On the Evaluation of Young Researchers

An INSA Report

Prepared by
Anurag Kumar (IISc[*]), Spenta R. Wadia (ICTS-TIFR[†]), Vivek Borkar (IITB[‡]),

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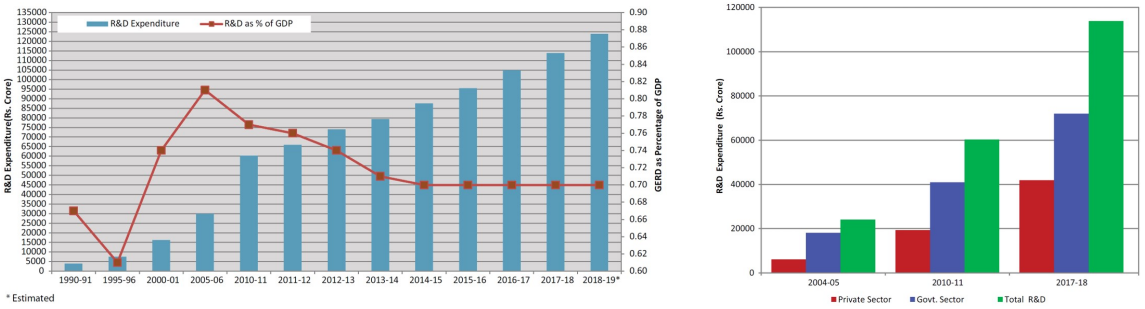
[*]Indian Institute of Science, Bengaluru
[†]International Centre for Theoretical Sciences (Tata Institute of Fundamental Research), Bengaluru
[‡]Indian Institute of Technology, Bombay

1 Introduction

Each year, India's top science and technology universities, such as the Indian Institute of Science (IISc), the Indian Institutes of Technology (the IITs), the Indian Institutes of Science Education and Research (the IISERs), and research institutes and laboratories around India, such as the Tata Institute of Fundamental Research (TIFR), recruit very high quality young faculty and researchers. Over the past 20 years, the availability of research funding in India has grown [8], both in terms of the amount of funding (Figure 1a) and the range of funding opportunities (Figure 1b)



(a) Absolute and as a % of GDP, 1990-2019

(b) Private-government-share, 2005-2018.

Figure 1: R&D expenditure in India [8]. It is to be noted that government funding is shared between direct funding to defence and space (about 50%), other science and technology ministries, and sponsored research in academia and research labs [8, Table 1.3].

As as result, as shown by Figure 2, over the past five years, India has pulled ahead of the UK, Germany, and Japan in the number of science and engineering publications per year. In 2020, China had about 670,000 publications, as against 450,000 from the USA, and 150,000 from India (these totals have been taken from [4, Table PBS-1, Page 9], and rounded off for easy reading).

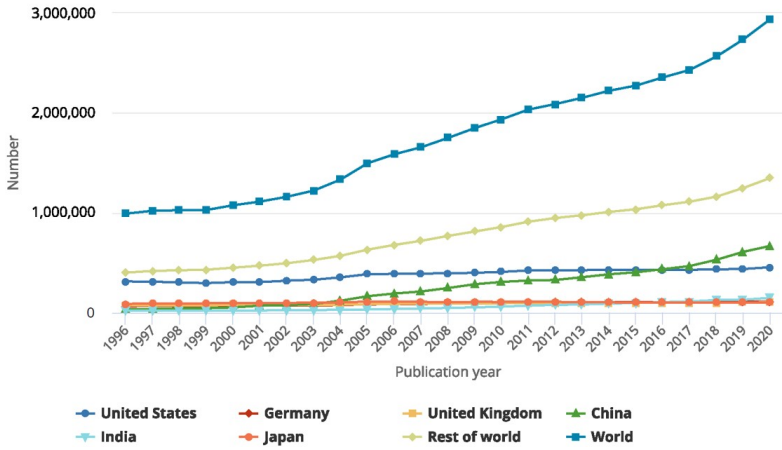


Figure 2: Number of science and engineering publications vs. year, for several countries and regions; adapted from [4]

Figure 3 shows an index based on the top 1% cited articles published by each country. A score lower than 1 means that fraction of highly cited articles from that country is lower than the world average. For India, this index shows an increasing trend over the past 20 years. However, even though the number of published articles out of India is comparable to those from Germany and the UK, India's highly cited publications index is about 0.9, whereas for the EU it is about 1.3.

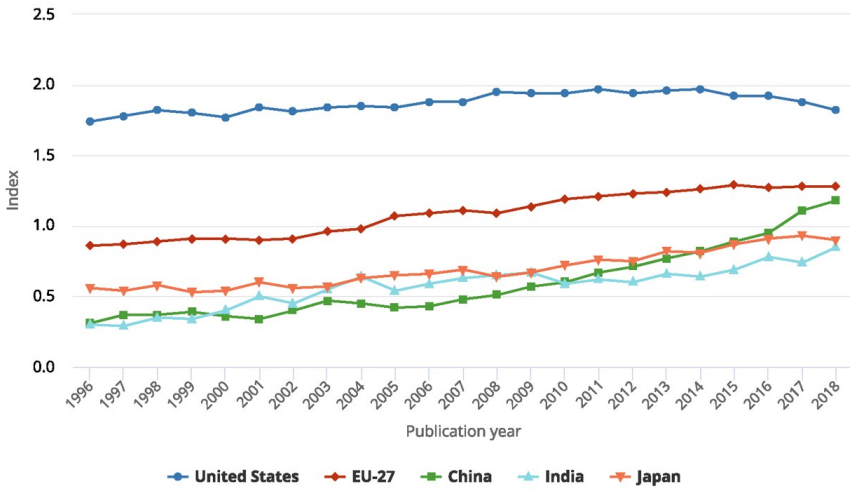


Figure 3: Share in top 1% cited journal articles vs. year, for several countries and regions. For example, if a country produces 100,000 articles in a year, and the number of citations of these articles (in the publishing year and two years thereafter) puts 1200 of these articles in the top 1% cited articles in the world, then the number 1.2 would be plotted; adapted from [4].

Rank	Region	University	FWCI
1	Overall	University of Oxford	2.25
2	Overall	Stanford University	2.32
3	Overall	Massachusetts Institute of Technology	2.41
4	Overall	Harvard University	2.21
5	Overall	University of Cambridge	2.1
6	Overall	Princeton University	2.21
7	Overall	California Institute of Technology	2.07
8	Overall	Imperial College London	2.2
9	Overall	University of California, Berkeley	2.18
10	Overall	Yale University	2.01
1	Asia	Tsinghua University	1.72
2	Asia	Peking University	1.59
3	Asia	National University of Singapore	2.03
4	Asia	University of Hong Kong	2.12
5	Asia	Nanyang Technological University, Singapore	1.96
201-250	India	Indian Institute of Science	1.1
501-600	India	Anna University	1.14
501-600	India	Jamia Millia Islamia	1.56
501-600	India	Mahatma Gandhi University	0.63
501-600	India	Shoolini University of Biotechnology and Management Sciences	2.15
601-800	India	Alagappa University	1.29
601-800	India	Aligarh Muslim University	1.28
601-800	India	Banaras Hindu University	1.48
601-800	India	Bharathiar University	0.94
601-800	India	IIT Guwahati	1.08

Rank	University	FWCI
1	Indian Institute of Technology Madras	1.08
2	Indian Institute of Science	1.1
3	Indian Institute of Technology Delhi	1.18
4	Indian Institute of Technology Bombay	1.04
5	Indian Institute of Technology Kanpur	1.1
6	All India Institute of Medical Sciences, Delhi	1.05
7	Indian Institute of Technology Kharagpur	1.14
8	Indian Institute of Technology Roorkee	1.21
9	Indian Institute of Technology Guwahati	1.08
10	Jawaharlal Nehru University	1.22

Figure 4: The Times Higher Education (THE) Field Weight Citation Impact (FWCI) for the THE top ten universities in the world, the THE top five in Asia, and selected universities in India. For India, the universities in the larger table are the top ten as per the most recent THE rankings, and the ones in the small table are the top 10 as per the NIRF rankings; it is noted that the IITs do not participate in the THE rankings. FWCI based on the period 2018-2022; source: SciVal/Scopus .

Figure 4 shows the FWCI (Field Weighted Citation Impact) for a few universities in the USA, the UK, Asia other than India, and India. FWCI is a measure of impact (provided by the SciVal interface to the Scopus database) which for an article is the ratio of the total number of citations actually received by an article in the year of publication and the following three years, and the average number of citations received, in the publication year plus three years, by all publications in the database published in the same year, of the same type, and within the same journal category [1]. Thus, FWCI takes into account the variability in the number of citations across fields, with an index of 1 indicating average impact. The FWCI of top science

and engineering universities in India, as per the NIRF rankings, are observed to be just about average. More comprehensive universities, such as Banaras Hindu University and Jamia Millia Islamia, despite having low THE rankings, have FWCI values close to 1.5.

We conclude that recruitment of world-class young faculty and researchers, and the improvement in research funding, has improved the number of publications emanating from India annually, but highly impactful research coming out of India remains at or below the world average. To be an aspiring science and engineering power house, we must do significantly better than the world average. What can India do to improve the impact of its research output?

1.1 In Summary

The **National Education Policy 2020** [3], in its Chapter 13 (of the detailed, draft document, as well as the shorter, final document) has emphasised the importance of merit and performance based recruitment and career advancement of faculty. Indeed, this section starts by asserting:

"The most important factor in the success of higher education institutions is the quality and engagement of its faculty."

Later, in this same chapter, the policy has underlined the role played by an enabling and visionary academic leadership to bring about the changes necessary for cultivating such merit and performance based excellence among the faculty.

Young researchers shape their working styles to what they perceive as important for getting a good evaluation. Current practices in researcher evaluation could lead to behaviours inimical to truly impactful research, and global excellence. With this in mind, in this document we examine some aspects of researcher assessment in India and in other parts of the world, and provide some recommendations that might encourage young researchers to develop more impactful research careers in India. Chaddah and Lakhotia, in an article published as a policy statement of the Indian National Science Academy (see [5]), have also drawn attention to good practices for researcher assessment, along with the need to reduce emphasis on publication counts as this has encouraged the growth of "predatory" journals.

2 Evaluation Processes in Institutions in India and their Consequences

2.1 Typical aspects of evaluation

The assessment processes for researchers in India are heavily dependent on the following:

- *Emphasis on numbers:* i.e., the number of published articles, the number of students graduated, the number of awards received, the number of invitations for lectures, etc. It has become a routine practice in application and nomination forms to have a section asking for just the applicant's or nominee's numbers for each of the items listed above.

  Consequences: As a result of this, young researchers work on incremental research problems to pile up such counts without pausing to define hard and risky questions, which could also lead to important open problems on the way, and the solution of which would be truly impactful and path-breaking. Awards and similar recognitions, at the early stage of a researcher's career, do provide encouragement. However, a large number of awards and fellowships, instituted by several academies and organisations, result in many short term goals that young researchers continually aspire for; the

evaluation committees only look at "counts," again discouraging young researchers from long term thinking.

- *Emphasis on impact factors in assessing publication quality:* The quality of a paper is often assessed based only on its appearance in a high impact factor journal, or in a journal or conference that appears high in popular ranking lists, rather than by its true contribution and impact on the field. In fact, some reporting forms have even asked for the *total impact factor* of all the journals the assessee has published in.

  Consequences: This again encourages the "numbers game" of publishing in high impact factor journals, rather than focusing on making strong contributions to important problems. Current trends get reinforced and the focus is on conducting research that is perceived as acceptable or fashionable, by publishing in highly ranked venues. Young researchers are, therefore, not encouraged to try and break new ground in their research, as it is risky to not follow the beaten path.

- *Emphasis on independent research:* When assessing a researcher, the committees look for independent contributions and always look askance at collaborations with well-established peers, particularly if the latter are based in a foreign country. When assessing joint publications, percentage contributions, by each author, are often sought, thereby not giving full recognition that the primary value of the work may be derived from the collaboration.

  Consequences: It is certainly important for a young researcher to demonstrate their ability to drive an independent line of investigation. However, we are at a time when problems require varied expertise for their solution, whether they are globally meaningful scientific questions, or problems of national importance. Indeed, leading universities around the world have interinstitutional collaborations in more than 80% to 90% of their publications; see the *collaboration* indicators at `https://www.leidenranking.com/ranking/2022/list`. The knowledge in any field is wide and deep. Emphasising that a young researcher must only work with students or post-doctoral fellows, whom they guide, limits our young researchers from participating in impact-making interdisciplinary research on important problems. The requirement, by assessment committees, that the assessee states % contributions by the various authors of each publication sends out yet another signal that collaborations are looked upon suspiciously.

- *Weak peer review process:* Assessment committees are provided the young researcher's CV, some sample papers, and little else to base their assessment on. Reference letters are sometimes obtained, but little care is taken as to whom to invite reference letters from, and what to ask for in the letters. As a result the letters do not add very much to the assessment process. In some committees only the chair sees the letters, and these do not play any explicit role in the committee's deliberations. Often casually written letters are taken with greater seriousness than they deserve, with much discussion ensuing on casual critical comments.

  Consequences: The lack of strong peer assessment, and with not all expertise being available around the table (the committee usually comprises senior researchers, who might not be fully aware of the nuances of emerging disciplines), the process devolves to just counts of papers, awards, citations, etc., and evaluation based on general impressions around the table (and biases, such as those based on the individual's "pedigree"). This devolution to "general impressions" is also what perpetuates the positive assessment of the same researchers over and over again, without any close review of their true contributions and impact over time.

2.2 Implication for the type of research being done

All the consequences discussed above come together to govern a very important aspect of the research process, namely, the choice of the *research problem*. The aspects of research evaluation described in Sec-

tion 2.1, promote a culture of working on research problems with the following characteristics:

- Incremental, "safe" research, to ensure quick success and publication counts.
- Avoidance of collaborations, even if they may lead to more impactful research, as they are looked askance by review committees, and, in any case, take too much time in setting up and in coordination, time that could be better spent in publishing a few more incremental papers.

In this context, it is important to appreciate the richness of research via the two models depicted in Figure 5 and Figure 6.

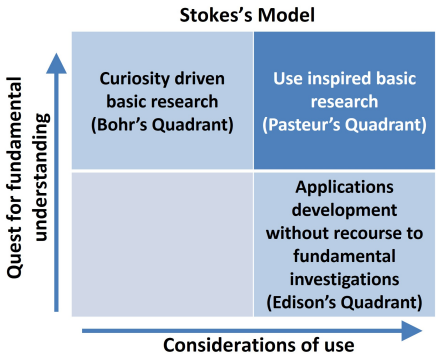


Figure 5: Stokes's four-quadrant model for research. Adapted from [9].

The four-quadrant model for research was proposed by Stokes in [9]. After discussing the limitation of placing all research on a one-dimensional scale from basic to applied, and recognising that a considerable amount of actual research cannot be fit into this one-dimensional model, Stokes proposed the two-dimensional model shown in Figure 5. Any research problem, whether use-inspired-research, or curiosity-driven-basic-research, or a problem that seeks to solve a use-inspired problem using a fundamentals driven approach, can be mapped into Stokes's quadrant model. In the context of "Pasteur's Quadrant," Stokes writes : "... as Pasteur's scientific studies became progressively more fundamental, the problems he chose and the lines of inquiry he pursued became progressively more applied." [9, Chapter 1, Page 13].

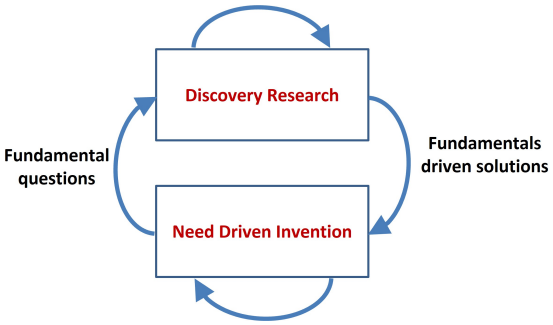


Figure 6: A dynamic model for research; the "self-transitions" model the generation of new questions and ideas within the same type of research. Adapted from [7].

Narayanamurti and Odumosu [7] point out the limitations of Stokes's four-quadrant model as being static and unable to illustrate the dynamic interactions between discovery research and invention. These authors introduce the idea of a Discovery Invention Cycle. Figure 6 is our attempt to compactly represent this cycle, which is extensively illustrated in [7] with examples from the evolution of the research that led to

several Nobel Prizes, and experiences at Bell Laboratories. One example the authors give is that of the invention of the solid-state semiconductor transistor, driven by the need to transmit communication signals over long distances, by a collaboration between a theoretical physicist (Shockley), an experimental physicist (Brattain), and mathematical physicist and electrical engineer (Bardeen), a feat that won the 1956 Nobel Prize in physics, and that made possible the entire computing and communication revolution. Narayanamurti and Odumosu go on to emphasise:

"*... all knowledge should be valued. Some knowledge production is oriented toward improving our understanding of the world through the process of discovery; some is focused on the creation of new techniques and devices, or on the synthesis and creation of engineered materials not found in nature, through the process of invention. The notion of the discovery-invention cycle attempts to view these two aspects of knowledge production as parts of a greater whole. Also by introducing new language, it allows us to escape the cognitive trap of thinking about research solely in terms of initial motivations, that is, "basic" and "applied."* "

In Figure 6, the arrows represent flows of ideas and questions betwen discovery research and need-driven-invention. The arrows that loop back into the same box, illustrate the fact that, for example, each type of research can lead to questions and ideas that lead to further research of the same type. Figure 6 can be the model of a variety of systems:

1. *An individual's efforts during their career:* Over a career, an individual could spend their entire time and effort in either of the boxes, or the time and effort could be split in some proportion over the two boxes. If the latter, the individual could move their effort back and forth between discovery research and invention, ideas from one leading to questions and insights for the other.

2. *A collaborative group's efforts:* Some members of the group might focus on discovery research whereas others would create experience and data from their creations (mechanical structures, electronic hardware, or software, etc.).

3. *A body of researchers:* for example, a university faculty or a research lab. The time and effort of such a body of researchers would split over time and population over the two boxes.

This dynamic model also captures the possibility that the proportion of time and effort in either box varies over time, depending on the demands of the research being conducted.

The four-quadrant model and the discovery-invention-cycle model capture many more nuances than the simple basic vs. applied, linear model, and serve to emphasise the richness of the research experience. Such experience comes from the way discovery research and applications driven research interplay, and also from collaboration between researchers with varied experience and mindsets. Such richness is essential for path-breaking and impactful research. The assessment processes for researchers need to ensure that young researchers are not discouraged from exploring the richness of research in their fields, but are instead encouraged to seek excellence and impact.

3 Researcher Evaluation Processes in Other Systems

3.1 The San Francisco Declaration

The following are excerpts from the San Francisco Declaration on the Assessment of Researchers [2].

- "Do not use journal-based metrics, such as Journal Impact Factors, as a surrogate measure of the

quality of individual research articles, to assess an individual scientist's contributions, or in hiring, promotion, or funding decisions."

- "Be explicit about the criteria used to reach hiring, tenure, and promotion decisions, clearly highlighting, especially for early-stage investigators, that the scientific content of a paper is much more important than publication metrics or the identity of the journal in which it was published."
- "For the purposes of research assessment, consider the value and impact of all research outputs (including datasets and software) in addition to research publications, and consider a broad range of impact measures including qualitative indicators of research impact, such as influence on policy and practice."
- "When involved in committees making decisions about funding, hiring, tenure, or promotion, make assessments based on scientific content rather than publication metrics."

3.2 Career Advancement in Universities

1. *Conversation with Prof. Sanjoy Mitter, MIT, Boston, USA:*
    - *Continuous assessment:* Assessment does not just happen at discrete points of time, but is an organic process embedded into the academic department culture. After making excellent faculty appointments (as also happens in top Indian institutes) the young faculty members are continuously encouraged and provided feedback, even to the extent of encouraging their activities in certain directions. This is viewed as a part of the intellectual functioning of the academic departments. There is an annual reporting process, which even the senior-most faculty take seriously. Thus, when the time for promotion review comes, the institution has a range of inputs to base their decision on, in addition to peer-review letters, without excessive reliance on numerical metrics such as citation counts and various indices. The objective is to cultivate the top-class young faculty appointees in a way that brings out their true intellectual strengths.
    - *Numerical indices:* In the assessment of individuals, little or no attention is paid to numerical indices, such as, the H-index, impact factors, and various indices created and marketed by publishing and ranking agencies.
    - *Order of authors in a publication:* Some PhD guides ask their students whether they would like to publish their papers on their own. Once a paper is jointly published, it is assumed that all authors have contributed, and it is not a good practice to analyse the relative contributions.
    - *Hierarchy and openness:* Institutions need to encourage young researchers to interact openly with senior researchers, without the latter dominating the former. There should be openness and integrity in discussing research questions, within and across disciplines. This results in the formulation of rich and novel research problems.
    - *Interdisciplinarity and breadth:* PhD students are encouraged to "dream," so that when they become faculty members they will seek varied research vistas, rather than adhere to the path shown to them by a PhD advisor.
    - *Observations on academic departments:* A young faculty member grows as a researcher within an academic department. The way academic departments function is, therefore, crucial to the intellectual socialisation of young faculty members, and to their development into world-class researchers. The department also has the closest opportunity to observe the performance of young faculty members after their appointments. Indeed, the most important committee in the promotion process of an Assistant Professor is the department promotion committee. Further, Assistant Professors are involved in the governance of departments. There are frequent seminars

and discussion meetings. A graduate coordinator is continuously in touch with all graduate students. All departments have standing visiting committees, comprising people of stature from academia, industry, and the government. Such committees provide assessments of departments.

2. *Conversation with Prof. Venkatesh Narayanamurti, Harvard University, Boston, U.S.A.*

   - *Continuous Assessment:* Having selected very high quality young faculty members, they need to be nurtured, and be provided regular feedback to get the best out of them. Regular feedback could include an early review (within a couple of years) to set expectations on both sides, and check if there are any early problems. A midterm review (before the first promotion/tenure review) could be used to provide feedback about what is going well and what is not, and, if things do not look good, to give a signal to the young faculty member that they might need to begin to look elsewhere for continuing their careers. To ensure that newly inducted faculty members find their moorings and succeed, some departments identify experienced and carefully selected mentors.
   - *Assessment of teaching:* Universities that value research must have a culture of good teaching as well, and must evolve ways to assess teaching performance of its faculty members. Student feedback is of mixed value, and the feedback comments must be read carefully to distinguish thoughtful feedback from casual or biased opinions. Other approaches for teaching evaluation would include (i) other faculty members attending the assessee's classes, (ii) and an evaluation of how the assessee develops and evolves their courses.
   - *Encouraging collaboration:* Research done under collaborations can create huge impact, and the assessment process must not ask questions that interfere with or jeopardise collaboration. All sorts of collaboration must be allowed to happen, between faculty members through their doctoral students, or even directly between faculty members. Exploitation in the name of collaboration needs to be identified and dealt with, rather than discourage collaboration for fear of exploitation.
   - *Observations on support for research:* New young faculty members must be provided start-up grants, so that they can begin their work very soon after joining the institution. Indian scientists suffer from poor visibility in various forums. Thus, travel support is essential; funding agencies must include travel support in research grants.
   - *Observations on departments and schools:*
     - Departments and schools must undergo periodic reviews by a committee consisting of international experts.
     - There must be a system for leadership development that looks out for faculty members with good interpersonal skills, and those who look beyond their own interests. Faculty members in administrative roles must be evaluated for their performance in these roles. Department Chairs with a good track record of handling their departments can be further selected for senior administrative roles (Dean, etc.). It is important that academic leaders also have respect in the academic community, so that their decisions and action are respected. Appointment of academics to administrative roles (such as chairs, or deans) should be for a fixed tenure, so that a variety of ways of running the systems are brought to the fore, and a larger cadre of potential leaders is created for higher level positions.

4 Recommendations for Young Researcher Assessment

1. *The San Francisco Declaration:* We recommend the adoption of the San Francisco Declaration on the Assessment of Researchers [2], in particular the points listed in Section 3.1. The intent of the

San Francisco Declaration is the clear message that researchers must be assessed on the work they have produced and its impact, rather than the entire focus of the assessment being on where they have published or the various counts (such as impact factors, or h-indices). Indeed, in a policy document of the INSA, Chaddah and Lakhotia ([5]) write, "The 'impact factor' of a journal must not be used as the primary indicator nor should it be used in isolation." In adopting the San Francisco Declaration, our recommendation is that the institution must not solely use scientometry in assessing researchers.

2. *Look for excellence and impact:* The assessment process must seek to identify excellence and impact rather than just "counts." Impact could be on the science of the field, or on practice in the field, or on society. Various items of evidence can be used to assess excellence and impact, not just a large number of papers, citations, or a high h-index. When assessing researchers, a well-conducted peer-review (see below) is a major ingredient of the assessment process. Other items of evidence, such as instruments or systems built, or direct impact on society or business, must be given weight, provided they have been peer reviewed in some way. A large number of peer-reviewed publications, citations, or various numerical indices should not sway the assessment process, but should be just one of many inputs, and, in any case, must not be used in an algorithmic manner. Indeed, to get away from just "piling up numbers," and focusing on impactful research, the candidates or nominees should be asked to identify 3 to 5 of their best publications, which should be the basis for the evaluation of the quality and impact of the published work. In this context, in [6] Chu and Evans write, "Reward and promotion systems, especially at the most prestigious institutions, that eschew quantity measures and value fewer, deeper, more novel contributions could reduce the deluge of papers competing for a field's attention while inspiring less canon-centric, more innovative work."

3. *Respect the importance of collaboration:* While it is important to look for evidence that a young researcher is capable of driving an independent line of research, the constant emphasis on "independent research done in India" stifles national and international research collaboration. It is evident that top-notch collaborators will not accept a young researcher as a co-author if the latter has not contributed to the research in substantial measure. While that is evident, what is not so evident is that, by looking with suspicion at collaborative research, we are keeping our young researchers away from engaging with research networks where some of the "hottest" research topics are being studied. Without being a part of such networks our researchers lose out in being at the cutting-edge, and also the visibility that comes as a result of such engagement.

   Ancillary recommendations in the context of collaboration:

   - *Support travel:* Being a part of such collaborative research networks requires funding for travel; hence, travel should not be looked upon as a "perk" but as a necessity for active researchers. While being essential for collaboration, the travel of researchers also has the following very important benefits:
     - Increases visibility which automatically improves citations and other indices. There is a nontrivial "out of sight, out of mind" factor if researchers are not visible to the extended research community.
     - Exposes researchers to current themes. Saying "it is all out there on the web, so why waste time traveling," is pointless, because there is just too much out there; we see the mass but not the direction of flow.
     - Provides opportunities to interact and collaborate with the international community. Even in the best of the cases, our community is either small or concentrated in a few directions. There is tremendous inertia against initiating novel cutting edge areas in many disciplines. New areas are opened up, usually, only through hiring from abroad in a few places. Where new ideas do germinate in India, our work often gets co-opted and uncited relative to comparable, even derivative work. This happens, again, due to the lack of visibility of our researchers on the international forums.

  - Like sports teams, one hones one's skills and raises one's aspiration level only by closely seeing the best.
- *Do not read too much into the order of authors:* Even though research communities have their own conventions for listing the order of authors on a paper (alphabetical, senior-author-last, student-first, technicians-in-the-middle, order-of-contributions, student-first-and-the-rest-in-order-of-contributions, and various permutations of such "rules"), or of the importance of the "corresponding" author, these conventions could vary across researchers even in the same community. Yet review committees often spend a lot of time trying to extract the precise contributions of an assessee from the order of their name in the author list. Some assessment processes require the assessee to report an estimate of their contributions to each paper.
  - Once there is evidence that the assessee is capable of independent research, nit-picking about their quantum of contribution to each paper is inimical to promoting the spirit of collaboration.
  - Just because the assessee has foreign collaborators on their papers, it must not be assumed that the assessee has played a secondary role. Indeed, the assessee might well be the major contributor, and would not be a part of a major international collaboration unless they had some expertise to offer.
  - The research ecosystem should cultivate an environment where collaborators are expected to play their respective roles in the research, and no one should join a collaboration for a "free-ride."
  - In some experimental disciplines, such as high-energy physics, there could be 100s of authors listed on a paper. In such situations, it is best to consult the spokesperson for the collaboration to assess an individual's contribution.
  - Finally, a careful reading of the peer reference letters might be the best guide to assess if the candidate has truly contributed to their published work.

4. *Recognise the importance of good teaching:* In a university setting, a researcher is responsible for knowledge assimilation, knowledge dissemination, and knowledge generation, or, in simpler words, learning, teaching, and research. These responsibilities have coexisted over centuries. Whereas, learning is a prerequisite for success in both teaching and research, it is not so evident that all three are intertwined. Today, it is self-evident that, for a good university faculty member, neither of these exists without the other. Experienced faculty members know how much their research has helped them deliver more impactful lectures, and how much their teaching has helped them hone their knowledge which has helped them in their research. Thus, an assessment process is seriously incomplete without a teaching assessment. Every assessment of a university faculty member must include a teaching assessment, for which the institution needs to work out a transparent and fair process. In such a process, in most institutions, there is substantial reliance on student feedback. Such questionnaires must be carefully designed to assess the quality of the course content, and the quality of pedagogy. Student feedback can be complemented with other inputs on the quality of a young faculty member's teaching.

5. *Recognise contributions to the profession and to the institution:* In addition to conducting research, researchers have responsibilities in the running of their institutions, and towards their profession (e.g., organising committees of conferences, and governance of professional societies). While the writing of textbooks, monographs, and surveys, does not directly advance knowledge in an individual's research area, these are essential for the dissemination of knowledge to students, and they serve as references for other researchers. All these aspects of a researcher's career are usually viewed as "service," and might be dismissed as unnecessary overhead by promotion assessment committees (and even by the researchers called on to undertake these activities). Contributions to such activities must be given weightage in the assessment of a young researcher for career advancement within their instutions.

Indeed, this must be clearly declared in the assessment policies, so that young researchers and faculty do not avoid accepting such responsibilities.

6. *Peer review:* We recommend a robust peer review process, whether the assessment is for career advancement or for peer recognition. In any research discipline, there is a growing number of areas and subareas, with increasing breadth and depth. Thus, the opinions of experts in the research area of the assessee must play an important role, rather than just publication metrics, and opinions "around-the-table." The following are recommendations for conducting the peer-review:

    - *Choice of referees:* The choice of referees makes or breaks the peer-review process. The referees must be chosen by no criterion other than that they are recognised experts in the assessee's research field. The practice of asking the assessee to provide a list referee names, from which a few are chosen, is a good one, but it must be ensured that there is a minimum number of referees outside the assessee's list, who can provide impartial and unbiased assessments. An expert in the candidate's field could be asked to suggest the names of such referees. An explicit process needs to be in place to handle the situation where most of the potential referees decline to write letters for the assessee, or simply do not respond.
    - *Reference letter requests:* The request for reference letters needs to be customised to each assessee. Specific questions need to be asked, and the referees can be asked to compare the assessee with researchers in the same area, at the same stage in their careers. The preparation of the request letter should be taken as a serious matter, and could be done by an assessment committee member who is broadly familiar with the research area of the assessee, or the Dean/Director/President (of the assessee's organisation) can request an expert to help prepare the request.
    - *Number of reference letters:* There must be a sufficient number of reference letters, so that the committee has a diversity of opinions on the various aspects of the assessee's work. At least six letters should be required for conducting the assessment. To get the required number of reference letters, several requests might need to be sent (even 12 to 15), each followed by one or two reminders. Finally, the list of all the potential referees from whom letters were requested, whether or not they accepted, should be placed before the assessment committee, showing also which list each referee was from (the assessee's list or the department's list).
    - *Availability of the letters to the entire committee:* The letters must be made available to all the assessment committee members, rather than be kept only with the committee chair (as is the practice in some institutions).
    - *Confidentiality:* It is imperative that confidentiality of the potential referee list, the referees who sent their letters, and the reference letters is respected by the organisation conducting the assessment and by the committee members.

7. *Assessment committees:* In many assessment processes, all the information pertaining to a candidate is placed before a committee for a final assessment (suitability for promotion, fellowship, award, etc.). Since it is these committees that make the final assessment, it is important the members are chosen with great care.

    - The committee members must be chosen not for their many recognitions and prominence in the community, but for their understanding of the discipline in which the decisions are to be made.
    - Some institutions have external standing committees who advise the institutional committees in the assessment process. An external committee can help avoid entrenched points of view, and can bring impartiality and fairness in the assessment process.

- These committees (internal or external) will, typically, not have expertise in the area of every candidate whom they are expected to assess. The chair of the committee should be empowered to consult or co-opt an expert, in cases where the chair feels that the assessment committee has inadequacy of expertise.
- A Conflict of Interest declaration process (see below) must precede every meeting in which the committee reviews a fresh batch of applications.

8. *Conflict of Interest (CoI):* The assessment committee members must declare their conflicts of interest with any of the candidates being assessed, in writing, before the deliberations start. Such written declaration of CoI would also be needed from committee members who wish to declare that they have no conflicts with any of the assessees.

9. *Continuous assessment, with the involvement of the assessee:* Within organisations (universities, and research labs), assessment must be continuous. Assistant Professors should be provided annual feedback from within the department, to reassure them as to their progress, or to provide some course corrections. When the formal institutional assessment is carried out, guidance must be provided to the assessee (if needed) when preparing for an assessment, and, after the assessment, the outcomes must be discussed with the assessee. It is essential for the system to maintain a record of the decisions made concerning an assessee's career progression. Since Deans and committees change, a detailed confidential record of the assessment proceedings is strongly recommended.

10. *Enunciation of processes:*

    - In universities and research laboratories, the assessment processes should be clearly described in terms of the criteria adopted and the processes followed. Further, there must be continuity in the procedures, and any changes contemplated must bear in mind that these do not adversely affect young researchers who are still building their careers.
    - In the assessment of nominations for peer recognition (such as academy fellowships, awards, medals, etc.), the criteria must be broadly defined to ensure that the search/selection or advisory committees are free to identify nominees that have done truly impactful research.

5 Ancillary Recommendations for the Research Ecosystem

- *The research funding process:* Modern research depends on research funding, hence, the funding process drives researcher behaviour. What has been written above, about the evaluation of young researchers for career advancement and professional recognition, holds also for the evaluation of the research proposals that they submit to funding agencies, and the evaluation of their performance after having been given a research grant.

  – The process of framing the CFPs (calls for proposals), and of evaluating the submitted proposals for grant of research funds, is very important for the research ecosystem. When large research programs need to be initiated, the funding agencies need to invite "think-tanks" of experts to deliberate over research directions and the framing of the CFPs.

  – The peer review process for identifying proposals to be funded must be transparent and well enunciated. Proposals from less known young researchers must not be dismissed if the work they propose does not fit into some well-established framework. Reputation and pedigree cannot be the basis of accepting proposals from senior researchers. The process should encourage truly novel and impactful research, rather than depend on various "counts" in the PIs' CVs, and general opinions of the committee. The committee can seek additional inputs from experts anywhere.

- *"Ease of doing science" - facilitating the scientific endeavour:* Even in a regime where the funding levels are adequate, the scientific endeavour is constrained by the ability to deploy the funds efficiently. The institutional processes and the national funding ecosystem need to ensure the following:
  - Once a project is approved, the funding agency must release funds as per a declared schedule, and the institution, where the project is being implemented, must facilitate the utilisation of funds so that project objectives are not delayed.
  - Institutional infrastructure (electrical power, space, procurement processes, etc.), and human resources (for installation and operation) must be available for the quick deployment and utilisation of complex equipment.
  - International collaboration, and the travel of collaborators to each other's laboratories must be facilitated.
- *Mentorship of doctoral students and young faculty:*
  - India has just 200 researchers per million population, thus trailing China in researcher density by a factor of at least 5, and the US by a factor of over 20. To correct this low researcher density, the training of large numbers of high-quality, independent thinking PhD students becomes a national imperative for India. There should be an ongoing process by which the PhD students are encouraged to "dream" of their own problems. Certainly, towards the end of the PhD research, advisors should expect the students to think on their own and come up with their own ideas. Thereby, when these students become faculty, they will not just follow the "beaten path" that they have seen in their advisors' labs, but would seek novel research directions.
  - In a similar manner, young faculty members, after they join an academic department should be able to interact freely and openly with their senior colleagues, without the fear of being dominated. On the other hand, the senior colleagues should play an active role in encouraging and mentoring the young faculty, whose success should be viewed as a win-win proposition for the entire academic department.
- *Identification and cultivation of institutional leaders:* The National Education Policy 2020 asserts [3, Para. 13.7]:

  "Excellent faculty with high academic and service credentials as well as demonstrated leadership and management skills will be identified early and trained through a ladder of leadership positions."

  Institutions must be on the look-out for some faculty members, who, while being academic achievers, also have interpersonal skills, and who look beyond their own personal interests. There must be regular evaluation of faculty members in administrative roles, so as to evaluate their performance in their leadership roles. There should be time-limited appointment of academics to administrative roles (such as directors, chairs, or deans), thereby permitting a variety of thought processes being brought to bear on the institution's vision and way of working, and a larger cadre of potential leaders is created for higher level positions.
- *Periodic, international expert reviews of universities and research institution:* It is easy for institutions to assume that they are doing well, not realise the need for changing anything, and thereby slip into a rut, while other, more agile and introspective institutions change rapidly and forge ahead. All institutions, no matter how well-established and reputed, must undergo periodic reviews. These cannot be "check-the-boxes" reviews that are often conducted for entire universities by government appointed committees.
  - Each university must identify reasonable size entities within it (such as departments, schools, divisions, or colleges) and appoint standing committees (of recognised international experts). One approach for appointing a review committee is to appoint an internationally eminent chair,

and then identify the other committee members in consultation with the chair, while always ensuring that there is no conflict of interest with the academic unit being reviewed. A standing committee is advisable, since the members retain memory of their visits, and can assess if the entity is progressing or continuing to slip.

  - Such reviews should be conducted periodically, every five to six years.
  - In addition to a review of the technical activities, the committee must separately meet the doctoral students and post-docs of the entity, as this may reveal concerns that these junior-most researchers might be reluctant to share with their advisors and the management.
  - The committee would be expected to give an objective and unbiased review report. The entity being reviewed must take the review reports seriously. The report should be made available to the members of the entity being reviewed. Critical comments in the reports should be taken as a signal to introspect and, thereby, bring about positive changes. An action-taken report must be prepared and made available to the committee when it meets for the next cycle of reviews.

- *Building research faculty in emerging institutions:*

  - The increasing number of publications shown in Figure 2, has been due to the emphasis several institutions of higher education have placed on high quality publication from their research faculty. Emerging institutions must begin a similar emphasis on high quality research publications in discriminating journals and conferences. Each field should have a basket of good journals and conferences, selected based on their sound editorial practices and reputation.
  - The faculty members of these institutions, specially the younger ones, might be isolated from the larger research community, and, thus, might not be "plugged in" to the current research directions. To encourage them to select good research problems, these faculty can be mentored by institutions with a more mature research ecosystem. One is reminded of the excellent mentorship program in the area of micro and nano electronics run by the nano science and engineering centres at IISc and IIT Bombay.
  - The faculty can be encouraged to engage with the local ecosystem, and work on data (such as epidemiological or medical imaging data), the study and processing of which can lead to novel research questions.
  - The younger faculty in these institutions are burdened with a heavy teaching load. All university faculty must be involved in research of a high standard, and, therefore, their teaching loads need to be capped so as to allow them time for independent thought to develop a research program.

6 Conclusion

In the recent two decades, in spite of the recruitment of many high quality young researchers, and the gradual increase in the availability of research funding (in absolute terms, though not as a fraction of the GDP) the impact of research emanating from India has not kept pace with its international competition. For India to be acknowledged as a science and technology power, a large amount of highly impactful research must originate from this country. For this to happen, it is essential that our young researchers select and work on challenging and risky problems, of the sort that engage the best minds of the day around the world. One of the factors that prevents this from happening, are the long-standing practices we have for assessing the work of young researchers. In this document, we have outlined the existing detrimental practices and their consequences, and we have suggested some good practices, which, if adopted, will encourage our young researchers to select problems that make impact, rather than those that only ensure a good assessment.

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