India’s rank and proportionate share in the global research output- part 2: how publication counting method and subject selection can vary the outcomes?

Vivek Kumar Singh¹, Parveen Arora², Ashraf Uddin³, Sujit Bhattacharya⁴

¹Department of Computer Science, Banaras Hindu University, Varanasi-221005.
²Department of Science and Technology, Govt of India, New Delhi-110021.
³Department of Computer Science, American International University-Bangladesh, Dhaka.
⁴CSIR- National Institute of Science Technology And Development Studies, New Delhi.

Abstract: During the last two decades, India has emerged as a major knowledge producer in the world, however different reports put it at different ranks, varying from 3rd to 9th places. The recent commissioned study reports of Department of Science and Technology (DST) done by Elsevier and Clarivate Analytics, rank India at 5th and 9th places, respectively. On the other hand, an independent report by National Science Foundation (NSF) of United States (US), ranks India at 3rd place on research output in Science and Engineering area. Interestingly, both, the Elsevier and the NSF reports use Scopus data, and yet surprisingly their outcomes are different. This article, therefore, attempts to investigate as to how the use of same database can still produce different outcomes, due to differences in methodological approaches. The publication counting method used and the subject selection approach are the two main exogenous factors identified to cause these variations. The implications of the analytical outcomes are discussed with special focus on policy perspectives.

Keywords: Indian Research, Publication Counting, Research Performance, Research Output Ranking, Scholarly Databases.

Introduction

The most recent report on Research and Development Statistics¹ released by Department of Science and Technology (DST) of Government of India (on page 13), shows three different curves for India’s research output rank, one ranking India at 3rd, second at 5th and third at 9th place. The three curves apparently are drawn from three different studies/reports. The National Science Foundation (NSF) report on Science and Engineering indicators² shows India ranked at 3rd place in global research output. The reports of the two commissioned studies of DST, done by Clarivate Analytics³ (owner of Web of Science database) and by Elsevier⁴ (owner of Scopus database), show India’s research output rank as 9th and 5th, respectively.

DST’s Elsevier and Clarivate Analytics reports use data from different databases, namely Scopus and Web of Science, respectively, and therefore, one may understand that varied coverage of databases may be responsible for the different outcomes of these reports, as explained in detail in the first part of this study (Singh et al., 2020)³. This study showed how the endogenous factors (related to use of different databases) cause variations in findings of different reports. However, given that the NSF and DST- Elsevier reports, both are based on Scopus database, and yet produce different outcomes; it is imperative that exogenous factors
Two key exogenous factors are identified to be responsible for the variations - the publication counting method used and the subject selection. The article analyses the findings of the NSF Science and Engineering Indicators report and DST-Elsevier report, and also some independently obtained data from Scopus database. The analytical results show that changing the publication counting method from whole counting to fractional counting significantly changes the outcome. Similarly, using data for different set (or subset) of subjects is also found to produce different evidence of research output volume rank of different countries.

**Objectives**

The article attempts to identify the impact of exogenous factors, mainly publication counting method and subject selection, on the outcomes of research assessment exercises. Data and outcomes in the two reports (NSF and DST-Elsevier reports) as well as independently obtained data from Scopus database, are analysed for the purpose.

**Data**

The study uses data from three sources: (a) NSF Science and Engineering Indicators Report, 2020, (b) DST-Elsevier commissioned study report 2019, and (c) Scopus database.

The NSF Science and Engineering (S&E) Indicators report obtained data\(^1\) from Scopus database for the period 2000-2018 for S&E in 14 subject areas (S1) pertaining to Science and Engineering area. These subject areas include Agricultural Sciences, Astronomy & Astrophysics, Biological & Biomedical Sciences, Chemistry, Computer & Information Sciences, Engineering, “Geosciences, Atmospheric & Ocean Sciences”, Health Sciences, Materials Science, Mathematics & Statistics, Natural Resources & Conservation, Physics, Psychology, Social Sciences. The data included in the analysis was for the document types of research article, review and conference paper (D1).

The DST-Elsevier report has also drawn data from Scopus database for a set of 16 core S&T subject areas (S2) during 2011-2016. These include Engineering, Medicine, Materials Science, Chemistry, Mathematics, Chemical Engineering, Energy, Immunology & Microbiology, Computer Science, Physics & Astronomy, “Biochemistry, Genetics, & Molecular Biology”, “Pharmacology, Toxicology, & Pharmaceutics”, Agriculture & Biological Sciences, Environmental Science, Earth & Planetary Sciences, Veterinary. The data included in the analysis was for the document types of research article, review and conference paper (D2).

We have mainly analysed the data for publication year 2016, mainly because (a) DST-Elsevier report only had data up to publication year 2016 and (b) publication year 2016 is one of the most recent periods with stable data. It may be noted that the two reports are just slightly different in their subject area selection, with NSF focused mainly on Science and Engineering (including some Social Sciences), whereas DST-Elsevier study included research output in all major areas of Science, Technology and Medicine. Thus, the two report mainly differ in coverage of subject areas like Social Science, Psychology, Health Science and Nursing.

---

\(^1\)https://ncses.nsf.gov/pubs/nsb20206/technical-appendix/
In addition to analysing the data from the two reports, we have also independently obtained research output data for some selected subject groups from Scopus for 20 most productive countries for the publication year 2016. These groups (S3) include the four broad subject areas of Scopus: (a) Life Sciences, (b) Physical Sciences, (c) Health Sciences, and (d) Social Sciences and Humanities; and some selected subject areas: (e) Computer Science, (f) Social Science and Arts & Humanities, (g) Engineering, (h) Agriculture & Veterinary Science and Biology (i) Medicine, Pharmacology, Immunology, Health & Dental Science. The data was obtained for document types ‘article’, ‘review’, and ‘conference paper’ (D3). This independently obtained data was mainly used to analyse and show what impact the subject selection may have on research output rank of countries.

Methodology
The method for analytical study comprised of quantitative and computational approach. The results are shown in tables and figures, drawn mainly by using Excel functions and utilities.

First of all, the 2016 publication data from the NSF report for 20 countries was analysed by varying the publication counting methods, from whole counting (WC) to fractional counting (FC). For this purpose, the proportion of collaborative output of the countries was obtained from the report. The variations in scores due to use of the two counting methods are observed and analysed. The DST-Elsevier report is also analysed along with its outcomes for the publication year 2016. The research output ranks of different countries for whole counting of NSF and DST-Elsevier reports are compared and correlated.

Secondly, the relationship between the reduction in publication score due to fractional counting and internationally collaborated paper (ICP) percentage for different countries is analysed. The objective was to observe whether countries that engage in higher international collaboration stand to lose in publication score due to use of fractional counting.

Thirdly, the independently obtained research publication data for publication year 2016 for different countries for different subject areas was analysed. The data for different subject areas are compared to observe the quantum of variations in research output ranks across different subject areas. The Spearman Rank Correlations are also computed for different subject area based research output ranks.

Results
The analytical results are organized into two parts. First, the impact of changing the publication counting method from whole to fractional on the research assessment outcome is analysed. The relationship between international collaboration and fractional counting is also presented. Secondly, the variations in research output volume and rank of different countries for different subject areas is observed and analysed.

Impact of fractional vs. whole publication counting methods
The difference between whole and fractional counting methods can be understood from the fact that whole counting method gives equal score/credit (score of 1) to each author (and hence the affiliating institution/country), for each publication record. However, fractional counting method divides the score/credit for each publication record among the authors (and hence the affiliating institution/country). Thus, if there are more authors in a research article, the score that each author gets, would be equally divided among them. This implies that authors (and
consequently affiliating institutions or countries) get lesser aggregate score of research publications if they publish more collaborated output involving higher number of authors.

For the 2016 data from NSF report, the research output ranks of 20 countries, using both the whole counting and fractional counting methods are computed. Table 1 shows the whole count and fractional count scores and research output ranks for the NSF report data, whole count for DST-Elsevier report data, and rank correlations between the different ranks in them.

It is observed that countries like UK, France, Canada and Australia that have higher whole count score of publications get lower fractional count score, and consequently the research output rank. On the other hand, countries like India, Russia, South Korea and Brazil get higher fractional count score and rank despite having relatively lesser whole count of publications. Looking at data for some specific countries help understanding the impact of the counting method further. For example, we observe that, UK has 161,910 absolute number of publications and 3rd rank as per whole counting method. However, if fractional counting is used instead of whole counting, its publication score decreases to 97,680.90 and rank decreases to 6th. A similar pattern is observed in cases of countries like France, Canada, Australia etc., which all stand to lose in terms of research output rank, while changing the counting method from whole to fractional.

A counter example is India, which has 150,013 absolute number of publications and 5th rank as per whole counting method. However, its score with fractional counting reduces to 1,35,787.79 but rank improves to 3rd. Thus, India ranking 5th in terms of absolute number of publications moves to 3rd rank if fractional counting method is used. This indicates that the reduction in score for India due to fractional counting is lesser as compared to other countries like UK and Germany, both of which have higher absolute research output than India. Similar patterns are observed in case of countries like Russia, South Korea, Brazil etc. that stand to gain in terms of rank, while changing counting method from whole to fractional.

Thus, it is observed that countries which have higher collaborated output stand to lose more in case the fractional counting method is used. On the contrary, countries which have less collaborated output stand to gain in rank if fractional counting is used.

In order to understand the differences in different ranks of NSF and DST-Elsevier reports, we have computed the Spearman Rank Correlation Coefficient (SRCC). The SRCC value between whole count rank of NSF and Elsevier is found to be 0.999. Thus, the two reports agree significantly in their research output ranks of countries (the first 19 ranks are actually similar, with difference in 20th place, with Taiwan in DST-Elsevier report and Sweden in NSF report). The SRCC value between whole and fractional count ranks of NSF report is found to be 0.947, which also indicate good agreement. However, the level of agreement is lesser than between whole counting ranks of NSF and DST-Elsevier reports. Thus, it can be observed that use of fractional instead of whole counting will cause more variations in ranks of countries that are close in publication volume but differ in their collaborated paper volumes. USA and China (with USA having at least 60,000 publications more than China) constitute an interesting example, as their relative research output ranks get affected with the use of fractional counting due to higher differences in their collaborated papers. UK is another example, which goes down to 6th rank with the use of fractional counting due to higher amount of collaborated papers. We will see below that the reduction in publication scores due to use of fractional counting are found to be highly correlated with the ICP instances of the countries.
We have also analysed the relationship between (a) reduction in score due to use of fractional counting, and (b) internationally collaborated paper (ICP) percentage of different countries. The motivation was to see if those countries which have higher proportion of their research output as internationally collaborated, actually suffer in score due to use of fractional counting method. For this purpose, the proportion of ICP instances for all the 20 countries was obtained and correlated with reduction percentage. Table 2 shows the absolute number of publications, publication score reduction due to fractional counting, and ICP instances and percentage for the 20 countries. It is observed that countries like UK (61.7% ICP), France (58.4% ICP) and Australia (59.5% ICP) get much higher reduction in score as compared to other countries. Countries with lower ICP% are the ones to get lowest score reduction due to fractional counting. The last column of the table 2 shows the ratio of percentages of reduction and ICP. A higher value indicates higher loss of score of a country, connected to higher ICP instances. A ratio of greater than ‘1’ for some countries is in a sense indication of intense multi-institutional, multi-country, and multi-disciplinary research collaboration, which unfortunately gets neglected with the use of fractional counting.
Table 2: NSF report data for year 2016- publication scores, reduction due to FC and ICP values

| Country     | Whole Count (WC) | Fractional Count (FC) | Reduction in score due to FC (in terms of % of whole data) | Internationally Collaborated Papers (ICP) | ICP as % of whole data (1) | Ratio (3/5) |
|-------------|------------------|-----------------------|-------------------------------------------------------------|------------------------------------------|---------------------------|------------|
| USA         | 541,080          | 427,264.63            | 26.6                                                        | 198,875                                  | 36.8                      | 0.72       |
| China       | 483,862          | 438,348.74            | 10.4                                                        | 98,327                                   | 20.3                      | 0.51       |
| UK          | 156,899          | 99,366.17             | 57.9                                                        | 90,497                                   | 57.7                      | 1          |
| Germany     | 154,913          | 108,295.59            | 43                                                          | 78,223                                   | 50.5                      | 0.85       |
| India       | 123,977          | 112,167.34            | 10.5                                                        | 21,815                                   | 17.6                      | 0.6        |
| Japan       | 120,505          | 101,297.3             | 19                                                          | 33,217                                   | 27.6                      | 0.69       |
| France      | 106,846          | 71,028.47             | 50.4                                                        | 58,878                                   | 55.1                      | 0.91       |
| Italy       | 96,822           | 70,534.27             | 37.3                                                        | 46,064                                   | 47.6                      | 0.78       |
| Canada      | 89,219           | 60,045                | 48.6                                                        | 47,015                                   | 52.7                      | 0.92       |
| Australia   | 80,404           | 53,781.62             | 49.5                                                        | 43,702                                   | 54.4                      | 0.91       |
| Spain       | 78,642           | 55,514.33             | 41.7                                                        | 39,412                                   | 50.1                      | 0.83       |
| South Korea | 74,018           | 62,735.09             | 18                                                          | 20,560                                   | 27.8                      | 0.65       |
| Russia      | 73,093           | 62,661.74             | 16.6                                                        | 18,032                                   | 24.7                      | 0.67       |
| Brazil      | 66,813           | 55,181.31             | 21.1                                                        | 21,673                                   | 32.4                      | 0.65       |
| Netherlands | 50,971           | 31,014.65             | 64.3                                                        | 31,414                                   | 61.6                      | 1.04       |
| Iran        | 47,548           | 42,855.86             | 10.9                                                        | 9,794                                    | 20.6                      | 0.53       |
| Poland      | 43,087           | 34,838.68             | 23.7                                                        | 13,218                                   | 30.7                      | 0.77       |
| Turkey      | 41,005           | 35,510.17             | 15.5                                                        | 9,112                                    | 22.2                      | 0.7        |
| Switzerland | 40,285           | 21,952.33             | 83.5                                                        | 27,791                                   | 69                        | 1.21       |
| Sweden      | 35,945           | 20,860.65             | 72.3                                                        | 22,929                                   | 63.8                      | 1.13       |

Figure 1: ICP% vs. Reduction% due to Fractional Count for the 20 countries [Data Source: NSF Report 2020]
To illustrate the relationship between reduction percentage and ICP % further, figure 1 presents a plot of ICP% and reduction%, ordered in descending order of the values for the 20 countries. It is observed that these two curves correlate well, with a Pearson Correlation Coefficient value of 0.98. This implies that ICP% and reduction% are strongly related, with higher ICP% indicating higher reduction% of score due to fractional counting. Therefore, it can be understood that there is a definite relationship between ICP and fractional counting method. The use of fractional counting method is observed to reduce the publication score of countries that have higher proportion of internationally collaborated output. Thus, though the use of fractional counting may be suggested [6,7] for research performance assessment at different levels of granularity, it is observed that using it for country-level studies results in masking of the important dimension of research collaboration networks of countries.

Analysing the impact of subject selection

The next exogenous factor that we analysed is the subject selection in different reports and its impact on the outcomes. The data downloaded independently from Scopus for 20 most productive countries for the publication year 2016 for document types ‘article’, ‘review’, and ‘conference paper’ for different subject areas is analysed for the purpose. The research output data for the four major areas of Scopus as well as some selected specific subjects, as described in the data section, are analysed and the research output ranks are computed. Table 3 shows the research output volume and ranks of the 20 most productive countries.

It is observed that research output ranks of the 20 countries vary across both, the major and the specific subjects. For example, if we look at major areas, it is observed that India is ranked at 3rd rank in research output in Physical Sciences, 5th in Life Sciences, and 10th in Health Sciences and Social Science, both. It may be seen that the four most productive countries- USA, China, UK and Germany are more or less at same research output rank in all the four major areas. The variations in relative ranks across different major areas are seen more in case of some countries, lower in the rank. One example is Russia, which is at 8th rank in research output in Physical Sciences, 12th in Social Sciences, 17th in Life Sciences and 23rd in Health Sciences. In terms of research output in all fields taken together, Russia is at 12th rank.

Similar variations are also seen for research output in specific subjects. For example, USA is at 1st rank in overall data but at 2nd in CS research output. China is at 2nd rank in overall data but at 1st rank in CS research output. UK, which is at 3rd rank on overall data, is at 4th rank in CS, 2nd in SS&AH, 4th in ENG and AGR, BIO & VET, and 3rd rank in MED, IMM & DEN. India also has variation in ranks, with rank 5th in overall, 3rd in CS and 10th in MED, IMM & DEN. Another interesting case is Japan, which is ranked 6th overall, but 11th in CS, 21st in SS&AH, 7th in ENG, 12th in AGR, BIO & VET, and 5th in MED, IMM & DEN. Thus, the relative research output ranks of different countries vary significantly across different subject areas.

Thus, it is observed that relative research output ranks of different countries vary across different subject areas. Therefore, any assessment exercise that uses a subset of data (from selected subject areas) may produce outputs different from those obtained using whole data from all fields taken together. In order to look at all such pair-wise variations, we have also computed Spearman Rank correlations between rankings on all the subject areas, as explained below.
Table 3: Research output and rank of different countries in various subject areas for the year 2016 as per Scopus data

| Country    | ALL Fields | Health Sciences | Life Sciences | Physical Sciences | Social Science | CS | SS & AH | ENG. | AGR, BIO, VET | MED, IMM & DEN |
|------------|------------|-----------------|---------------|-------------------|----------------|----|---------|------|--------------|---------------|
|            | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 | TP R | TP R | TP R | TP R | TP R | TP R | TP R | TP R | TP R | TP R | TP R | |
| USA        | 574705 1 202087 1 146895 1 258315 2 105178 1 62875 2 72433 1 102951 2 47685 1 201151 1 | TP R |
| China      | 487196 2 84881 2 108614 2 355630 1 23545 3 77341 1 11749 5 187942 1 36031 2 86346 2 | TP R |
| UK         | 170925 3 57345 3 39042 3 76659 5 37672 2 18711 5 26168 2 28748 6 13523 4 55396 3 | TP R |
| Germany    | 161325 4 45471 4 38557 4 90793 4 20936 4 20968 4 12255 3 33744 4 12951 5 44827 4 | TP R |
| India      | 142562 5 28305 10 35331 5 93821 3 11021 10 30131 3 5979 12 42511 3 11464 6 34491 6 | TP R |
| Japan      | 121416 6 37592 5 30450 6 70788 6 6041 15 16579 6 3474 18 32095 5 9182 11 37908 5 | TP R |
| France     | 111244 7 30261 8 24908 8 63287 7 15119 8 15417 7 9533 8 22420 8 9383 9 30022 9 | TP R |
| Italy      | 101875 8 32492 6 25239 7 53786 9 13852 9 12621 8 8678 9 20895 10 8822 12 32971 7 | TP R |
| Canada     | 94366 9 31486 7 23787 9 45177 11 16672 6 11260 9 11166 7 17839 11 9440 8 30799 8 | TP R |
| Australia  | 86629 10 29572 9 22457 11 38267 13 18039 5 8851 12 12022 4 14389 14 10547 7 28526 10 | TP R |
| Spain      | 83918 11 24281 11 20520 12 42024 12 16055 7 9631 11 11563 6 15161 13 9359 10 23992 11 | TP R |
| Russia     | 80025 12 8973 23 11135 17 59473 8 10016 12 7208 14 7085 10 21337 9 4033 17 10111 20 | TP R |
| South Korea| 79922 13 21920 14 18180 13 49287 10 5796 16 11041 10 4232 14 25882 7 5739 13 22815 12 | TP R |
| Brazil     | 69935 14 22417 12 23639 10 29731 15 9673 13 6908 15 5817 13 10695 18 15080 3 21674 13 | TP R |
| Netherlands| 53779 15 21998 13 14560 14 21940 18 10227 11 5440 16 6703 11 7748 20 4852 15 21392 14 | TP R |
| Iran       | 51156 16 12734 18 12042 15 31732 14 3535 30 5203 18 1827 35 16564 12 4297 16 15163 16 | TP R |
| Poland     | 44503 17 9763 20 10123 18 27926 16 5051 20 5437 17 3337 20 11585 16 4908 14 10077 21 | TP R |
| Turkey     | 43474 18 17376 15 8593 20 20099 21 5139 19 4218 22 3641 16 8617 19 3778 19 17560 15 | TP R |
| Switzerland| 41984 19 14928 16 11196 16 20775 19 5139 19 4349 21 3097 21 6456 23 3965 18 14309 17 | TP R |
| Sweden     | 37821 20 13054 17 9841 19 18383 22 6055 14 4181 23 3958 15 6947 21 3699 21 12485 18 | TP R |
Table 4: Spearman Rank Correlation Coefficients (SRCC) of different subject area rankings

| Subject Area       | All Fields | Health Sciences | Life Sciences | Physical Sciences | Social Science | CS | SS & AH | ENG | AGR, BIO & VET | MED, IMM & DEN |
|--------------------|------------|-----------------|---------------|-------------------|----------------|----|---------|-----|----------------|---------------|
| All Fields         | 1          | 0.84            | 0.95          | 0.94              | 0.66           | 0.95| 0.45    | 0.87| 0.83           | 0.91          |
| Health Sciences    | 0.84       | 1               | 0.91          | 0.62              | 0.64           | 0.76| 0.42    | 0.54| 0.77           | 0.97          |
| Life Sciences      | 0.95       | 0.91            | 1             | 0.86              | 0.61           | 0.91| 0.35    | 0.76| 0.88           | 0.95          |
| Physical Sciences  | 0.94       | 0.62            | 0.86          | 1                 | 0.44           | 0.95| 0.22    | 0.96| 0.72           | 0.77          |
| Social Science     | 0.66       | 0.64            | 0.61          | 0.44              | 1              | 0.58| 0.95    | 0.28| 0.61           | 0.61          |
| CS                 | 0.95       | 0.76            | 0.91          | 0.95              | 0.58           | 1   | 0.36    | 0.9  | 0.78           | 0.85          |
| SS & AH            | 0.45       | 0.42            | 0.35          | 0.22              | 0.95           | 0.36| 1       | 0.053| 0.41           | 0.38          |
| ENG                | 0.87       | 0.54            | 0.76          | 0.96              | 0.28           | 0.85| 0.28    | 0.61| 0.71           |              |
| AGR, BIO & VET     | 0.83       | 0.77            | 0.88          | 0.72              | 0.61           | 0.78| 0.41    | 0.59| 1              |              |
| MED, IMM & DEN     | 0.91       | 0.97            | 0.95          | 0.77              | 0.61           | 0.85| 0.38    | 0.71| 0.8            | 1             |

Table 4 present the matrix for SRCC values for ranks on different subject areas. It is observed that research output rank on SS&AH have the smallest correlation with other subject areas, indicating that different countries have significantly different amount of research output in this area. Similarly, among major areas, Physical Sciences and Health Sciences have SRCC value of 0.62, indicating different relative orders of countries in research output in these areas. SRCC values between ENG and Health Sciences is also low, again indicating differences in relative research outputs of different countries in these areas. Among specific subject areas, CS and SS & AH, and AGR, BIO & VET and MED, IMM & DEN subject areas have relatively higher pairwise rank correlations. The observations above, thus, clearly indicate that different countries have different strengths of research in different subject areas. Given that the relative research output volumes and ranks in different subject areas are not congruent, using a subset of research output data in an assessment exercise, may produce outcomes that are not only different from other subject areas but also from the overall research output data.

Discussion

The analytical results above highlight how the two exogenous factors (publication counting method and subject selection) can produce significantly different outcomes of research assessment exercises. It is observed that if the research output rankings are based on whole counting method, the NSF and DST- Elsevier reports obtain a very high rank correlation (with same country ranks from 1st to 19th place). However, the research output ranks of countries in NSF based on fractional counting are observed to be more different from DST- Elsevier report, despite the fact that they are very close in terms of subject area composition of data, and draw the data from the same database. Interestingly, a country like UK which is ranked at 3rd rank in terms of absolute research output moves to 6th rank if fractional counting is used. Similarly, India which is at 5th rank in terms of absolute research output moves to 3rd rank with use of fractional counting. There are several other examples illustrated in results. Thus, it can be said that use of fractional counting can produce significantly different outcomes as compared to use
of *whole* counting. Similar observations were recorded in earlier studies by Gauffriau & Larsen (2005) and Gauffriau et al. (2008), where it was concluded that publication counting methods are decisive for rankings based on publication and citation studies.

It is further observed in the analytical results that use of *fractional* counting impacts the rank of countries more which have very high or very low international collaboration. Countries like Switzerland get a reduction of as large as 83% in their publication score due to use of *fractional* counting. A country like UK, with significant publication volume, gets a significant reduction in publication score due to use of *fractional* counting, decreasing its research output rank from 3rd to 6th. On the contrary, countries that have lower international collaboration stand to gain in publication score, an example being India moving to 3rd rank from 5th rank on research output. Therefore, it is extremely important to understand the consequences of use of *fractional* counting in country-level assessment exercises. The use of *fractional* counting can artificially improve publication rank of a country, without any reflection on the country’s overall research quality. Given that the previous studies (such as Glanzel (2001) and Khor & Yu (2016)) have shown that internationally collaborated research gets higher citations, use of *fractional* counting for country-level research assessment exercises need to be seen with this caution. In such cases, the important dimension of international collaboration in research gets masked, whereas use of the *whole* counting method would ease out this effect or situation. This consideration may have plausibly influenced OECD in using whole counting in its science and technology indicators scoreboard (see for example OECD and SCImago Research Group (CSIC), 2016). However, it may also be noted that a study by Tarkhan-Mouravi (2019) have shown that use of whole counting can inflate research outputs of some countries several times. Therefore, as far as it stands for country-level assessment, it would be a better alternative to use *whole* counting, if rankings and assessment are expected to capture important dimension of international collaboration as well. In case, fractional counting method is used, the rankings for a country should be read in conjunction with the ICP.

Another important thing to take into consideration here is that subject selection can also vary the research output ranks of countries. As observed in the results, research output rank of the same country varies significantly on data for different subject areas. For example, India is at 3rd rank in research output in Physical Sciences, 5th in Life Sciences, and 10th in Health Sciences and Social Science, both. Similarly, Russia is at 8th position in research output in Physical Sciences, 12th in Social Sciences, 17th in Life Sciences and 23rd in Health Sciences. Therefore, subject-specific assessments, though useful to understand the relative research strength of a country in a specific area, should not be taken as an overall evidence of research capability of a country. In fact, one may prefer to use an assessment based on wholistic data, comprising of all disciplines, for an overall picture. Subject-specific assessments can nevertheless indicate subject areas, in which a country should focus more in order to improve its overall position in global research landscape (Social Science is one such area in case of India). The point that could be understood from the observations here is that countries occupy different rank in terms of subject area, thus bundling a set of subject disciplines (e.g. NSF- S&E) vis-a-vis whole set of subject disciplines (e.g. NSF- S&T or DST- Elsevier) for a particular database (say Scopus) is bound to create variation in the overall rank of a country. The same will apply equally in case of data drawn from different databases (say Scopus, Web of Science, Dimensions). In other words, rank based on a mix of subject area (NSF S&E) and on overall subject areas (DST-Elsevier) for a country would vary when compared with comparators, both for the same or different databases used.
Conclusion

The paper analyses the impact of methodological approaches (mainly publication counting method used and subject selection) on outcomes of research assessment exercises and provides meaningful conclusions.

First, use of reports based on fractional counting at country level should be read with other important dimensions like quality and international collaboration. A balanced understanding of research strength of a country needs inputs on several important dimensions, including citations and international collaboration, unfortunately use of fractional counting masks the important dimension of international collaboration.

Secondly, assessment exercises with a subset of research output data, including from selected disciplines, may have their own use cases, but may not be a true representation of overall research strength of a country. A wholistic assessment based on comprehensive data may be preferred for country-level studies.

This study contributes in enriching the methodological aspects that require careful considerations while undertaking studies based on research publications. It opens up for example, the current debate on the ‘methodological dilemma’ on fractional counting vis-à-vis whole counting (see for example, Egghe et al. 2000, Tarkhan-Mouravi, 2020). The study also points out that any assessment exercise that uses a subset of data (from selected subject areas) may produce outputs different from those obtained using whole data from all fields taken together. We argue that scientometrics based studies require these types of insights to make the results more reliable and useful to the policy community at large.

Thus, the two-part study on factors that can affect the outcomes of research assessment reports helps in understanding impact of both, the endogenous factors (database-related) and exogenous factors (methodology-related). Both studies taken together present useful observations and implications for science administrators and policy makers. These studies, however, do not analyse other kinds of research outputs (such as patents) and the impact of number of journals from a country indexed in different databases, which would be an equally interesting thing to pursue as a future work.

References

1. Research and Development Statistics at a Glance, 2019-20, Report of Ministry of Science and Technology, Govt. of India. Retrieved from: https://dst.gov.in/document/reports/research-development-statistics-glance-2019-20, May 2020.
2. Science and Engineering Indicators (2020), Report by National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey (HERD). Retrieved from https://www.nsf.gov/statistics/2018/nsb20181/, Apr. 2020.
3. DST- Clarivate Report (2019). Bibliometric Study of India’s Research Output and Collaboration (2011-16), Vol. 01. A study commissioned by the Department of Science and Technology, Government of India, Feb. 2019.
4. DST- Elsevier Report (2020). International Comparative Performance of India’s Research Base: Scholarly Output, Impact, Collaboration, Knowledge Transfer. A study
commissioned by the Department of Science and Technology, Government of India, 2011-16, Feb. 2020.

5. P. Singh, V.K. Singh, P. Arora, S. Bhattacharya (2020). India’s rank and proportionate share in the global research output- part 1: how data drawn from different databases can produce different outcomes? Manuscript submitted to Current Science.

6. OECD and SCImago Research Group (CSIC) (2016), Compendium of Bibliometric Science Indicators. OECD, Paris. Accessed from http://oe.cd/scientometrics.

7. Tarkhan-Mouravi, S. (2020). Traditional indicators inflate some countries’ scientific impact over 10 times. Scientometrics, 123(1): 337–356. https://doi.org/10.1007/s11192-020-03372-1

8. Gauffriau, M., & Larsen, P. (2005). Counting methods are decisive for rankings based on publication and citation studies. Scientometrics, 64(1): 85–93.

9. Gauffriau, M., Larsen, P.O., Maye, I. et al. (2008). Comparisons of results of publication counting using different methods. Scientometrics, 77(1): 147–176.

10. Glänzel, W. (2001). National characteristics in international scientific co-authorship relations. Scientometrics, 51(1): 69–115.

11. Khor, K. A. and Yu, L. G. (2016). Influence of international co-authorship on the research citation impact of young universities. Scientometrics, 107(3): 1095–1110.

12. Egghe, L., Rousseau, R., & Van Hooydonk, G. (2000). Methods for accrediting publications to authors or countries: Consequences for evaluation studies. Journal of the American society for information science, 51(2): 145–157.