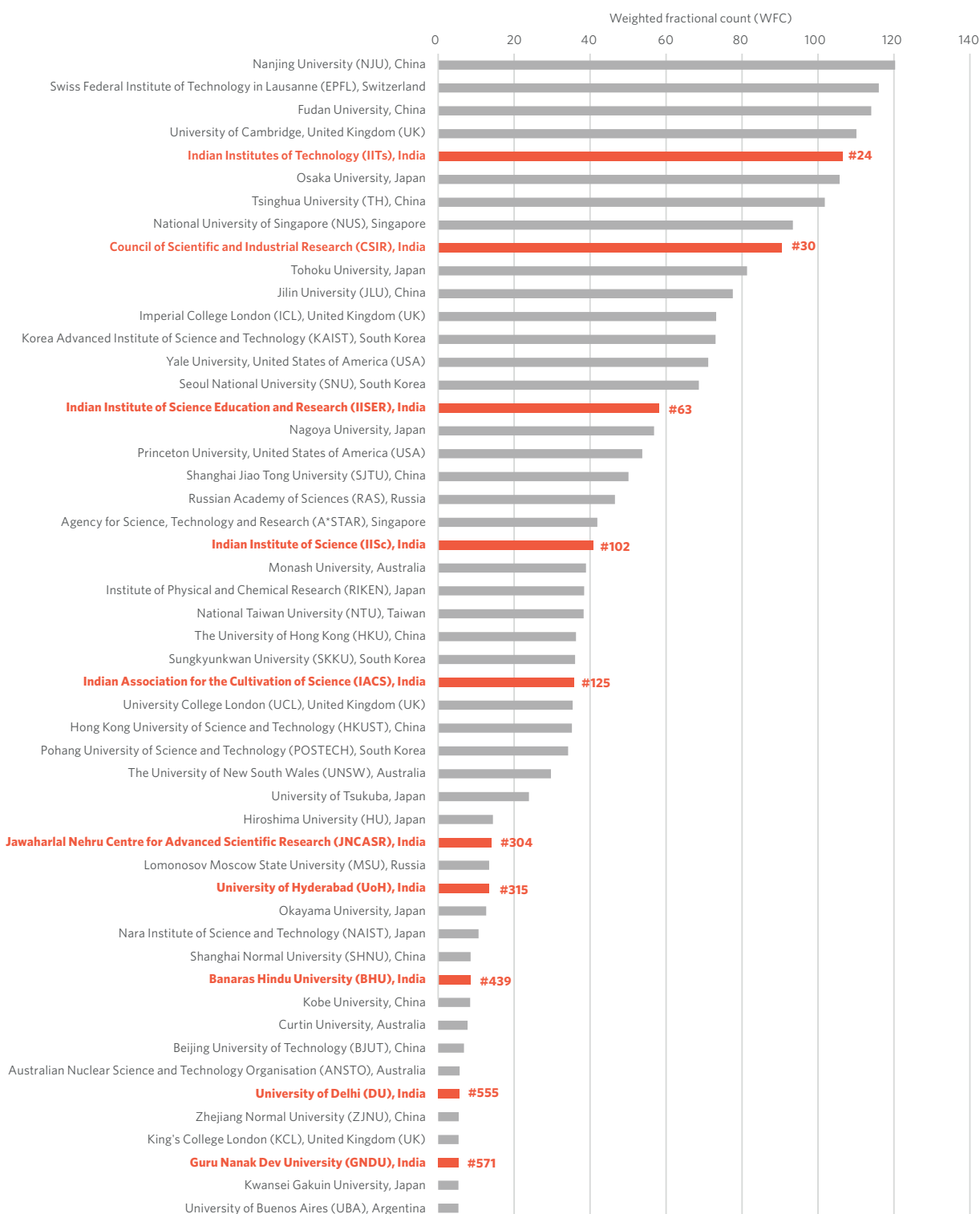
India's marked growth sets it apart from the comparator countries considered in this study. Of these countries, only Russia experienced a similar increase in growth rate, although its weighted fractional count (WFC) is less than half of India's (Fig. 3). The Nature Index highlights India's historic love affair with chemistry — mirroring a strong propensity towards the discipline across Asia — and the physical sciences.

In chemistry, India's top institutions are competitive with those in Europe, the USA and Asia, and stand up to be counted among the world's top ranks (Fig. 4). India is ninth (WFC = 448.9) in the index global ranking for Chemistry (Fig. 5). Not surprisingly, the top-ten journals where Indian scientists publish are all in chemistry and the physical sciences, with 50 per cent of India's overall Nature Index output coming from chemistry alone (Fig. 6).

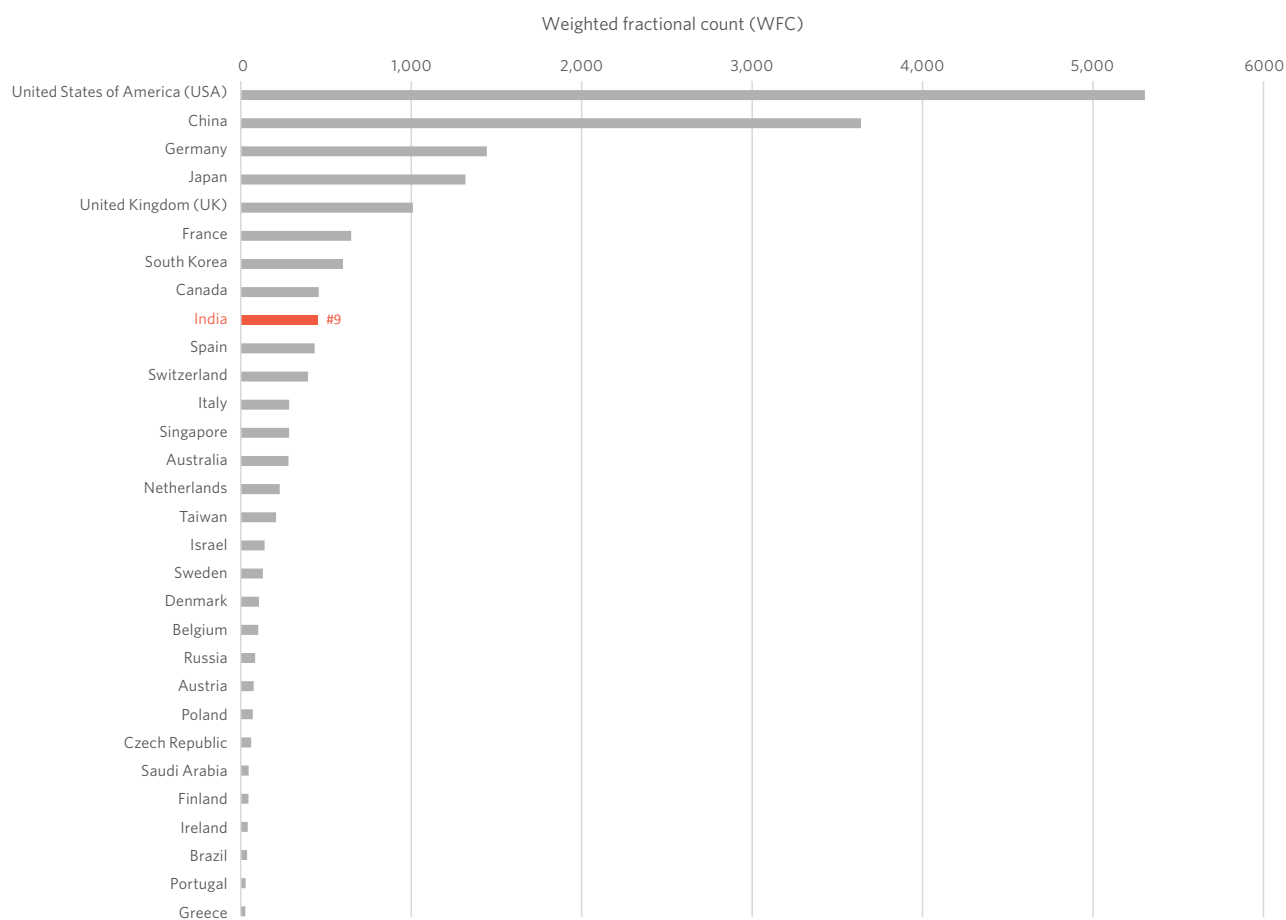


**FIGURE 3 R&D expenditure and overall output in the Nature Index 2014** | India's R&D spending as a percentage of its GDP is relatively low compared to other nations with a similar output in the Nature Index 2014.





**FIGURE 4 Indian institutions are highly ranked in Chemistry** | This graph shows Indian institutions in the context of a selection of well-recognized global institutions in the field of chemistry. Indian institutions are rubbing shoulders with many global leaders in the Nature Index. Global institutional ranks are for chemistry WFC output in the Nature Index for 2014.



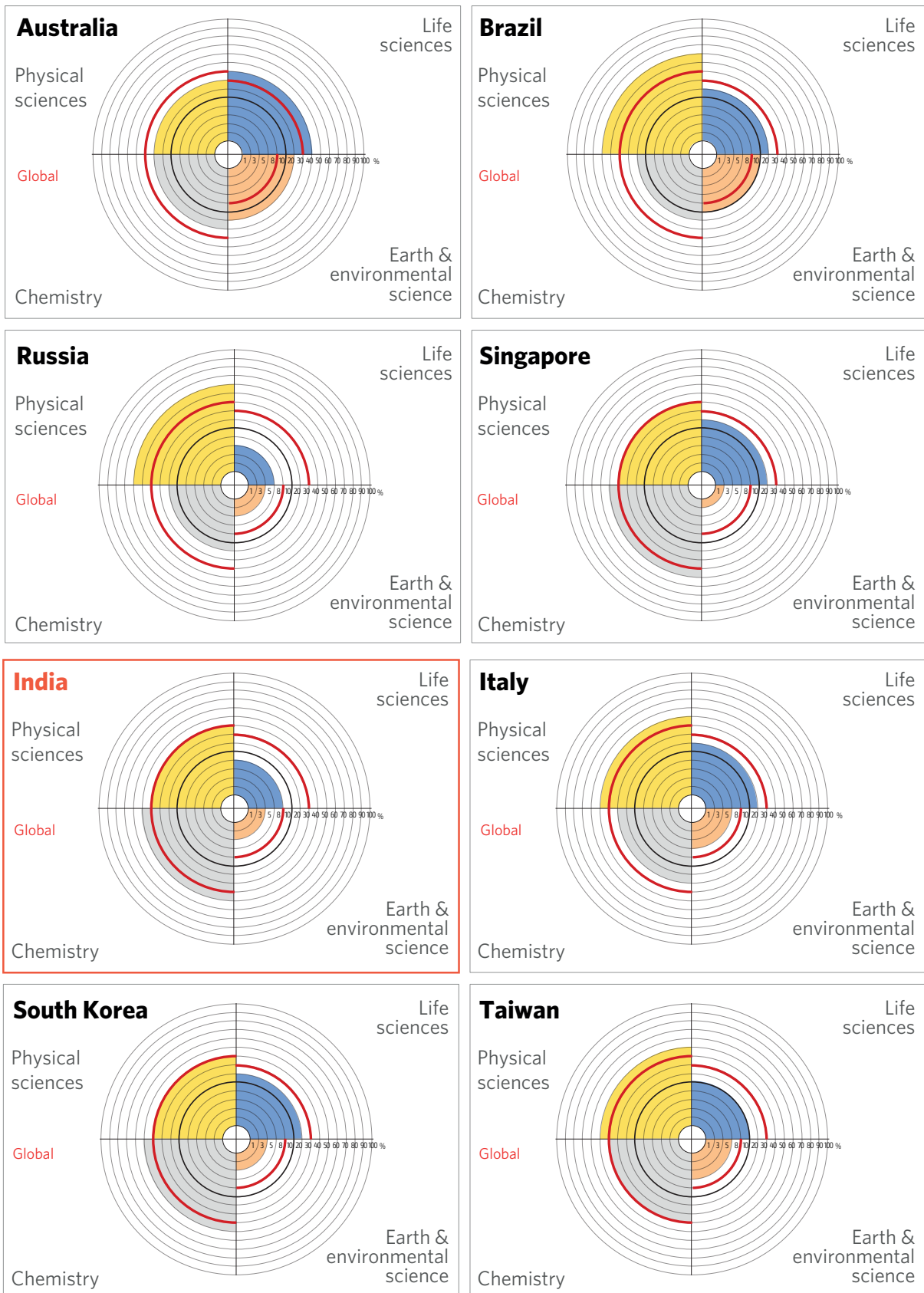
**FIGURE 5 India's love affair with chemistry** | India is among the top-ten leading countries in chemistry in Nature Index 2014 as measured by weighted fractional count (WFC).

Between 2012 and 2014, Indian chemistry research increased particularly rapidly, with the country's chemistry-specific WFC growing by almost 100 over the course of three years with a compound annual growth rate of 8.6 per cent. This is the largest increase among the comparator countries considered here.

Indian institutions compare very favourably on a global level in chemistry, producing more output in the Nature Index during 2014 than some of the world's top institutions in Asia, Europe and North America (Fig. 4). In particular, the Indian Institutes of Technology are among the world's top institutions in chemistry (ranked 24th globally in 2014), rubbing shoulders with world class centres such as the University of Cambridge (at 20) and Osaka University (at 25).

Overall, Asia's traditional strength in the physical sciences and chemistry reflects a regional pattern — besides India, other Asian nations such as Singapore, Taiwan and South Korea show a great focus on these subject areas. However, these countries show greater engagement in the life sciences than India. Russia as a traditional stronghold in the physical sciences is continuing to produce most of its output in this discipline (Fig. 6).

Italy, by comparison, has a more balanced output. Across the Atlantic, Brazil's strongest interest is also in the physical sciences, although it also has one of the highest relative Earth and environmental sciences outputs. Of all the countries, Australia is the most balanced, with a slight emphasis on the life sciences. ■



**FIGURE 6** Relative subject area focus | Indian research published in the Nature Index in 2014 is focused on chemistry and the physical sciences relative to its overall output. Graph shows the percentage of each country's overall WFC arising from research in four broad subject areas. Red line is the global average. Note the scale amplifies values below 10 for clarity.

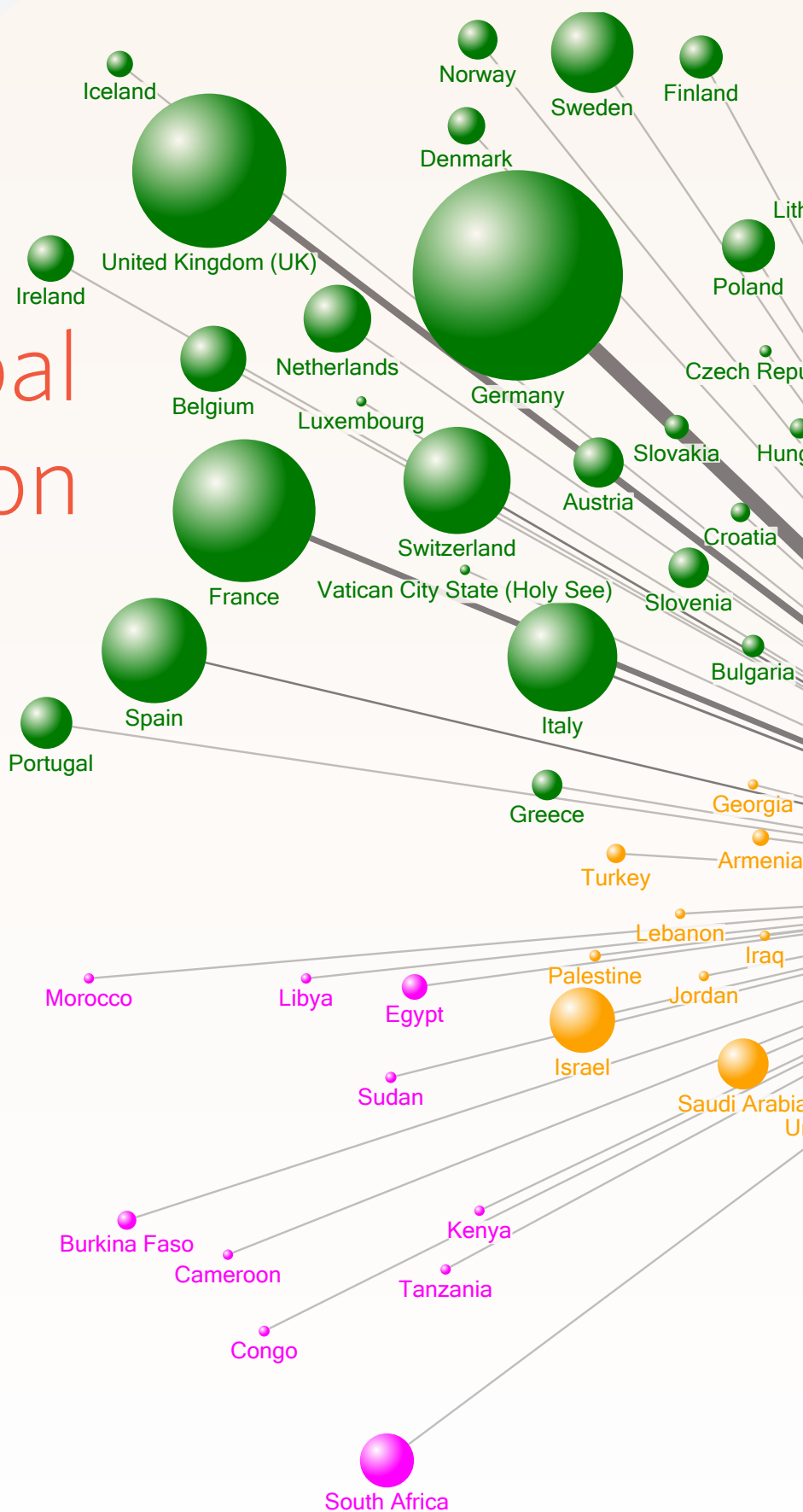
\*Subject areas can overlap, so that the total percentage may exceed 100 per cent.

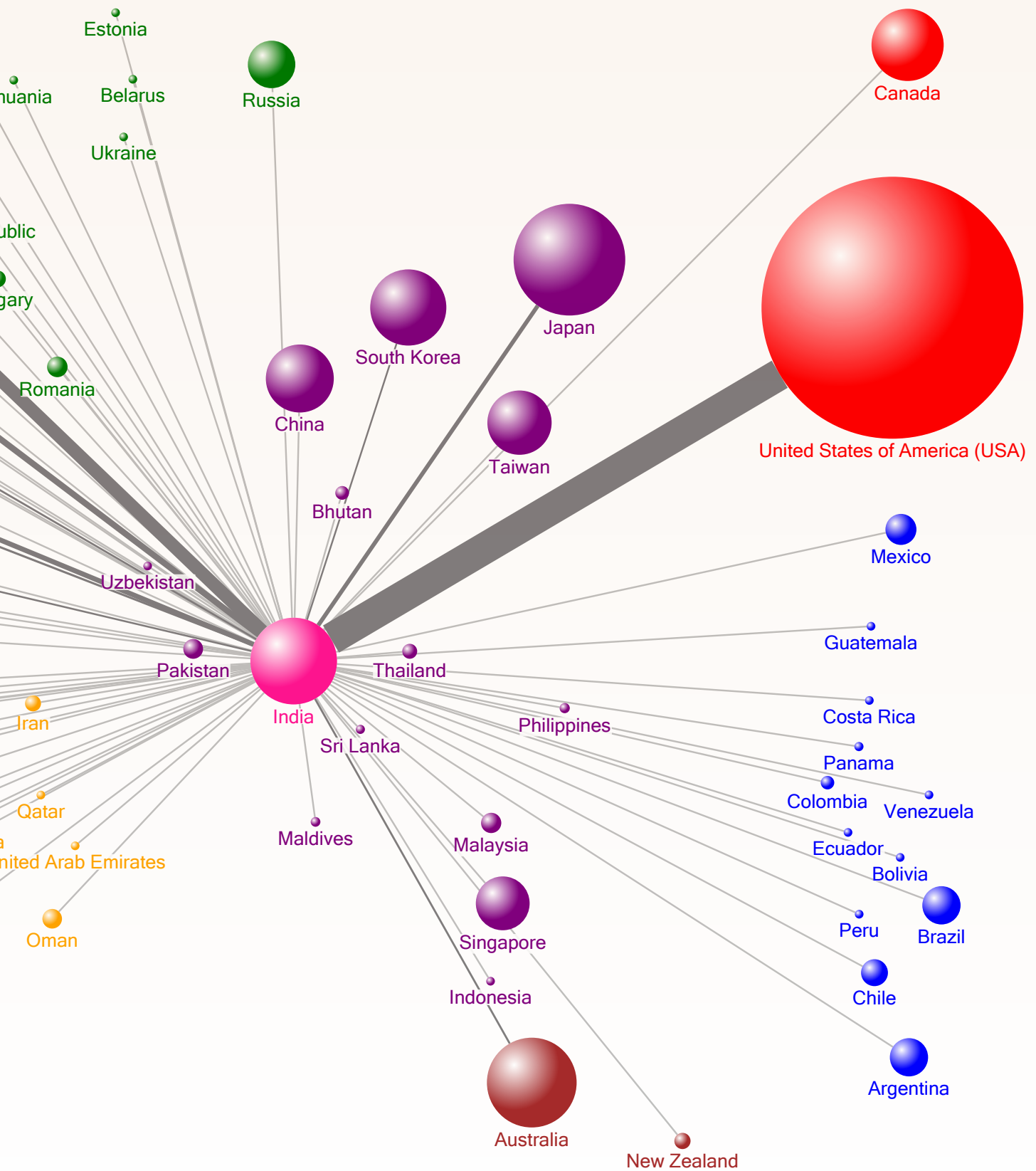
# India's global collaboration network

In 2014, India co-authored papers in Nature Index journals with researchers from 85 countries. Most of these efforts were with researchers in the USA, producing a weighted collaboration score of 180 (Weighted collaboration score is the sum of all WFC from papers that include both Indian researchers and researchers from its partner country). This connection dwarfs the next largest collaboration, with Germany (weighted collaboration score of 80). Other strong collaborations are mostly with European countries, East Asia and Australia (Fig. 7). In terms of authorship, India is mostly an equal partner in these collaborations — and does not ride on the coattails of scientific powerhouses such as the USA or the UK — contributing on an average half of the collaborations' WFC outputs.

The 2014 data reveal that institutions in India collaborate mostly with international counterparts, but their largest collaborations tend to be with other domestic institutions. They invest more in individual domestic collaborations but tend to participate in many international collaborations.

Data from the index suggests that industry–academia collaboration is yet to take off in India, but Indian academic institutions have good collaborative ties with international corporations (see page 11). The same is true for Indian corporations, which form partnerships with international academic institutions. They undertake much of this through international subsidiaries. ■





**FIGURE 7 India's global connections** | This graph shows India's bilateral collaborations on papers published in the Nature Index in 2014. The size of each country and the thickness of the lines connecting them to India reflect their weighted collaboration score with India. This score is based on the sum of all WFCs for papers that include both Indian researchers and researchers from its partner country.  
 \*India's size is not to scale.



# India's top institutes: an international comparison

The Indian success story contains recent highlights of scientific brilliance, especially in materials science, nanosciences and astrophysics, at its many Indian Institutes of Technology (IITs). These technology schools have the country's highest institutional WFC, followed by the government-funded laboratories of the Council of Scientific and Industrial Research (CSIR) and the Indian Institutes of Science Education and Research (IISER).

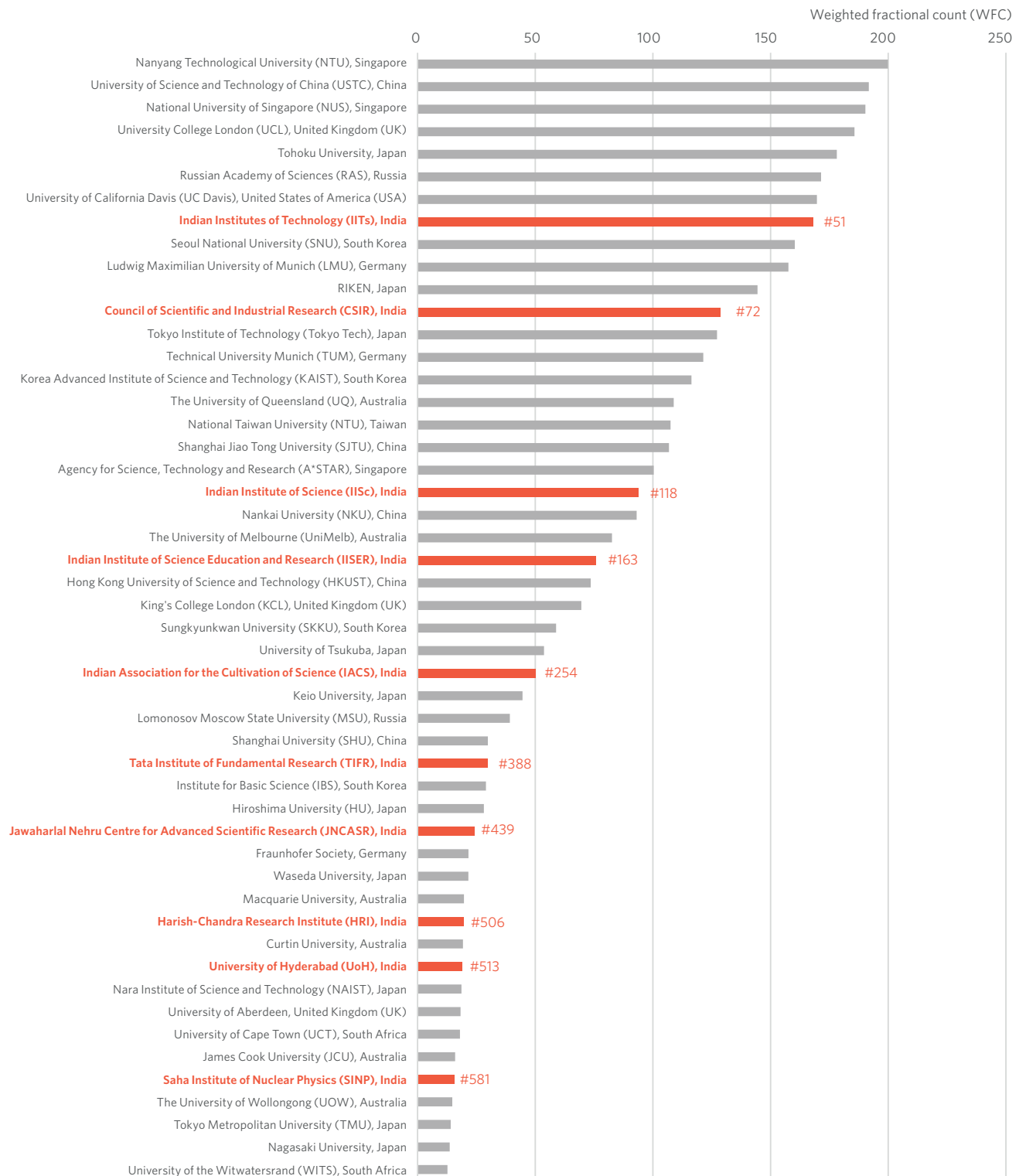
Aside from conglomerates or groups of institutes, the standalone institute that shines through is the Indian Institute of Science (IISc) with its formidable chemistry and physical sciences departments. The Tata Institute of Fundamental Research with its strong fundamental research in particle physics and astrophysics made a mark with its contribution to the CERN experiments that led to the discovery of the Higgs boson particle.

Rounding out the top-ten institutions in India in 2014 are the Indian Association for the Cultivation of Science (IACS), Tata Institute of Fundamental Research (TIFR), Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR),

Harish-Chandra Research Institute (HRI), University of Hyderabad (UoH) and Saha Institute of Nuclear Physics (SINP) (Fig. 8).

For this analysis, Indian institutions were compared to foreign institutions based on geography, international reputation and comparative global ranks. For instance, the IITs rank 51st in the index, placing them close to top universities in the region such as Nanyang Technological University (NTU) and National University of Singapore (NUS) in Singapore. The IITs also rank close to top institutions in Europe and the USA, and surpass some of the world's top research hubs, such as the LMU in Germany (59) and RIKEN in Japan (61).

Most of the top institutions reflect the country's focus on research in chemistry, followed by the physical sciences. The Nature Index 2014 reflects a paucity of research in the life sciences and Earth and environmental sciences. An exception to this generalization is IISc, which achieved 18 per cent of its overall WFC in the life sciences. TIFR and HRI are also notable exceptions, focusing heavily on the physical sciences. ■



**FIGURE 8 Indian institutions' global standing** | This graph shows Indian institutions in the context of a selection of well-recognized global institutions. Overall, India's leading science power houses are well placed to compete on a global level. Global institutional ranks are for overall WFC output in Nature Index 2014.

# Collaborations: more global, less local

In the Nature Index, India's international collaborations far outweigh domestic collaboration (Fig. 9). Although the largest collaborators for Indian institutions tend to be other Indian institutions, each has a larger number of smaller collaborations with international counterparts. In other words, there are fewer domestic collaborations, but they tend to be more substantial than international collaborations.

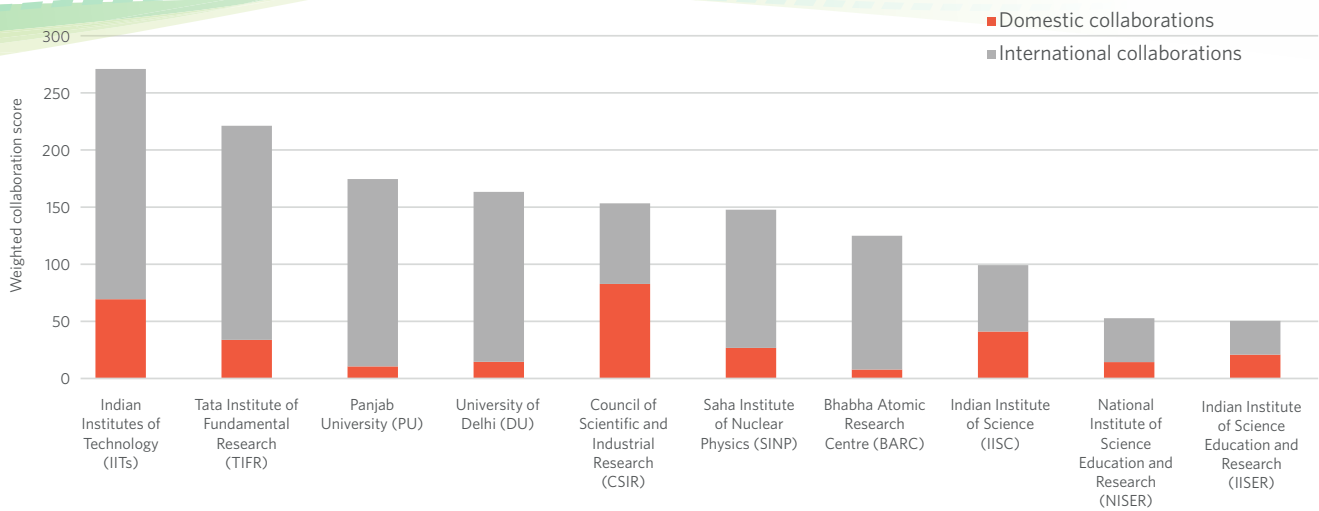
Looking specifically at institutions, India's top-ten collaborating institutes ranked by their weighted collaboration score are the Indian Institutes of Technology (IITs), Tata Institute of Fundamental Research (TIFR), Panjab University (PU), University of Delhi (DU), Council of Scientific and Industrial Research (CSIR), Saha Institute of Nuclear Physics (SINP), Bhabha Atomic Research Centre (BARC), Indian Institute of Science (IISc), National Institute of Science Education and Research (NISER), Indian Institutes of Science Education and Research (IISERs).

The index shows that the strongest collaborations come from the IITs, which have significant tie-ups with IISERs, TIFR, NISERs and the French National Centre for Scientific Research (CNRS). TIFR has a robust partnership with CNRS along with IISc, University of Regensburg (UR), Germany and Kolkata-based Saha Institute of Nuclear Physics (SINP).

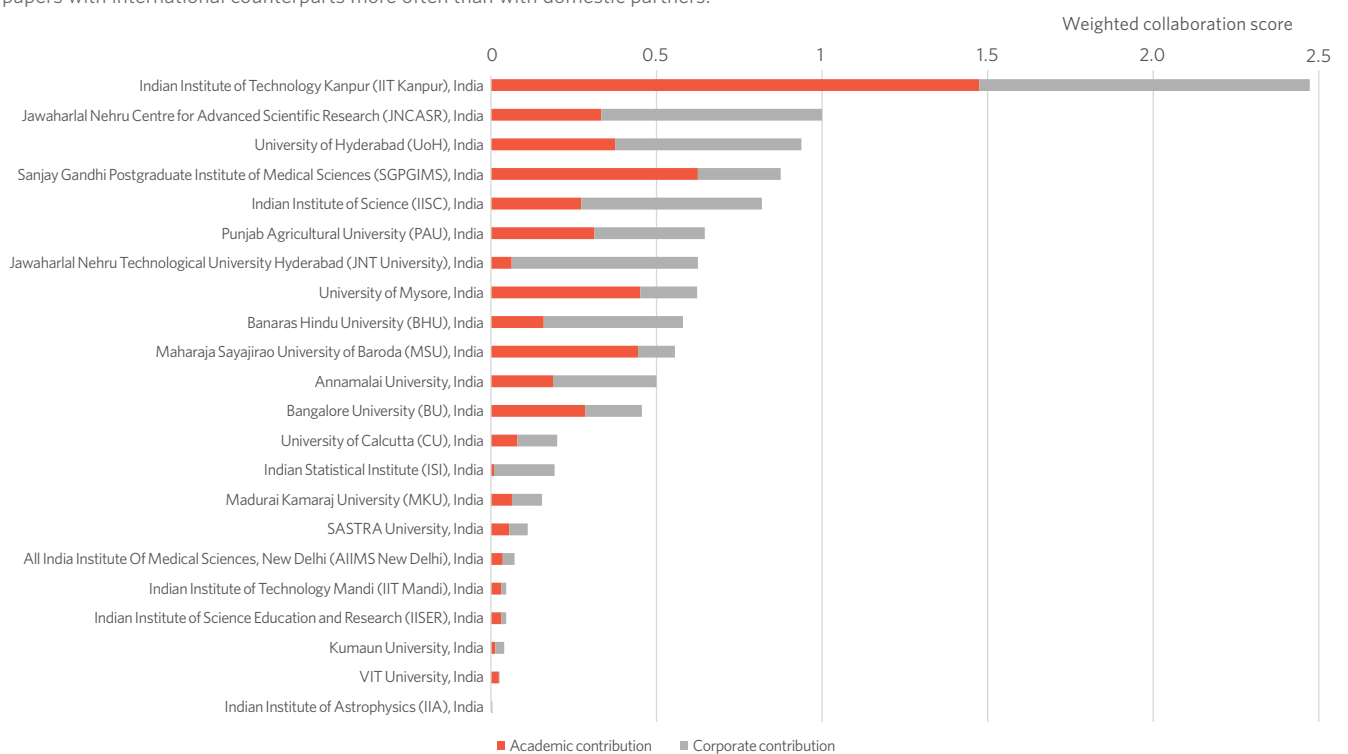
CNRS is also among the top collaborators of Panjab University, which has a noteworthy international associations repertoire featuring the Chinese Academy of Sciences (CAS), Helmholtz Association of German Research Centres, Institute for High Energy Physics (IHEP), Russia; Belarusian State University (BSU), Russian Academy of Sciences (RAS), University of Science and Technology of China (USTC), China, Wayne State University (WSU), USA, and Joint Institute for Nuclear Research (JINR), Russia.

In terms of links between industry and academia, the Nature Index reveals almost no domestic collaborations, except for IIT Kanpur's tie up with Hikal Ltd/BioOrganics & Applied Materials Pvt. Ltd. Within the natural-sciences-focused journals covered by the index, Indian academic institutions collaborate mainly with international corporations (Fig. 10). Indian corporates also mainly collaborate with international academic institutions through their international branches. The top Indian corporate collaborators are Serum Institute of India Ltd (SII) (mainly due to their Dutch subsidiary), Dr Reddy's Laboratories Ltd, Tata Steel Ltd, Shasun Pharmaceuticals Ltd, Hikal Ltd, BioOrganics & Applied Materials Pvt. Ltd, Reliance Industries Limited (RIL), Pondicherry Biotech Private Ltd and Panacea Biotech (Fig. 11). ■

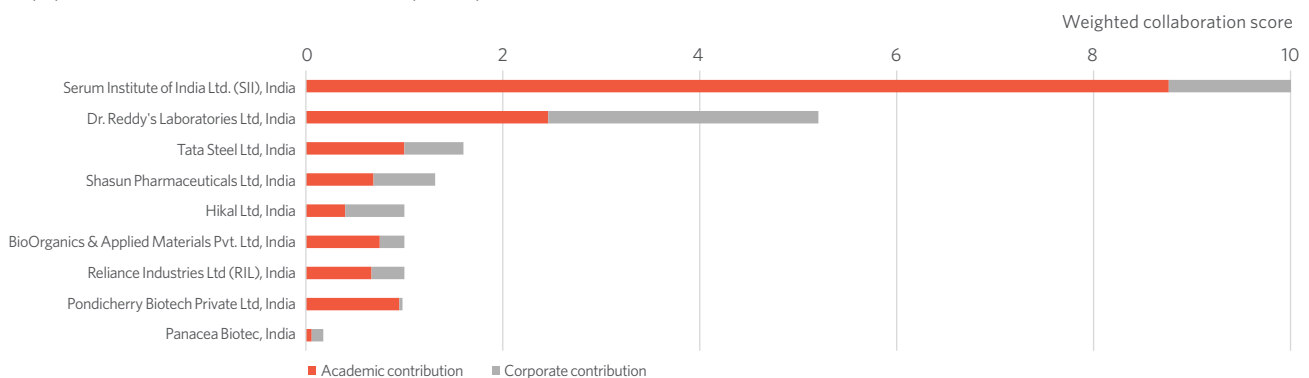




**FIGURE 9 India's top-ten collaborating institutions in Nature Index 2014** | Researchers from India's top collaborating institutions co-authored papers with international counterparts more often than with domestic partners.



**FIGURE 10 Indian academic institutions are reaching out to corporate collaborators** | This graph shows the contributions made to collaborations by Indian academic institutions and their corporate counterparts in Nature Index 2014. Weighted collaboration score is based on the sum of all WFCs for papers that include both academic and corporate partners.



**FIGURE 11 Indian corporations are partners with academic collaborators** | This graph shows the contributions made to collaborations by Indian corporations and their academic counterparts in Nature Index 2014. Weighted collaboration score is based on the sum of all WFCs for papers that include both corporate and academic partners.

# Commentary

## Mr M. S. Unnikrishnan

**Member, Apex Council for Prime Minister's Fellowship Scheme for Doctoral Research and Managing Director and CEO, Thermax Limited**



"As somebody from industry whose company is among the top spenders in R&D in India and which actively works with several IITs and other institutions on research projects, I am rather surprised to see that

"in terms of links between industry and academia, the Nature Index reveals almost no domestic collaborations".

While this could be explained as a factor of limited number of journals which the index makes use of, it is also true that most companies which enter R&D projects with academic institutions, do not envisage or target research paper or publication as the main output. In several instances, companies specifically bar researchers from publishing a significant portion of their research because of patent and copyright issues. Such research then stays away from the ambit of indices like the one brought out by Nature. To see this as a mark of poor linkages between industry and academia will be fallacious in my view."

## Dr Y. S. Rajan

**Chairman, NIT Manipur and Senior Honorary Professor, ISRO**



"In a country where the middle class is obsessed with second decimal points to decide admissions, ranking is a life-and-death affair. Several global ranking systems mix many parame-

ters that are largely influenced by capital investment. Consequently, India gets ranked low in these systems. I am glad to see that CII and Nature Index have concentrated on one output parameter that can indicate quality scientific papers. It provides a more realistic assessment of the quality of institutions, and their strengths and weaknesses. India does fairly well, although there is a long way to go. A major takeaway from the study from an industrial and commercial technology viewpoint is that Indian institutions that have started working with foreign industries and institutions are partnering with Indian industries, albeit at limited levels.

CII can, and should, try to bring the four together, since it has connections with all four. It can take India forward in industry-academia linkages, which are not well as per Nature Index survey. Perhaps there is a need to also have an additional survey on intellectual property rights outputs and commercialization of R&D."

## Prof. R Natarajan

**Former Chairman, AICTE & Former Director, IIT Madras**



One of the main reasons for India's lacklustre performance in world university rankings (such as Shanghai Jiao Tong, Times Higher Education and Quacquarelli Symonds) over

the years, is its poor score in the number of papers in high-impact journals and citation counts, although the criteria includes other factors, such as perception scores.

In terms of Nature Index, Indian institutions seem to have done well, especially for chemistry and physical science papers. The report highlights the shortcomings in Indian science, such as "bureau-

cracy, government indifference, unfair appointments (or appointments not based on experience), and lack of resources.” However, despite limited resources and complexities, the international science community seems to be still hopeful for Indian science.

### **Dr Baldev Raj**

**Director, National Institute of Advanced Studies**



“The CII-Nature Index Report on scientific research output from India is concise yet comprehensive. A few messages that emerge from it are that we need more investment in R&D by both industry

and government. We also need to improve translational research, which leads to the creation of technology and patents. Statistics clearly demonstrate the capability of Indian science both in quality and quantity. De-bureaucratization and avoiding disruptions in funding of those individuals and institutes which are doing well are other critical parameters for our continued success.”

### **Prof. Indranil Manna**

**Director, Indian Institute of Technology, Kanpur**



Internationalisation, which is one of the focus of this report, is an important component of engineering education today. The Government of India and the Ministry of

Human Resource Development (MHRD) are placing major emphasis on internationalisation of Indian campuses not just at the post-graduate and PhD level but also at the undergraduate level. IIT Kanpur is working on avenues to take foreign students at the undergraduate level specially from countries in the Saarc region, South East Asia, East Africa and the Middle East. Our aim is to create a mechanism through which we will be able to shortlist foreign students who will be on par with those in India who are able to clear the Graduate Aptitude Test in Engineering (GATE). The launch of Imprint scheme, endorsed by the highest leadership in the country, shows the kind of value the Government is placing on taking a joint industry-institute partnership approach to research and focusing on solving the problems of the country. Imprint is different from all previous schemes created so far since it brings all IITs together for the first time. It envisages industry and academia working as joint collaborators with equal stakes in solving the country’s problems. The Government slogan today is Million Challenges, Billion Minds and we are all working towards tapping the potential of those billion minds.

### **Prof. Ashok Jhunjunwala**

**Professor, IIT Madras**



“In addition to the research in pure science that this report highlights, a lot of work is also being done in India in engineering, which is more translational and relates to academia working closely with industry”.



Confederation of Indian Industry

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December 2015

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