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Exploring the relationship between journals indexed from a country and its research output: an empirical investigation

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Abstract
Scientific journals are currently the primary medium used by researchers to report their research findings. The transformation of print journals into e-journals during the last two decades has not only simplified the process of submissions to journals but has also increased their access across the world. It is well-known that there are significant differences in the total number of journals indexed from different countries. It is, however, not very concretely known whether the lack of appropriate number of publication venues in a country (including in one or more subject areas) may inhibit its publication propensity in one way or other. This article, therefore, attempts to explore the relationship between the number of journals indexed from a country and its research output. Scopus database is used as reference database and the master journal list of Scopus is analysed to identify number of journals indexed from 50 selected countries, that have significant volume of research output. The publication data for the countries is obtained from Scopus. The following major relationships are observed: (a) number of journals from a country and its research output, (b) growth rate of journals and research output for different countries, (c) global share of journals and research output for different countries, and (d) subject area-wise number of journals and research output in that subject area for different countries. The results show that for majority of the countries, the number of journals indexed is positively correlated to their research output volume. A similar relationship is also observed in the subject area-wise analysis, confirming existence of the positive correlations between number of journals in a subject area and the research output in that subject area. However, several countries do not fully conform to the observed relationship, indicating that there are several other factors driving the research output of a country. The study, at the end, presents a discussion of the outcomes and provides implications for policy perspectives for different countries.

Keywords Journal indexing · Publication sources · Research productivity · Scholarly databases · Scholarly journals · Scopus

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Introduction

Scientific competency has become an important determinant for creating wealth and economic growth, as new technologies are increasingly science-based and draws from cross-disciplinary scientific fields. This has created competition among nations to develop a strong research 'niche' particularly in newly emerging areas. Developing a research ecosystem and infrastructure to support this ecosystem has thus become a priority in developed as well as emerging and developing economies. Journals are seen as a key scientific infrastructure of a country. Robert Merton (1963) underscored the primary purpose of journals in addressing the contested claims for 'priorities' in research discoveries. He highlighted the key role of journals in settling disputes, and showed that the research publications in journals led to scientific disputes dropping to 72% in the eighteenth century, in the latter half of the nineteenth century it dropped to 59% and by 33% in the first half of the twentieth century. The increasing acceptance of journals in the scientific community can be postulated happening due to various factors such as the peer review process becoming more institutionalized, frequency and fast dissemination of papers, journals' availability in different disciplines/sub-disciplines and in newly emerging areas among others.

Journals have thus become the key communication channel of science and they have played this role right from the first journal published way back in 1665, named Philosophical Transaction of the Royal Society. Since then, thousands of journals have come into existence over a period of more than 250 years. The exponential growth of research papers in journals (Price, 1961) and an estimate by Jinha (2010) that 50 million research articles were in existence till 2009, are among the various indications that highlight that the scientific enterprise is intrinsically linked with journals. There are now different varieties of journals, some published and managed by professional societies, a large number by major commercial publishing houses, and some by higher education institutions. While majority of the journals are highly specialized- publishing mainly into a specific subject area, several others (such as Nature, Science) publish articles and scientific papers across a wide range of scientific fields. Journals are also often classified as national or international, depending on their overall character. However, with the emergence of new era of e-publishing, such differentiation in journals is becoming obsolete. The new e-publishing paradigm has also reduced different kinds of barriers related to article submission in journals and their dissemination to the readers.

The availability of large number of journals has perhaps motivated creation of multiple scholarly databases, which were initially used to measure and understand citation links. Over a period of last 50 years, several scholarly databases have come up. The Web of Science, Scopus, Google Scholar, Dimensions databases are some popular examples. There are also some subject specific databases such as Agricola, Mathsci, Pubmed, Inspec, dblp etc. These databases index journals published from different countries in different subjects and languages. Owing to being a repository of research metadata, these databases are now also being used for research evaluation exercises at different levels- individuals, institutions or countries. Scopus and Web of Science are the two most popularly used databases for such purposes. However, some studies (such as Mongeon & Paul-Hus, 2016; Singh et al., 2020, 2021a) have shown that the different databases have varied coverage of journals and, therefore, research evaluation exercises that use different databases often produce different outcomes. For example, Singh et al. (2020) have shown that India ranks at 11th, 5th and 7th in global research output in Web of Science, Scopus and Dimensions, respectively, for the period 2010–19. The varied coverage of journals in databases is found to be the main reason for such variations. In this context, it is equally important to explore what impact the journal indexing by a database may have on the measured research output of a country, i.e., whether countries having higher number of journals indexed show higher research output.

Over the last few years, these databases have tried to expand their coverage by indexing a greater number of journals, more so from developing countries. This has indirectly impacted the numbers and suddenly the research output from some countries increased manifold. Some studies (such as Basu, 2010) have even shown for specific countries that the growth of national outputs was actually a matter of increased coverage of the concerned database. Many other studies (Collazo-Reyes, 2014; Erfanmanesh et al., 2017; Leta, 2011) have pointed out towards this phenomenon in different settings, but often attributing the growth to several other factors operating together. It is in this context that this article attempts to explore the relationship between journals indexed from different countries and their research output. The Scopus Master Journal List[1] (updated till June 2020) is used for extracting the data for journals indexed from different countries, and the publication records for those countries are obtained from Scopus database.[2] The data is computationally analysed to identify relationship between the number of journals indexed from a country and its research output, over a period of 15 years (2005–2019).

Examining this issue and framing the research problem, it was found that despite the high concentration by publishers dominantly coming from a few North economies, the affiliation of journals shows a wide dispersion. As visible in the two dominant databases, Web of Science and Scopus, one finds that the journals from many developing and emerging economies are now increasingly being indexed in these databases. Many studies in particular have pointed out the 'home bias' or 'home advantage' especially observed in citation influence (Gingras & Khelfaoui, 2018; Tahamtan et al., 2016). Scholars have also examined this issue with journals indexed from a country as an indicator for assessing whether it influences research productivity (Meo et al., 2013; Mueller, 2016). The hypothesis that is built from this indicator is that the number of journals of a country may have an impact on its measured research output volume i.e., it is based on the 'home advantage' thesis. The influential studies in this direction are highlighted in the literature review. However, as we see later, the subject area-wise patterns in the relationship, the impact of advent of e-journals and the overall long-term trend has not been captured in earlier studies. Therefore, more empirical studies are required to understand the relationship between number of journals indexed from a country and its research output. The present paper addresses these issues and thus attempts to fill some important research gaps.

Though, some previous studies (such as Basu, 2010; Leta, 2011; Najari & Yousefvand, 2013; Collazo-Reyes, 2014; Bhattacharya et al., 2015; Erfanmanesh et al., 2017, Moed et al., 2018) have addressed one or more aspect of the research question- whether indexing of higher number of journals from a country (NCJ) in a database lead to a higher research output for that country (in the database). However, these studies took data for a shorter period, the data was for early e-publishing era, and no subject area-wise analysis was done. Moreover, varying evidence is obtained in different studies, with Basu (2010), Collazo-Reyes (2014) and Erfanmanesh et al. (2017) showing evidence of a linear relationship, whereas, Leta (2011), Najari and Yousefvand (2013) and Moed et al. (2018) attributing the

[1] https://www.elsevier.com/?a=91122.

[2] www.scopus.com.

observed patterns to various other factors. This study, therefore, not only attempts to bridge this research gap by carrying out an updated, systematic and comprehensive analysis, but also tries to settle the dispute regarding the relationship observed differently in different studies. The present study is unique in following respects:

- *First*, it uses data for a larger time-period of 15 years (2005–19) for the analysis, which is able to appropriately capture all kinds of patterns. Using this large time-period also allows to observe whether the rate of growth of number of journals of different countries correlates with their rate of growth of research output.
- *Secondly*, the study not only tries to understand the relationship between number of journals and research output for various countries, but also analyses whether the rate of growth of number of journals correlate with the rate of growth of research output. Similarly, the growth of global share of journals and growth of global share of research output for different countries is also analysed.
- *Thirdly*, the study provides an updated analysis on the topic, which is very useful and relevant given that the scientific publishing has now largely transformed into e-publishing.
- *Fourth*, it also performs a subject area-wise analysis of the relationship between number of journals in a subject area from a country and research output in that subject area for the country.
- *Finally*, the study identifies countries with exceptional performance of higher research output despite having lower number of journals and probable factors driving that are discussed, along with relevant policy suggestions for different countries.

Related work

Several previous studies have dwelt into the question of database-induced variations in research output, rank and global share of different countries and have found that use of a different database for sourcing data may produce different outcomes. For example, Singh et al. (2020) have shown that the volume, rank and global share of ten highly productive countries vary across the Web of Science, Scopus and Dimensions databases, with the same countries ranked differently in different databases. These variations are essentially observed due to different number of journals indexed by different databases. The differential indexing of databases also implies that for a given country, different databases may be indexing different amount of its home or national journals, which in turn affect the research output volume and rank of the country in global perspective. Another set of studies (Mongeon & Paul-Hus, 2016; Singh et al., 2021a) have compared the journal coverage of Web of Science, Scopus and Dimensions databases and have shown that different databases have varied journal coverage which in turn results in different countries being ranked in different order on research output in different databases.

Several other studies (such as Basu, 2010; Leta, 2011; Michels & Schmoch, 2012; Najari & Yousefvand, 2013; Collazo-Reyes, 2014; Bhattacharya et al. (2015); Erfanmanesh et al., 2017, Moed et al., 2018) have focused their attention on directly or indirectly understanding the relationship between indexing of journals from a country and its research output. Data for specific countries was analysed in different studies. We now look at some of these most relevant studies.

Basu (2010) considered declining productivity of India during 1990s and hypothesized that it was actually due to decline in number of Indian journals being indexed in the respective databases. The SCIMAGO data was analysed for 90 countries over the period 1996–2006 and a linear relationship between the number of journals indexed and the number of papers published was found, for a majority of countries. Some countries, like France, Japan and China, showed a pattern of higher number of their papers packed into their home journals, which led to introduction of Journal Packing Density (JPD). China's atypical rise in productivity in 2007 was largely attributed to high JPD.

Leta (2011) investigated the cause of rise of Brazil's productivity during late 1990s and early 2000, focusing on the question whether it was attributed to a true penetration of Brazilian science in the international arena or it was simply a result of an increase in number of Brazilian journals being indexed in academic databases. The study found that the rise in graduate courses in Brazil since 1990s enforced a strict criterion of productivity, that led to the adoption of international scientific models. This, in turn provided impetus to publish research internationally, which led to the enhancement in productivity. Several other initiatives such as Scientific Electronic Library On-line also made Brazilian science visible, which in turn impacted productivity. The study concluded that the home journals of Brazil in world's scholarly databases played a marginal and not a dominant role in the growth of Brazil's productivity, rather other factors were found contributing more to the cause.

Michels and Schmoch (2012) attempted to find the reason behind the surge of articles in the Web of Science (WoS) database during 2000–2008 period. The question explored was whether there had been an actual rise in scientific work around the world or the huge rise in scholarly publications was simply a result of addition of journals in the database. It was found that the traditional journals covered by WoS had swiftly decreased and newer ones were added. The study observed that out of the 34% rise in article growth, 17% was contributed by the inclusion of old journals that had been published for a long time but were not indexed by the database so far. The study, however, did not directly study the relationship between journals indexed from a country and its research output.

Najari and Yousefvand (2013) focussed on the scientific productivity of Iran in medical sciences and its contribution in this field to the Middle East and the world. Scopus Data for the time period 2000–2011 was analysed and different scientometric indicators (such as self-citations, % age of cited articles, international collaboration etc.) were computed. It was observed that in the year 2011, Iran accounted for 32.77% publications from the Middle East and 1.57% from the world, and ranked 17th and 23rd among the 226 countries in terms of number of articles and citations, respectively. It was concluded that the exponential growth of the country's research output was mainly due to the improvement of quantity and quality of indexed journals, which also indicated improvements in the research system of Iran.

Collazo-Reyes (2014) discussed about the unusual growth of Latin American and the Caribbean (LA-C) journals in Web of Science (WoS) in merely a four years span (2006–2009), it was observed that this was due to a change in the WoS editorial policy instead of the growth in the LA-C scientific community. As a result of this, the Portuguese language paved its way to become the second scientific language, after English, for LA-C journals in WoS. Among the LA-C countries represented in WoS, it was observed that Brazil comprised the highest share of scholarly data in WoS, which was an outcome of a larger share of its papers indexed in its home journals i.e., a high Journal Packing Density (an average of 100 articles per volume). Brazil's papers indexed in local journals comprised 26% of its entire WoS production, however, the citations received was just 7.5%. Further, 89% of Brazilian papers in its local journals were contributed by Brazilian authors. The

Scopus database also comprised a significant share of LA-C (Latin American-Caribbean) journals but with a steady pace of growth in the considered time period (2006–2009). For the rest of the LA-C countries that were represented in WoS, low levels of productivity and impact was observed. The study, thus found a relationship between number of journals indexed and research productivity for some countries in LA-C.

Bhattacharya et al. (2015) examined the causality behind India's relative decline in the late 1980's and the publication growth from 1995 onwards based on both the databases Web of Science and Scopus. Drawing from global publication activity, the paper argued that India, to a large extent, epitomizes the scientific activity in emerging and developing economies. The study identified the following determinants of growth: expansion of journals in the global databases and significant increase in the Indian journals; expansion of institutes involved in publishing; increase in international collaboration; significant research activity in newly emerging areas. The inclusion of Indian journals progressively in the two databases (for example in 2005 there was 50 and 164 journals indexed in SCIE-E and Scopus, respectively which increased to 105 and 362 journals in 2012). It was an important factor as the average number of home papers in some journals were to an extent of 50% of the overall articles in the journal.

Erfanmanesh et al. (2017) analyzed the qualitative and quantitative role of country journals in the scientific performance of a country. They addressed three aspects: overall publication success of a country, correlations between the number of journals indexed and the number of papers published, and relationship between the number of papers published and the quality of country journals indexed in Scopus. The study analysed the data for 102 countries in the time period of 2005–2014 as obtained from SCImago Journal and country rank (http://www.scimagojr.com). It was found that for the majority of the 102 countries, the publication success largely depended on the number of country journals indexed in Scopus database, the number of papers published in country journals as well as the quality of the country journals indexed (as measured by indicators such as h-index, SJR, CiteScore etc.) The study found that Scopus comprised of maximum journals from Western Europe (48.9%) and North America (27.7%) with UK and US in a dominant position.

Moed et al. (2018) performed a trend analysis of Russia's scientific productivity in the two popular academic databases- Web of Science and Scopus. Russia launched the Project 5–100 in 2013 with an aim to set the share of Russia's research output to 2.4% of the global Research Output and at-least five universities of Russia to feature among the world's top 100 universities ranked according to popular global ranking by the year 2015. The paper, thus, tried to identify factors contributing to the massive increase of Russia's publications in Scopus in 2000–2016. It was concluded that the publication counts and growth rate of publications from Russian institutions was very much impacted by the choice and coverage of database. Not only indexing of more Russian journals in databases contributed to the growth, but there was also an increase in Russian publications in other journals.

While most of these previous studies have tried to understand the relationship between the number of country journals indexed in a database and the scientific productivity of the country, they did not agree on the type and magnitude of the relationship between the two. For example, Basu (2010), Collazo-Reyes (2014), & Erfanmanesh et al. (2017) support existence of a linear relationship between number of journals indexed from a country and its research output; but studies by Najari and Yousefvand (2013) and Moed et al. (2018) have indicated that improvement in quality of research of the countries was also a major factor, with Leta (2011) suggesting that number of journals indexed have only a marginal role on the research output. Therefore, the relationship between number of journals indexed and research output of countries needs a fresh look to settle the disputed previous understanding. A fresh and updated study is also required due to the fact that journal publishing has now transformed to e-publishing mode. With the e-publishing mode becoming the main approach, journals are becoming more international in nature, and the barriers for submissions in the journals from across the world as well as for access to articles published in them have diminished. Therefore, one may expect that the relationship between number of journals indexed from a country and its overall scientific productivity, may have weakened over time. Accordingly, a fresh study with up-to-date data is required. Further, none of the previous studies analysed whether these relationships are also seen for different subject areas, in the sense that whether countries having higher number of journals in a subject area also have significantly higher research output in that subject area. Therefore, it would be interesting to see whether the research strengths of countries (measured as output in specific subject area) are related to number of journals in the subject area indexed in the database. The present study, therefore, attempts to fill this research gap and present an up-to-date study on the relationship between number of journals indexed from a country and its published research output, both in overall terms and also at the level of different subject areas.

Data and methodology

The data for analysis was obtained from Scopus database. *First of all*, the Scopus Master Journal List (updated till June 2020) was downloaded from the Scopus website.[3] The Master Journal List contained 5 worksheets, namely Scopus Source Titles, Serial Conference Proceedings with Profile, All Conference Proceedings, More information on Medline, and ASJC Classification Codes. Out of these five worksheets, we used first worksheet which contained list of 40,385 source entries for a total of 114 countries. The list comprised of three source types- Journal, Book Series, and Trade Journal. There were 38,045 records for Journals, 1527 records for Book Series and 812 records for Trade Journal. We have only considered the source type Journal which resulted in processing of 38,045 journal records. For each journal record in the list, there was a total of 55 fields. These fields included Source record ID, Source title, Coverage, Print-ISSN, E-ISSN, Active or Inactive, Source Type, Publisher's Country/Territory etc. We processed this list to identify journals indexed from different countries by using the field- Publisher's Country/Territory. Since, some journals were found to be inactive for certain years, therefore we did a year-wise sampling of active journals. This means that for a given year (say 2010), all journals which are active are included for analysis. When sampling for the next year (2011), if some of the journals 'active' in 2010 become 'inactive', they are excluded from the 2011 list. This was done due to the fact that Scopus will record publications for active journals only in a given year. In this way, the journals indexed from 114 different countries were identified, out of which we selected 50 countries, with highest research output in Scopus, for detailed analysis. In addition to overall counts of journals, the subject-wise counts of journals for the 50 countries were also obtained. The 27 major subject areas of Scopus were used for the purpose.

Secondly, for the 50 selected countries, the total number of publications were obtained from Scopus database for the period 2005–2019 by using queries of the form: (PUBYEAR > 2004 AND PUBYEAR < 2020) AND AFFILCOUNTRY("*X*"), where *X*

[3] www.scopus.com

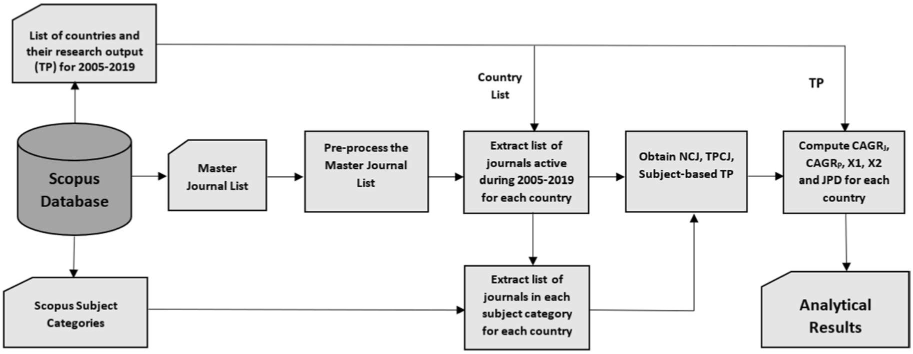

Fig. 1 Schematic diagram of the methodological steps

was substituted by the name of the country. A total of 50 such queries were executed and the publication records of document types 'article' and 'review' were downloaded. Only 'article' and 'review' document types were selected since they are the main publication items in journals. It may be noted that the data period selected for analysis is the one when majority of the traditional journals transformed to e-journals, with some even discontinuing the print publication.

Thirdly, the publication counts for the 50 countries in their home journals (referring to journals indexed from that country) was obtained from Scopus database for the period 2005–2019. This was done by using the query of the form: SRCID (Y_1 OR Y_2 OR Y_3.....OR Y_n) AND AFFILCOUNTRY("*X*") AND ((PUBYEAR > 2004 AND PUBYEAR < 2020)), where Y_1, Y_2, ... Y_n were the unique ids of the *n* journals indexed in Scopus from a given country *X*. These publication records were also limited only to document types 'article' and 'review'.

Fourth, the publication counts for the 50 countries in the 27 major subject areas was obtained from Scopus database for the period 2005–2019. This was done in two steps, first by formulating a query of the form PUBYEAR > 2004 AND PUBYEAR < 2020 AND AFFILCOUNTRY("*X*"). Then results retrieved from the above query were further processed by the Analyse Search Results tab provided by Scopus and under that, the results retrieved were listed according to 27 Subject areas. Thus, the publication counts for 50 countries in 27 major subject areas of Scopus for 2005–2019 were obtained. In this case too, publication records were limited only to document types 'article' and 'review'.

The data obtained as above was computationally analysed to identify the relationship between number of journals indexed and the research output volume for the 50 countries. Figure 1 presents a schematic diagram of the methodology used for the computational analysis. The number of journals, total publications (TP), publications in home journals, and publications in different subject areas were identified and different relationships were observed. The growth rate of number of journals and publications for the period 2005–2019 was computed by calculating Compounded Annual Growth Rate (CAGR) for each of the 50 countries. Two CAGR values, namely $CAGR_J$ and $CAGR_P$, referring to journals (J) and publications (P), respectively, were computed. The CAGR is defined by the following expression:

$$\mathrm{CAGR} = \left(\left(\frac{V_{\mathrm{final}}}{V_{\mathrm{begin}}} \right)^{\frac{1}{t}} - 1 \right) \times 100$$

where, for CAGR_P, V_{final} is the number of publication records in the year 2019, V_{begin} is the number of publication records in the year 2005, and t is the time period in years. In a similar way, the CAGR_J was also computed for all the countries.

The correlations between different values, for the given time period, are computed for all the countries, by computing Pearson correlation coefficient. For example, the Pearson correlation coefficient between NCJ and TP data for a country was computed using following expression:

$$\mathrm{Correl(NCJ, TP)} = \frac{\sum \left(\mathrm{NCJ} - \overline{\mathrm{NCJ}} \right) \left(\mathrm{TP} - \overline{\mathrm{TP}} \right)}{\sqrt{\sum \left(\mathrm{NCJ} - \overline{\mathrm{NCJ}} \right)^2 \left(\mathrm{TP} - \overline{\mathrm{TP}} \right)^2}}$$

where, NCJ is the number of journals from a country, and TP is its research output. Correlation between other values was also computed in a similar manner.

The growth rate of number of journals and number of publications for the whole world was also computed. Two ratios, $X1$ and $X2$ were computed thereafter, for all the countries, where $X1$ refers to ratio of home journals of a country divided by total journals of the world, and $X2$ refers to ratio of total papers of a country divided by total papers of the world. Next, the subject-specific number of journals and publication counts for the 50 countries and correlations between them were observed. Finally, the ratio of research output in home journals to the total research output was computed for all the countries. The different data were processed by writing programs in Python and the results obtained are presented in tables and figures. The major variables computed and computationally analysed are listed below:

Variable	Description
NCJ	Number of Journals from a country
TP	Total Research Papers from a country
TPCJ	Total Research Papers of a country in Home Journals
NCJ-S	Number of Journals in a subject-area
TP-S	Total Research Papers in a subject-area
CAGR_J	Compounded Annual Growth Rate of Journals
CAGR_P	Compounded Annual Growth Rate of Papers
X1	Ratio of home journals of a country divided by total journals of the world
X2	Ratio of total papers of a country divided by total papers of the world

Results

The results first present some observations with respect to number of journals from different countries and the rate of their growth. Thereafter, the research output volume of different countries is computationally analysed, followed by correlation between the two, to identify the relationship between them. The global share of journals from different countries and the global research output share of the countries are observed next. A subject-specific computational analysis of the relationship between number of journals and research output of different countries is presented later. This is then followed by the results for the ratio of research publications in home journals to the total research publications, for different countries.

Number of journals from different countries

The number of journals indexed from the selected 50 countries during the period 2005–2019, along with the total number of journals indexed from the whole world in Scopus during this period, are presented in Table 1. It can be observed that a good number of journals are indexed from US and selected European countries (UK, Netherlands and Germany, to name particularly). Since, we have the journal data for a period of 15 years, we have also computed the growth in number of journals for different countries by computing the Compounded Annual Growth Rate of number of journals (denoted as $CAGR_J$). We can see that the countries like South Korea (11.58%), Iran (15.31%), Malaysia (15.78%), Portugal (13.05%), Egypt (10.4%), Romania (13.4%), Thailand (13.99%), Indonesia (21.69%), Chile (11.93%), Colombia (16.19%) and Serbia (12.89%) have all recorded $CAGR_J$ value of greater than 10%, indicating good amount of growth in number of journals indexed in Scopus from these countries. Countries like US (1.38%), China (2.12%), UK (2.64%), Germany (2.53%), France (0.63%), Canada (0.77%), Netherlands (1.91%), Belgium (1.47%), Finland (1.45%) and Hongkong (1.42%) are the ones to have low growth recorded in the number of journals indexed. Japan (-0.04%) and Israel (-2.90%) are the two countries showing decline in number of journals indexed in Scopus during this period.

Figure 2 shows the trend of growth/decline of number of journals for the 50 selected countries. It is seen that South Korea, Brazil, Russia, Iran, Switzerland, Malaysia, Portugal, Romania, Indonesia, Colombia and Serbia show clear pattern of continuous growth in number of journals indexed in Scopus. Countries like Japan and France show initial growth but then a decline in number of journals indexed. Israel also shows a declining pattern in number of journals indexed. For a recent relative picture of number of journals indexed from different countries, Fig. 3 shows the total number of journals indexed from the 50 selected countries as in the year 2019. It is seen that US, UK, Netherlands, Germany and Switzerland have the highest number of journals indexed in Scopus. In fact, US, UK, Netherlands and Germany, these four countries, taken together, alone account for about 63% of the total journals published in the world, as indexed in Scopus. Other countries have much lower number of journals published in comparison to these countries, though several countries are growing rapidly in terms of number of journals published, as indexed in Scopus. The relative positions of different countries on the number of journals published and indexed is thus clearly understood from this figure.

Table 1 Year-wise number of journals (NCJ) for 50 countries and $CAGR_J$ (2005–19)

NCJ = Number of Country Journal (active and inactive)																$CAGR_J$
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
US	4845	4967	5012	5130	5356	5538	5654	5681	5735	5832	5879	5969	5859	5854	5947	1.38
China	417	446	466	480	494	513	514	519	548	549	550	583	562	562	571	2.12
UK	3827	3987	4091	4266	4479	4718	4879	5001	5085	5216	5344	5418	5446	5551	5658	2.64
Germany	1094	1170	1209	1264	1357	1411	1485	1493	1507	1544	1558	1597	1586	1573	1592	2.53
Japan	376	382	390	401	411	414	425	431	427	415	419	414	383	371	374	− 0.04
India	191	210	226	249	310	361	422	431	434	445	439	461	422	425	432	5.59
France	418	428	437	444	462	476	503	498	493	490	490	491	484	467	459	0.63
Italy	257	262	272	280	299	324	352	368	381	399	422	436	452	459	487	4.35
Canada	213	217	221	222	237	229	233	234	241	239	239	233	221	226	239	0.77
Spain	205	222	238	269	307	322	388	427	447	456	487	495	527	550	592	7.33
Australia	102	108	111	138	164	171	185	180	175	173	172	183	174	166	174	3.62
South Korea	51	61	83	110	124	147	169	182	186	193	203	212	227	247	264	11.58
Brazil	95	157	188	219	235	258	282	303	311	318	327	336	347	362	375	9.59
Russia	240	190	196	210	239	244	256	267	290	302	325	386	418	451	506	5.10
Netherlands	1553	1571	1616	1671	1705	1733	1821	1870	1927	2009	2051	2066	2052	2038	2064	1.91
Iran	21	26	30	43	59	78	101	103	110	117	129	142	148	157	178	15.31
Turkey	79	85	88	112	138	152	165	162	169	174	182	192	183	186	197	6.28
Switzerland	282	293	324	359	390	430	470	492	513	548	605	640	671	678	695	6.20
Poland	174	187	198	222	249	252	268	279	288	292	299	318	321	343	371	5.18
Taiwan	44	45	50	52	63	63	69	73	70	69	73	75	79	83	86	4.57
Sweden	24	26	27	32	34	33	39	41	41	43	45	43	42	41	45	4.28
Belgium	94	96	95	100	102	104	125	123	117	122	117	114	117	112	117	1.47
Denmark	19	18	17	20	21	22	29	28	25	33	31	30	27	29	30	3.09
Austria	28	33	36	35	38	41	49	48	48	48	49	51	47	44	46	3.36
Malaysia	11	17	27	36	46	53	67	72	73	75	77	81	92	96	99	15.78

Table 1 (continued)

NCJ = Number of Country Journal (active and inactive)															$CAGR_J$
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Czech Republic	88	91	100	104	115	121	138	142	152	160	166	176	180	179	186	5.12
Israel	14	12	12	13	13	13	12	12	12	12	12	12	9	8	9	− 2.90
Portugal	10	11	14	17	21	21	31	32	38	39	42	47	49	54	63	13.05
Mexico	41	44	47	69	73	73	81	89	93	102	101	103	105	106	107	6.60
Norway	14	13	13	14	15	14	22	20	22	25	24	25	25	27	29	4.97
Greece	23	25	25	36	42	48	53	56	54	55	50	47	51	49	47	4.88
Finland	29	33	31	30	33	32	43	42	42	44	39	39	40	35	36	1.45
Hong Kong	17	17	16	16	20	19	20	23	21	22	22	22	22	21	21	1.42
Singapore	78	84	87	98	104	108	105	108	106	108	111	116	125	129	134	3.67
South Africa	38	38	41	53	56	59	63	64	66	67	69	72	71	73	81	5.18
New Zealand	24	26	25	39	50	59	60	62	58	62	66	66	61	56	57	5.94
Egypt	44	49	63	75	105	153	164	179	185	202	209	217	204	189	194	10.40
Saudi Arabia	5	6	6	7	19	19	21	20	20	19	19	19	19	19	20	9.68
Romania	27	28	33	59	86	100	125	137	152	155	166	172	171	175	178	13.40
Ireland	11	12	12	13	13	15	18	16	21	20	20	20	22	20	22	4.73
Thailand	8	12	12	18	22	22	27	28	28	27	29	28	39	46	57	13.99
Argentina	23	26	28	40	42	45	49	53	52	55	56	58	57	59	64	7.06
Pakistan	15	32	34	44	71	80	92	97	94	94	89	88	73	75	54	8.91
Indonesia	3	3	3	3	6	10	14	18	19	25	29	33	42	52	57	21.69
Hungary	55	56	78	86	87	86	97	97	95	93	92	97	93	94	93	3.56
Ukraine	27	16	17	23	27	28	30	35	39	38	44	44	41	46	57	5.11
Chile	19	35	49	66	67	68	72	78	81	84	87	93	96	98	103	11.93
Colombia	12	13	22	37	46	49	57	68	79	85	88	94	97	108	114	16.19
Slovakia	29	26	29	31	37	38	43	44	45	45	46	50	56	59	65	5.53

Table 1 (continued)

	NCJ = Number of Country Journal (active and inactive)															$CAGR_J$
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Serbia	12	13	28	33	37	41	45	51	51	53	55	59	63	67	74	12.89
World	15,606	16,250	16,832	17,842	19,069	19,980	21,076	21,525	21,924	22,450	22,917	23,455	23,409	23,640	24,278	2.99

NCJ Number of journals from a country, *CAGR* Compounded Annual Growth Rate

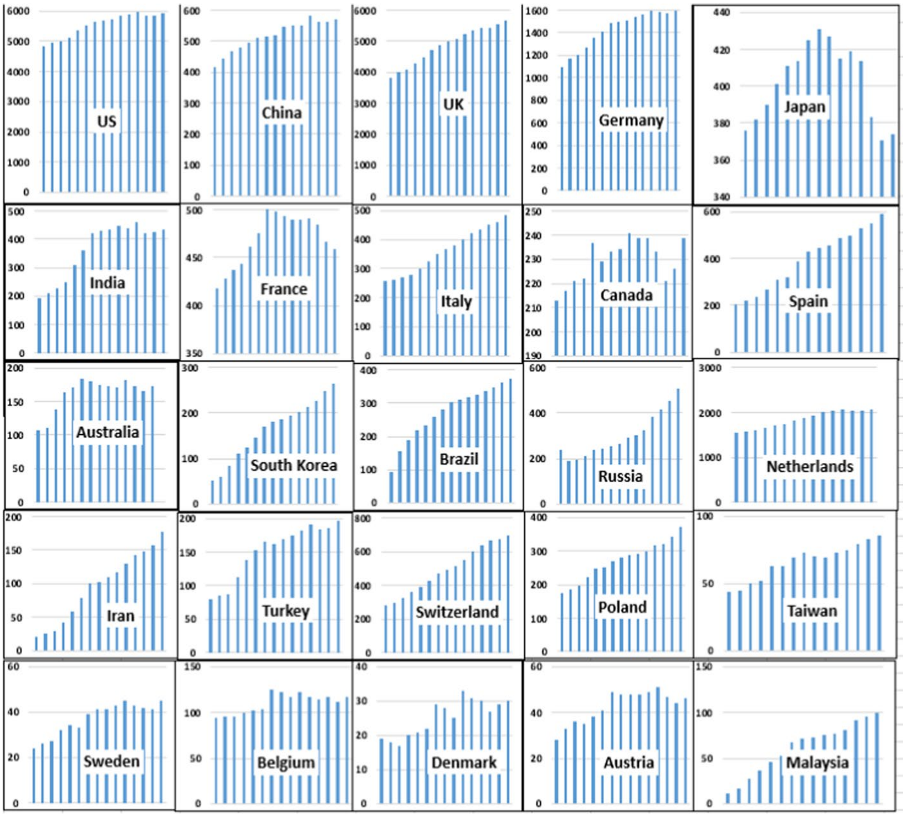

Fig. 2 Number of journals (NCJ) indexed from a country in Scopus (on y-axis) during the 2005–19 period (on x-axis) for the 50 countries. Each bar represents the number of journals published from a country in a specific year

Research output from different countries

The total number of publications for the 50 selected countries during 2005–2019 period are obtained from Scopus database. As indicated earlier, these counts are only for document types 'article' and 'review'. Table 2 shows the publication counts along with the Compounded Annual Growth Rate of publications (denoted by $CAGR_P$). It is seen that US, China, UK and Germany are the leading countries in terms of research papers published in this period. In terms of rate of growth, it can be observed that countries like India (10.13%), Iran (16.27%), Malaysia (17.75%), Egypt (11.94%), Saudi Arabia (18.01%), Pakistan (15.87%), Indonesia (23.45%), Colombia (15.65%) and Serbia (11.11%) are the ones having high growth rate of number of publications. Countries like US (2.66%), UK (3.76%), Germany (3.12%), Japan (0.93%), France (3.05%), Canada (4.18%), Taiwan (3.43%), Israel (3.15%), Greece (3.48%) and Hungary (3.64%) have relatively low growth in the number of publications. However, many of these countries have a high volume of research output, and hence despite the growth

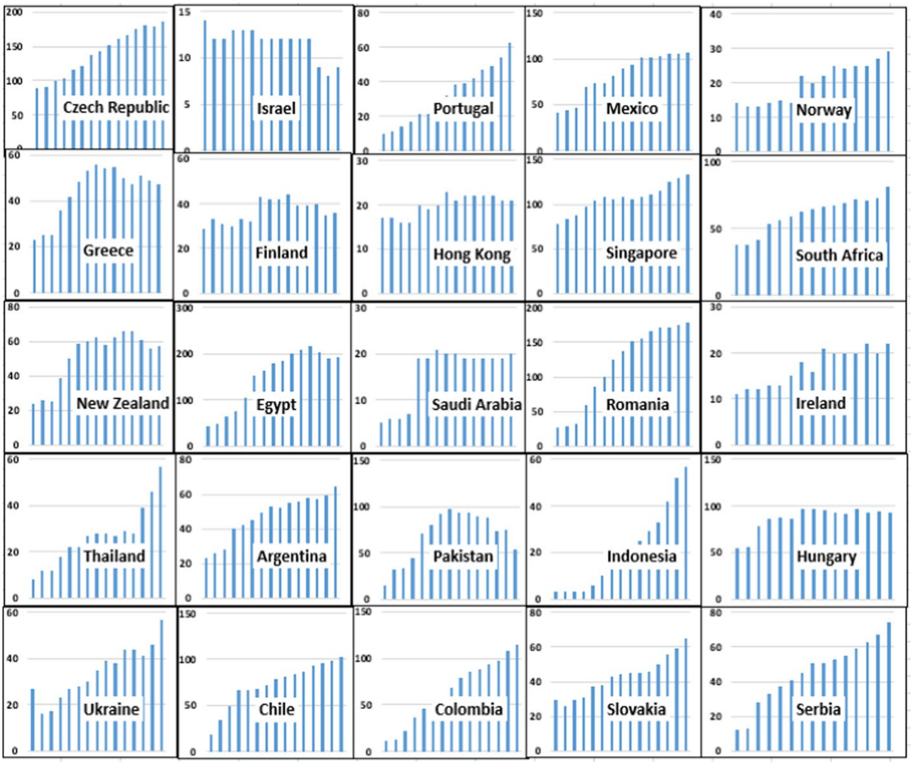

Fig. 2 (continued)

rate being low or moderate, the absolute amount of research output is significant. For example, China has a $CAGR_P$ value of 9.65%, which is good growth rate, particularly given that its publication volume is already significantly large. Interestingly, as we will see in the next section, most of the countries having high $CAGR_J$ also have high $CAGR_P$, indicating that the rate of growth of journals from a country is related to rate of growth of publications of that country.

Relationship between number of journals and research output

In order to understand the nature of relationship between number of country journals indexed and its research output, first of all, correlation was computed between the two for all the 50 countries. For example, for the country US, Pearson correlation is computed between its number of journals during 2005–2019 and its research output during the period. This is then repeated with data for all the countries. Table 3 presents the Pearson correlation coefficients for the 50 countries. It may be observed that the Pearson correlation coefficient for 32 out of 50 countries is higher than 0.9. Thus, except for some countries like Israel and Japan, majority of other countries have high Pearson Correlation Coefficient value, indicating a moderate to strong positive correlation between number of journals and research output of the countries. The average of all the correlation values for all 50 countries is 0.84. Most of the correlations (except for Japan and Israel) were found significant

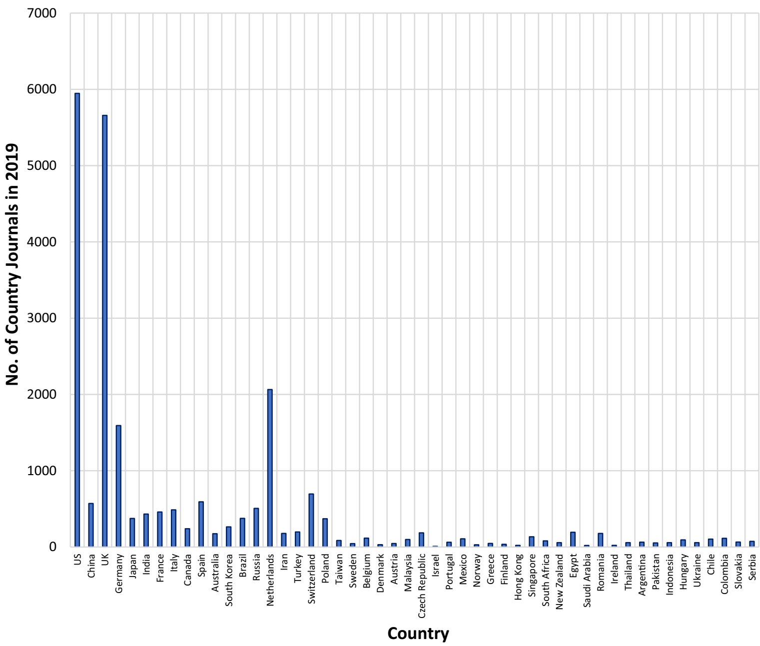

Fig. 3 Number of journals (NCJ) indexed from different countries in the year 2019. (x-axis represents countries and y-axis represents number of journals. Each bar represents the number of journals published from a country)

at 0.01 level (2-tailed). The high values of correlation coefficients can thus be taken as an indicator of positive relationship between number of journals and research output of a country.

To get further insight into the relationship between two variables, we tried to observe the relationship between $CAGR_J$ and $CAGR_P$ values too, for all the countries, i.e., whether the countries with high $CAGR_J$ have high $CAGR_P$ and those having low $CAGR_J$ have low $CAGR_P$. We observed many examples of such kind, such as Iran, Malaysia, Egypt, Indonesia, Colombia and Serbia, all of which had both $CAGR_J$ and $CAGR_P$ above 10%. Similarly, countries like US, UK, Germany, France, Canada, Japan, Israel, Finland are the prominent examples of countries having low values of both $CAGR_J$ and $CAGR_P$. Motivated by these observations, we plotted a scatter plot of $CAGR_J$ and $CAGR_P$ values of the 50 selected countries, as shown in Fig. 4. Countries like Indonesia, Malaysia, Iran and Colombia etc. are the ones having both $CAGR_J$ and $CAGR_P$ in the high value quadrant. Similarly, a large number of countries are in the quadrant of low $CAGR_J$ and $CAGR_P$ values. Some exceptions are China, India, Saudi Arabia, and Pakistan, all of which have relatively moderate $CAGR_J$ value but higher $CAGR_P$ value. We tried a linear regression fit for the observed patterns and found that R^2 value is 0.693. A value of 0.693 for R^2 is usually considered a moderate fit. Thus, we can conclude that there is a moderate linear relationship between $CAGR_J$ and $CAGR_P$, with about 69% points being a good fit to the straight line.

In order to have the relationship between NCJ and its number of publications understood in yet another way, two ratios—*X*1 and *X*2—are also computed. The value *X*1 represents the ratio of NCJ to the total number of journals in the world, as indexed in

Table 2 Year-wise number of total papers (TP) of 50 countries and their $CAGR_P$ (2005–19)

TP = TPCJ + TPOJ															$CAGR_P$
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
US	348,248	366,272	371,282	380,164	397,417	407,883	426,866	445,537	460,780	471,311	475,637	481,551	490,437	502,160	516,612	2.66
China	141,750	165,402	178,564	198,408	220,183	230,892	253,777	286,180	332,272	366,824	388,257	416,343	444,463	495,549	564,672	9.65
UK	95,164	103,814	108,306	108,802	114,057	116,550	122,055	128,567	136,372	138,709	142,996	147,372	150,662	157,059	165,463	3.76
Germany	87,137	93,059	94,884	97,128	101,764	104,861	110,466	116,583	120,813	124,724	125,999	130,153	133,139	135,224	138,114	3.12
Japan	87,307	91,469	90,180	91,507	93,900	90,475	93,229	95,648	97,981	95,950	93,931	96,747	97,085	98,617	100,373	0.93
India	33,428	38,410	42,763	47,863	54,627	63,009	74,893	81,519	88,358	100,049	106,566	110,942	109,663	118,503	142,083	10.13
France	58,205	63,298	65,580	69,725	74,058	75,391	78,707	82,040	85,857	87,866	87,945	91,325	91,718	92,005	91,358	3.05
Italy	45,123	49,383	52,939	55,940	60,068	60,572	64,412	69,711	75,879	78,981	80,775	84,096	86,147	90,451	94,936	5.08
Canada	49,301	53,584	56,050	58,797	62,838	64,329	67,162	71,140	74,598	77,120	78,350	80,003	82,340	86,146	91,145	4.18
Spain	36,092	41,349	44,139	47,683	51,634	54,126	59,494	64,057	67,742	70,269	70,518	73,538	75,535	78,225	84,238	5.81
Australia	32,724	36,724	38,718	42,186	46,388	49,802	53,660	58,151	65,220	69,873	73,304	76,037	78,285	82,956	89,357	6.93
South Korea	24,596	28,056	31,658	36,453	40,844	44,911	48,905	54,574	59,504	64,649	67,805	69,407	70,414	72,294	76,472	7.86
Brazil	20,630	27,200	30,767	35,253	38,706	40,864	44,670	49,159	51,910	55,402	57,237	61,571	65,015	69,347	72,872	8.78
Russia	31,127	28,068	29,727	31,836	32,975	32,813	35,832	35,325	40,368	45,706	53,833	61,452	65,227	71,850	77,561	6.28
Nether-lands	26,538	28,524	29,764	30,964	34,247	36,182	37,990	41,309	43,525	44,847	45,185	46,655	47,443	49,258	51,701	4.55
Iran	6202	8672	11,752	14,988	19,171	22,667	31,597	34,677	37,244	40,501	41,103	47,581	50,188	53,606	59,474	16.27
Turkey	18,013	19,819	21,545	22,754	26,074	27,194	28,971	30,477	32,951	33,862	35,706	38,167	35,293	36,493	41,570	5.73
Switzerland	18,952	20,874	21,862	22,713	24,369	25,572	27,809	30,273	32,031	33,580	34,289	35,841	37,419	38,114	39,132	4.95
Poland	18,575	20,927	21,131	22,883	24,185	24,529	26,333	29,000	31,392	32,720	34,516	36,387	36,271	37,534	39,907	5.23
Taiwan	17,656	20,688	22,082	24,620	26,646	27,499	29,540	30,858	31,541	30,730	29,109	28,627	27,382	27,246	29,266	3.43
Sweden	18,433	19,619	20,069	20,247	22,023	22,707	24,054	25,993	27,928	29,766	30,992	32,182	33,228	34,355	35,714	4.51
Belgium	14,456	15,230	16,348	17,466	18,898	19,544	20,935	22,423	23,918	25,319	25,694	26,268	26,831	27,709	27,682	4.43
Denmark	9891	10,638	11,087	11,771	12,786	13,806	15,318	16,740	17,986	20,142	20,809	21,669	22,390	23,279	24,084	6.11
Austria	9854	10,616	11,381	12,007	12,835	13,405	14,668	15,447	16,543	17,597	18,181	18,874	19,312	20,160	20,984	5.17
Malaysia	2374	3028	3541	4897	7698	9862	13,295	14,828	17,095	18,844	21,100	22,325	22,799	24,023	27,535	17.75

Table 2 (continued)

TP = TPCJ + TPOJ	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	$CAGR_P$
Czech Republic	7404	8736	9607	10,008	10,795	11,669	12,857	13,757	14,606	15,951	17,131	17,739	18,275	18,633	19,502	6.67
Israel	11,428	12,482	12,608	12,889	13,086	13,120	13,620	14,293	14,660	15,433	15,763	16,543	16,715	17,572	18,195	3.15
Portugal	5693	7106	7491	8799	9866	10,789	12,340	13,964	15,609	16,692	17,126	18,086	18,575	19,585	21,356	9.21
Mexico	8247	9003	9657	10,761	11,679	11,708	12,785	14,222	15,137	16,481	17,174	18,353	19,846	21,380	23,232	7.15
Norway	7571	8417	9011	9586	10,879	11,241	12,410	13,310	13,812	14,718	15,008	16,294	17,110	18,472	19,524	6.52
Greece	9051	10,530	11,248	11,815	12,912	12,621	13,032	13,211	13,432	13,604	13,117	13,692	13,702	14,417	15,115	3.48
Finland	9186	9880	10,097	10,464	11,131	11,415	12,180	12,850	13,551	14,662	15,127	15,473	15,730	16,181	17,142	4.25
Hong Kong	8746	9643	9767	9794	10,615	10,538	11,320	12,034	13,278	14,077	14,326	15,157	16,191	17,904	19,149	5.36
Singapore	6827	7534	7607	8292	9124	9949	10,739	11,948	13,086	13,942	14,708	15,170	15,875	16,364	17,237	6.37
South Africa	6204	7146	7242	8073	9062	9863	11,327	12,459	13,844	16,620	16,370	18,043	19,174	20,483	22,664	9.02
New Zealand	6790	7162	7642	7858	8538	9245	10,219	10,470	11,016	11,543	11,731	12,092	12,671	13,140	13,877	4.88
Egypt	3951	4351	4827	5481	6949	7576	9509	11,076	12,413	13,339	14,378	16,366	15,894	18,579	21,452	11.94
Saudi Arabia	1955	2162	2261	2579	3496	4970	7603	9864	12,263	14,956	16,431	17,813	18,094	19,679	23,439	18.01
Romania	3132	3463	4083	6183	7871	8295	9340	9812	10,814	10,198	10,750	10,497	10,077	10,205	11,363	8.97
Ireland	4702	5467	5945	6536	7441	8234	8832	8916	9311	9755	9649	10,334	10,748	11,687	12,490	6.73
Thailand	3737	4667	5131	5730	6484	7063	7850	8806	9071	9715	10,175	11,365	11,959	13,883	14,957	9.69
Argentina	5878	6538	7047	7684	8640	9120	9731	10,198	10,601	11,183	11,348	11,699	12,103	13,042	13,009	5.44
Pakistan	2233	2929	3479	4205	5184	6069	7915	8399	9755	10,180	10,667	12,464	14,858	17,194	20,333	15.87
Indonesia	885	996	1006	1103	1480	1815	2283	2685	3284	4257	5850	7826	10,464	13,979	20,859	23.45
Hungary	5727	6065	6403	6756	7048	6813	7683	8038	8033	8604	8695	8917	9108	9614	9793	3.64
Ukraine	5563	4968	4969	5413	5551	5468	6248	6809	7557	8595	8546	8752	9337	10,536	11,652	5.05
Chile	3368	3980	4456	4921	5598	5853	6632	7442	7946	9276	10,034	11,124	11,606	12,854	13,793	9.85
Colombia	1272	1715	1987	2874	3474	3901	4370	5187	5693	6313	7077	8243	9242	10,379	11,270	15.65

Table 2 (continued)

TP = TPCJ + TPOJ																$CAGR_P$
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Slovakia	2606	2999	3181	3493	3517	3741	4129	4349	4843	5341	5436	6104	6071	6082	6489	6.27
Serbia	1452	1607	1777	3304	3882	4403	5062	6365	6294	6251	6189	6428	6531	6688	7049	11.11
World	1,291,181	1,396,113	1,464,044	1,513,234	1,602,123	1,646,399	1,761,770	1,848,900	1,968,219	2,055,870	2,092,607	2,154,451	2,240,691	2,293,203	2,472,338	4.43

TP Total papers, *TPCJ* Total papers in home journals, *TPOJ* Total papers in outside journals

Table 3 Pearson correlation coefficients of NCJ vs TP for all the 50 countries

Country	Pearson correlation coefficient (TP vs NCJ) for 15 years
US	0.96
China	0.90
UK	0.97
Germany	0.95
Japan	0.03
India	0.87
France	0.76
Italy	0.99
Canada	0.61
Spain	1.00
Australia	0.73
South Korea	0.98
Brazil	0.97
Russia	0.99
Netherlands	0.98
Iran	1.00
Turkey	0.97
Switzerland	0.99
Poland	0.97
Taiwan	0.80
Sweden	0.90
Belgium	0.79
Denmark	0.87
Austria	0.82
Malaysia	0.97
Czech Republic	1.00
Israel	− 0.84
Portugal	0.99
Mexico	0.92
Norway	0.96
Greece	0.83
Finland	0.59
Hong Kong	0.70
Singapore	0.93
South Africa	0.93
New Zealand	0.81
Egypt	0.87
Saudi Arabia	0.68
Romania	0.97
Ireland	0.93
Thailand	0.96
Argentina	0.97
Pakistan	0.43
Indonesia	0.95

Table 3 (continued)

Country	Pearson correlation coefficient (TP vs NCJ) for 15 years
Hungary	0.77
Ukraine	0.95
Chile	0.91
Colombia	0.97
Slovakia	0.95
Serbia	0.96

Average value = 0.84

NCJ Number of journals from a country, *TP* Total papers

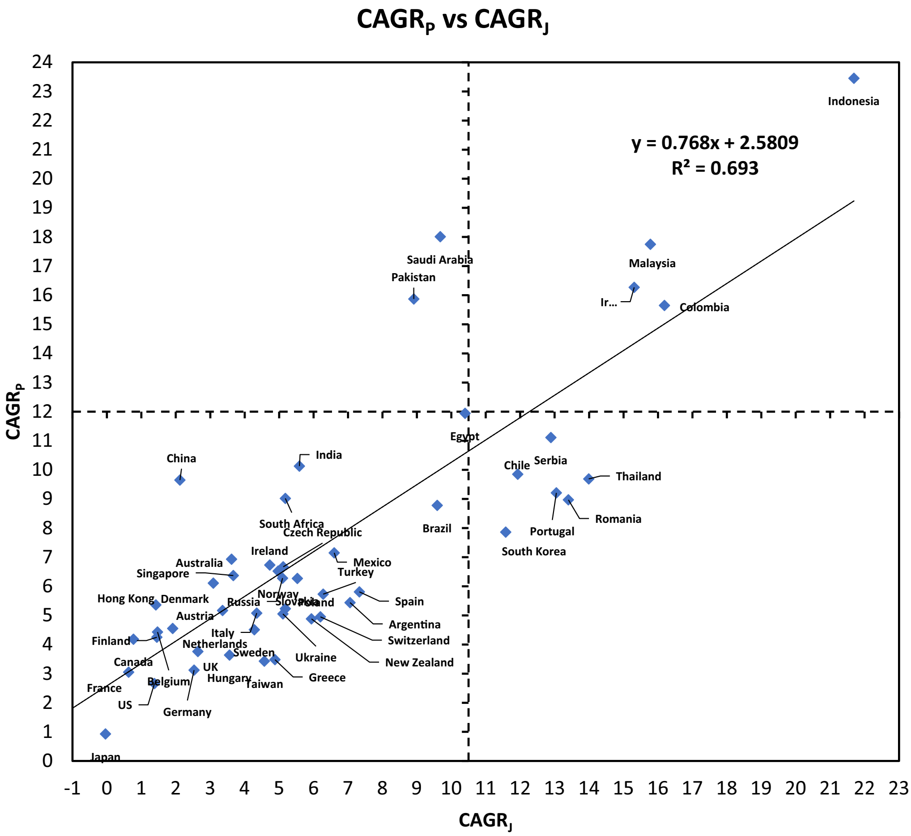

Fig. 4 $CAGR_J$ vs $CAGR_P$. [Each (x, y) point represents a country]

Scopus for all the years under consideration. The value *X*2 represents the ratio of number of publications from a country to the total number of publications from the world, as indexed in Scopus for all the years under consideration. Figure 5 plots the values of *X*1 and *X*2 for all the 50 selected countries for the period 2005–2019. The *X*1 and *X*2

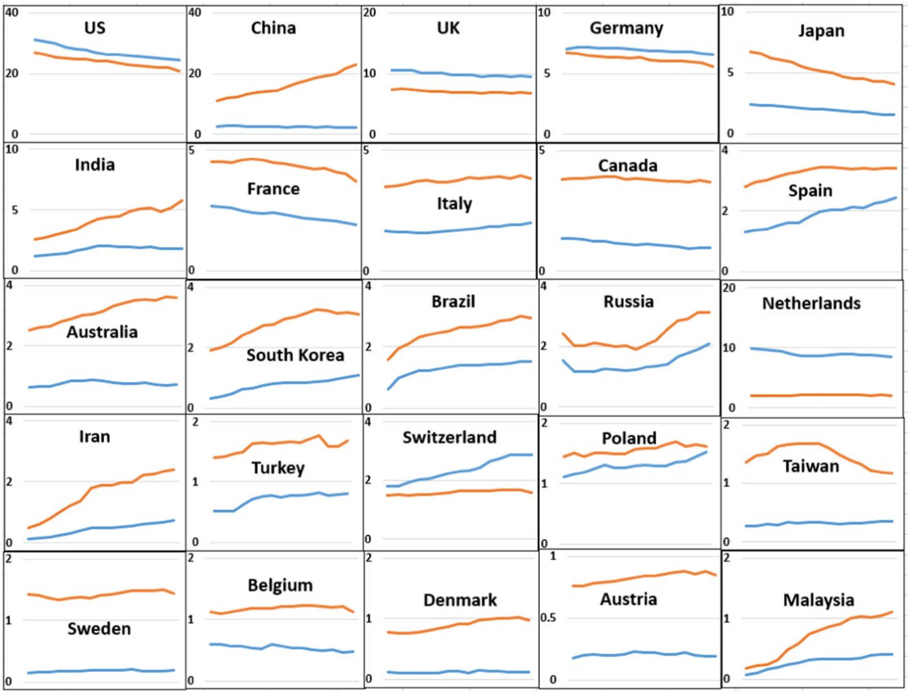

Fig. 5 *X*1 (blue line) and *X*2 (red line) with respect to time. (The x-axis represents year and the y-axis represents value. *X*1-ratio of country journals to world-wide journals, and *X*2- ratio of country papers to world-wide papers). (Color figure online)

patterns drawn in the figure show that for majority of the countries *X*1 and *X*2 have similar pattern, indicating that as the global share of its number of journals increase, the global share of its publications has also increased. Some notable exceptions are, however, there in form of countries like China, India, Malaysia, South Africa, Saudi Arabia, Iran, and Pakistan, all of which have higher growth in global research output share as compared to global journal share. Similarly, Switzerland and Romania are prominent examples of decrease in global research output share despite an increase in the global journal share.

Subject area-wise computational analysis of number of journals and research output

The relationship between number of journals and research output of the countries was also observed for different subject areas. The objective was to see if countries having higher number of journals in a subject area get higher research output in that subject area. In other words, whether there exists a linear relationship between number of journals of a country in a given subject area and its research output in that area. For this purpose, the 27 major subject categories of Scopus were chosen as subject areas. For each subject area, the number of journals were identified for each country through a year-wise sampling, as used earlier (referred to as NCJ-S). Similarly, the research output in each subject area for each country was also obtained (referred to as TP-S). Thereafter for each country the correlation

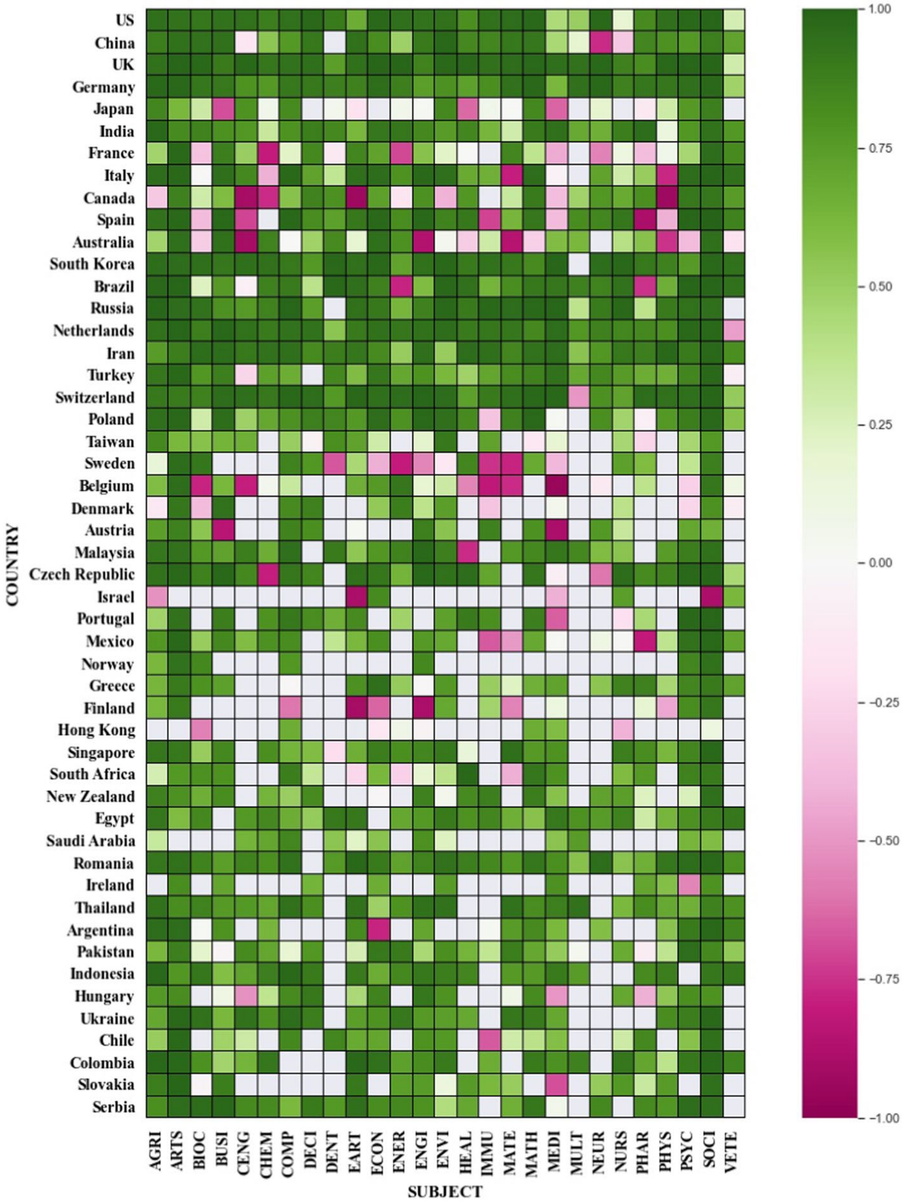

Fig. 6 A 2-d matrix representing Heatmap of Correlations between NCJ-S and TP-S for different countries in different subjects. *AGRI* Agricultural and Biological Sciences, *ARTS* Arts and Humanities, *BIOC* Biochemistry, Genetics and Molecular Biology, *BUSI* Business, Management and Accounting, *CENG* Chemical Engineering, *CHEM* Chemistry, *COMP* Computer Science, *DECI* Decision Sciences, *DENT* Dentistry, *EART* Earth and Planetary Sciences, *ECON* Economics, Econometrics and Finance, *ENER* Energy, *ENVI* Environmental Science, *HEAL* Health Professions, *IMMU* Immunology and Microbiology, *MATE* Materials Science, *MATH* Mathematics, *MEDI* Medicine, *MULT* Multidisciplinary, *NEUR* Neuroscience, *NURS* Nursing, *PHAR* Pharmocology, Toxicology and Pharmaceutics, *PHYS* Physics and Astronomy, *PSYC* Psychology, *SOCI* Social Sciences, *VETE* Veterinary. (Color figure online)

was obtained between year-wise values of NCJ-S and TP-S. Figure 6 shows a 2-d matrix of Pearson correlation coefficient values between NCJ-S and TP-S for the 50 countries in the 27 subject areas. The 'green' color denotes values greater than '0' and 'red' color denotes values less than '0'. Intensity of the color denotes the strength of correlation. Some values are not available (marked by 'white' color). It is observed that the majority of the values are positive, indicating positive correlation between NCJ-S and TP-S. In fact, out of 1,350 correlation coefficients, 277 values are NA, 955 are greater than '0', and only 118 are negative. Among values greater than '0', 703 values are in the range 0.7–1.0, 131 values are in the range 0.5–0.7, and 121 values are between 0 and 0.5. Thus, a large majority of the correlation coefficient values between NCJ-S and TP-S show positive relationship between number of journals in a subject area from a country and its output in that subject area. In other words, those countries that have higher number of journals indexed in a subject area, also get higher number of publications in that subject area. It would be interesting to mention here certain examples. We can see that US and UK have good number of journals in Agricultural & Biological Sciences (AGRI) and Arts & Humanities (ARTS) and also good research output volume in these subject areas. Australia and Brazil have lesser number of journals in Chemical Engineering (CENG) and also low research output volume in this subject area. There are, however, also some exceptions, indicated by a negative correlation.

Ratio of publications in home journals to total publications

We measured the proportion of research publications from a country that appear in its home journals. This is done to see if countries with high growth of research output are actually getting higher proportion of its research papers appearing in home journals. The ratio of TPCJ and TP are computed for all the 50 countries over the period of 15 years. Table 4 presents the ratio of publications in home journals (TPCJ) to the TP for different countries. In general, for most of the countries the proportion of research output appearing in home journals have declined, except for some countries like Switzerland and Malaysia. For countries like US, UK, Germany, which has large number of home journals, the decline in publications in home journals is not that significant. Some other major countries that show a decline in proportion of papers in home journals are France, Poland, South Africa, Pakistan etc. Most of the other countries either continued with almost similar proportion of papers in home journals or show a very slight decline over time. This is an indirect indication that their growth in research output involves factors beyond publications in nationally oriented journals. Few countries show an increase in the proportion of papers in home journals, such as Switzerland and Malaysia, both of which saw an increase in number of journals indexed. One interesting pattern worth observing is that of China. It is seen that China, which published 63% of its papers in home journals during 2005, shows a constant decline of the proportion values, becoming just 17% in the year 2019. This is a clear indication that China's total publication growth is significantly higher as compared to its journal growth. In fact, China, has expanded its publication base significantly during this period. These results provide a general observation that majority of the countries have expanded their research publishing beyond home journals, since the proportion of papers published in home journals has decreased for majority of the countries.

Table 4 Year-wise Ratio of TPCJ by TP for all the 50 countries

TPCJ/TP	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
US	0.56	0.55	0.53	0.52	0.53	0.53	0.52	0.53	0.52	0.50	0.50	0.49	0.48	0.47	0.46
China	0.63	0.58	0.55	0.52	0.49	0.46	0.40	0.36	0.34	0.30	0.27	0.25	0.22	0.20	0.17
UK	0.44	0.43	0.42	0.41	0.42	0.42	0.42	0.41	0.41	0.41	0.42	0.42	0.42	0.41	0.41
Germany	0.24	0.22	0.22	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.19	0.19	0.19	0.17	0.16
Japan	0.27	0.26	0.24	0.23	0.25	0.26	0.24	0.24	0.22	0.20	0.20	0.20	0.18	0.17	0.16
India	0.27	0.24	0.23	0.24	0.25	0.28	0.29	0.28	0.28	0.28	0.32	0.29	0.24	0.22	0.27
France	0.18	0.17	0.16	0.16	0.17	0.17	0.16	0.15	0.14	0.14	0.13	0.13	0.12	0.11	0.09
Italy	0.12	0.10	0.10	0.09	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.08
Canada	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04
Spain	0.18	0.18	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.14
Australia	0.07	0.07	0.06	0.07	0.06	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03
South Korea	0.15	0.15	0.18	0.18	0.19	0.21	0.20	0.19	0.19	0.18	0.18	0.17	0.16	0.17	0.15
Brazil	0.29	0.36	0.38	0.38	0.39	0.39	0.39	0.37	0.34	0.32	0.30	0.28	0.27	0.27	0.26
Russia	0.51	0.45	0.45	0.47	0.49	0.53	0.50	0.47	0.45	0.44	0.43	0.45	0.48	0.49	0.48
Netherlands	0.22	0.22	0.22	0.20	0.21	0.20	0.19	0.19	0.20	0.19	0.19	0.19	0.18	0.18	0.17
Iran	0.12	0.09	0.10	0.11	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13	0.12	0.11
Turkey	0.15	0.15	0.14	0.16	0.19	0.22	0.24	0.24	0.21	0.20	0.20	0.19	0.19	0.16	0.15
Switzerland	0.08	0.07	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.10
Poland	0.39	0.38	0.36	0.37	0.38	0.38	0.37	0.37	0.33	0.29	0.27	0.27	0.26	0.23	0.20
Taiwan	0.08	0.07	0.07	0.06	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.05
Sweden	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.01
Belgium	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02
Denmark	0.04	0.04	0.04	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.03	0.02	0.02	0.01	0.01
Austria	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Malaysia	0.11	0.13	0.12	0.14	0.11	0.11	0.10	0.11	0.12	0.12	0.17	0.16	0.17	0.19	0.14

Table 4 (continued)

TPCJ/TP

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Czech Republic	0.33	0.30	0.30	0.27	0.26	0.27	0.28	0.27	0.24	0.22	0.22	0.20	0.19	0.18	0.17
Israel	0.03	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01
Portugal	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.04	0.05	0.04	0.03	0.04	0.04	0.04
Mexico	0.15	0.16	0.15	0.17	0.17	0.17	0.18	0.17	0.16	0.17	0.15	0.13	0.12	0.12	0.11
Norway	0.05	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.03
Greece	0.06	0.06	0.04	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.04
Finland	0.05	0.03	0.02	0.02	0.04	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Hong Kong	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Singapore	0.05	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
South Africa	0.15	0.15	0.13	0.13	0.13	0.12	0.13	0.12	0.12	0.11	0.12	0.12	0.11	0.10	0.11
New Zealand	0.05	0.05	0.05	0.06	0.06	0.05	0.06	0.04	0.05	0.04	0.04	0.04	0.04	0.03	0.04
Egypt	0.10	0.07	0.06	0.06	0.05	0.04	0.04	0.05	0.06	0.06	0.05	0.05	0.04	0.05	0.05
Saudi Arabia	0.14	0.11	0.09	0.10	0.09	0.08	0.05	0.04	0.03	0.03	0.03	0.02	0.03	0.03	0.03
Romania	0.37	0.33	0.34	0.46	0.50	0.49	0.47	0.42	0.42	0.39	0.40	0.39	0.36	0.33	0.32
Ireland	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Thailand	0.23	0.21	0.18	0.16	0.16	0.15	0.15	0.16	0.12	0.13	0.12	0.11	0.11	0.14	0.12
Argentina	0.10	0.09	0.09	0.10	0.11	0.11	0.11	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08
Pakistan	0.43	0.41	0.36	0.35	0.34	0.31	0.31	0.32	0.31	0.26	0.23	0.22	0.19	0.18	0.14
Indonesia	0.14	0.13	0.12	0.10	0.13	0.15	0.17	0.18	0.14	0.12	0.13	0.13	0.14	0.13	0.10
Hungary	0.22	0.21	0.23	0.23	0.22	0.22	0.23	0.21	0.18	0.19	0.17	0.16	0.15	0.16	0.13
Ukraine	0.16	0.06	0.06	0.10	0.12	0.14	0.11	0.19	0.22	0.24	0.29	0.27	0.26	0.25	0.24
Chile	0.15	0.21	0.21	0.24	0.25	0.24	0.23	0.22	0.21	0.19	0.17	0.16	0.14	0.13	0.12
Colombia	0.16	0.19	0.23	0.31	0.33	0.32	0.32	0.30	0.27	0.26	0.23	0.24	0.19	0.17	0.16
Slovakia	0.23	0.19	0.17	0.18	0.17	0.18	0.16	0.16	0.18	0.16	0.14	0.14	0.14	0.13	0.15

Table 4 (continued)

TPCJ/TP															
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Serbia	0.29	0.23	0.36	0.27	0.26	0.25	0.20	0.19	0.20	0.19	0.18	0.18	0.18	0.16	0.16

TPCJ Total papers in home journals, *TP* Total papers

Discussion

The results obtained about number of journals and research publications show interesting patterns. First, we discuss some observed trends about number of journals from different countries indexed in the Scopus database. It is observed that while US, UK, Germany and Netherlands continue to have the highest number of journals indexed in Scopus, several other countries have also witnessed a rapid increase in number of journals indexed. This growth in number of journals indexed is happening more in southeast Asian countries (like Indonesia, Thailand, South Korea), Western Asian countries (like Iran) and non-English speaking European countries (like Spain and Portugal). Thus, Scopus appears to be indexing more and more journals from a wider list of countries. For many countries, the number of journals indexed has multiplied manifolds during the 2005–19 period. Examples include South Korea (5 times), Iran (8 times), Malaysia (9 times), Brazil (4 times), Portugal (6 times), Romania (6 times), Indonesia (19 times), Colombia (9 times), Thailand (7 times) and Serbia (6 times). The above statistics provide a broad overview of the global journal landscape based on country affiliation. Causality behind the trend may be influenced by a large number of latent factors. The presence of big publishing houses, reputed universities and research institutes and professional/academic societies, liberal endowment funds can be plausible factors for the skewness observed in journal affiliations country wise. The demand of inclusivity and addressing global audience could be the motivating factor behind journals from emerging and developing country journals getting included in the database. Addressing the bias of journals only from English speaking country may also be another reason behind the shift that is observed in journal inclusion. Therefore, a more in-depth study is required to arrive at a more informed understanding of the distribution of journal indexing from different countries.

We now discuss the observed relationship between number of journals indexed from a country and its research output. It is observed that the number of journals (NCJ) and research output (TP) from a large majority of countries, are found to be correlated well. Out of 50 countries, 32 have Pearson correlation coefficient greater than 0.9, indicating a strong positive correlation. These patterns thus indicate that countries having higher number of journals indexed do also have higher research output. A similar kind of positive association was also observed in the previous studies by Basu (2010), Collazo-Reyes (2014) and Erfanmanesh et al. (2017), all of which found a linear relationship between NCJ and its research output. However, at the same time, we observe that some countries do not show a strong positive correlation, or at least the rate of growth of journals ($CAGR_J$) is not commensurate with the rate of growth of research output ($CAGR_P$). For example, Israel and Japan have the lowest correlation values. Similarly, as in 2019, China, which is 2nd in world in terms of research output has a smaller number of journals indexed (7th rank according to number of journals indexed). Therefore, China's growth in research output cannot be attributed much to growth of its number of journals. Another example is India, which is ranked 6th in global research output, but has only limited number of journals indexed as in the year 2019 (11th rank according to number of journals indexed). Thus, in case of India too, other factors have also played a role in growth of research output. Netherlands, which has the 3rd highest number of journals indexed, ranks at 15th place in global research output. These examples thus support findings of Leta (2011), Najari and Yousefvand (2013) and Moed et al. (2018), all of which indicate that growth of research output of a country has to be attributed to both quantity (growth in journal indexing) and quality (increase in internalization and quality of science) factors.

The results also show that for a majority of countries, the rate of growth of research output ($CAGR_P$) correlates with the rate of growth of journals ($CAGR_J$). Moreover, the results show a close to linear relationship between $CAGR_J$ and $CAGR_P$ (Fig. 4), thus supporting findings about linear relationship by Basu (2010), Collazo-Reyes (2014) and Erfanmanesh et al. (2017). However, in this case too, there are several exceptions such as Saudi Arabia, Pakistan, China, India and South Africa, all of which have higher rate of growth of research output as compared to rate of growth of journals. Similarly, countries like South Korea, Thailand, Romania and Portugal register a high growth rate in number of journals but their research output growth is not in the same order. For these countries, the research output volume can be attributed to other factors (such as quality), as suggested by Leta (2011), Najari and Yousefvand (2013) and Moed et al. (2018). The plots for $X1$ and $X2$ (Fig. 5) also show interesting patterns of relationship. For majority of the countries, $X1$ and $X2$ follow similar trend, i.e., as the countries' global share of journals has increased, its global share of publications has also increased. However, again exceptions are observed in form of countries like China, India, Saudi Arabia, South Africa and Indonesia, all of which is growing higher in terms of global share of research output as compared to growth of global share of number of journals. These countries have improved their research output volume at a rate which is higher than rate of growth of journals. This indicates that they have also witnessed an overall improvement of standards of research publishing so as to get the publications accepted in the well-known international journals. The e-publishing era may also be acting as a facilitator for wider acceptability and dissemination of research conducted in these countries.

The subject area-wise computational analysis of the relationship between number of journals and research output of countries, also shows a kind of positive correlation for majority of the countries. It is observed that for majority of the countries the correlation coefficient computed is positive and strong (Fig. 6). It can be seen that, out of 1350 correlation coefficients, 955 are greater than '0', with 703 values in the range 0.7–1.0 and 131 values greater than 0.5. Thus, a large majority of the correlation values between NCJ-S and TP-S show positive relationship between number of journals in a subject area from a country and its output in that subject area. In other words, those countries that have higher number of journals indexed in a subject area, also get higher number of publications in that subject area. For example, US and UK have good number of journals in Agricultural & Biological Science (AGRI) and Arts & Humanities (ARTS) and also good research output volume in these subject areas. Australia and Brazil have lesser number of journals in Chemical Engineering (CENG) and also low research output volume in this subject area. However, in case of subject area specific patterns too, exceptions are observed, as seen in the 'red' colored values in the Fig. 6.

In order to ascertain this attribution of increase in research output to increase in number of journals, one would need to understand the pathways of the relationship between the two. Is the relationship happening due to a common underlying factor that is affecting both the variables positively is an important question that needs a detailed examination. Scopus has increased its coverage significantly in recent years and has paid special attention to journals from developed/emerging economies. Thus, Scopus is much more diversified now in terms of indexing journals from different countries. Therefore, one may be tempted to postulate that this is the underlying factor that has led to increasing positive association between journals indexed from a country and research output. However, a closer examination of the association between ratio of output in home journals (TPCJ) and total research output (TP) for various countries (Table 4) provide evidence that this postulate is not tenable. Table 4 indicates that many countries show a decline in proportion of papers published in their home journals during 2005–2019. Thus, while the number of journals for most of the countries has increased during this period, the proportion of papers published in home journals has not increased, or in other words, research output has grown at a rate faster than rate of growth of home journals and got expanded to include other internationally oriented journals too. One good example is China which published 63% of its research output in home journals in 2005, which reduced to only 17% in 2019. In the same period, China's research output has grown significantly, which would not have been possible unless China would have expanded its publication base and improved the quality of its research output to the standards of well-known international journals. India and Brazil are found to have largely maintained their research output proportion in home journals from 2005 to 2019, but at the same time have also grown significantly in terms of their total research output. Thus, it appears that other factors like internationalization of scientific publishing and growth in publication base (including growth in number of researchers) of different countries may also be playing an important role in growth of their research output.

Some previous studies have explored the reasons behind the growth of research outputs and have identified various factors behind the growth. For example, impact of Gross Expenditure on R & D (GERD) and Full Time Equivalent (FTE) have been examined in some studies (Coccia, 2009; Lancho-Barrantes et al., 2020; Meo et al., 2013), while the impact of collaboration network structure on research output of a country was another factor to be examined (Guan et al., 2016). Bhattacharya et al. (2015) have explored the different changes that have happened in scientific research per se, looking at the endogenous and exogenous factors behind publication growth. Leta (2011), Najari and Yousefvand (2013) and Moed et al. (2018) have underscored that the growth of NCJ cannot alone be sufficient enough to explain the growth of research output for the countries. However, this study has dived deep to bring out how the journals from different countries are indexed in Scopus and how the pattern of indexing changes. The relationship that is seen from this granular level provides a deeper insight than that was possible in earlier research, in spite of the limitation of not being able to draw the underlying cause of the relationship (common factor) or whether one variable is affecting the other or vice-versa.

In the broader context of the discussion proposed above, it would also be relevant to discuss some policy perspectives about availability of suitable publication venues in different countries. There are several points that can be looked into. First, the lack of appropriate publication venues in certain countries results in missed opportunities of higher research output growth of the country. Secondly, concentration of majority of the journals in certain selected countries, indirectly guide the research agenda and theme in other countries. Many times, researchers ignore working on domestic and locally relevant problems, as such research work is less likely to find a place in the outside international journals. In this process many times the national context and local relevance of the research work is lost. Given that research has a special significance for the local and national context in which it is done and the problems that it solves, there should be enough venues for publishing such research work. Therefore, availability of more publication venues in a country should be an important goal for the science policy. This is specially more relevant for developing countries, which are expanding in terms of GERD, FTE etc. but perhaps not enough in terms of publication venues.

Another aspect that is closely related to this whole discussion is the current trend of journals to charge Article Processing Charges (APC) for publishing research papers. It has been observed that these charges are rooted in the so called 'global north' economic context and are exorbitant and unaffordable for researchers in the 'global south'. One interesting example in this context is the 'Read and Publish Agreement' in The Netherlands signed between the Association of Dutch Universities and the Koninklijke Nederlandse Akademie Van Nettenschappen. This agreement allows all participating institutions to publish Open Access in more than 2000 Open Access Hybrid journals of Springer with APC fees covered under the agreement along with full access to all Springer subscription journals. Similar arrangements are observed in North economies between the publishers and academic bodies. However, there are almost no institutional support mechanisms available in the developing countries to bear the APC. Therefore, if there are suitable number of publication venues in a country, they are more likely to be situated in the context and one may expect that such barriers of high APC may not be there with them. Accordingly, it should be an important policy consideration for developing countries to support development of enough publication venues for their researchers.

Conclusion

The study explored the relationship between number of journals indexed from a country and its research output. The results confirm a positive correlation between the number of journals (NCJ) and the research output (TP) of majority of the countries. Further, positive correlations are also observed in the growth rate of journals ($CAGR_J$) and papers ($CAGR_P$), and also in the growth of global share of number of journals (*X*1) and papers (*X*2) for a majority of the countries. There are, however, several countries which produce higher research output as compared to number of journals published by them and indexed in database. China, India, Brazil and Russia are some examples to mention. The proportionate share of publications in home journals has, however, declined for a good number of countries, indicating that other factors like wider publication base and internationalization of scientific publishing from those countries may also have a role to play.

Despite publishing becoming more concentrated globally with a few publishers dominating the global publication landscape; a country's affiliation of a journal is an important assertion of its scientific capacity. Journals develop over a long period to attract global attention. An influential journal has various quality attributes that lead towards making a global impact. *A journal is an institution in itself.* A reflected glory comes to a research organization/professional society/university if its journal is indexed in a global database and attracts scholarly research that provides new pathways for scientific research and creativity. Thus, there has to be dedicated support for a country to develop journals. The study suggests that the developing countries should focus on developing more publication venues for its researchers, both for providing suitable venues for publication of research output and also for supporting publication of research on domestic and locally relevant problems and issues. Development of such publication venues may also help in rationalizing the APCs, and perhaps improve the whole scientific publishing model.

Limitations

This study has explored the relationship between number of journals indexed from different countries and their research output. In this process, we have taken the information of country of journals from the Scopus master journal list. It may be noted that some of the major commercial publishers- Elsevier, Nature, Springer etc.- have a large number of journals marked as being published from some specific countries, mainly US, UK, Germany and Netherlands. Therefore, the results must be seen in this light and that there may be distortions in the relationships observed for these countries. Further, we have taken the publisher country as country of a journal. However, there are debates on what should be a good way to classify country of a journal, whether this should be the publisher country or the country which its Chief Editor (or the main editors) belong to. This work used the former and hence, results may be used with this understanding.

The second major limitation of this work is that it only analyses the relatedness of number of journals and research output for various countries and does not go deeper to analyse the pathways necessary to understand the attribution. It is quite clear that the growth of NCJ cannot alone be sufficient enough to explain the growth of research output for all the countries. Such an attribution would need to analyse the pathways of the relationship between the two, in the notion of 'necessary' and 'sufficient' conditions of logical formalism. Existence of correlations cannot be taken as a 'necessary' and 'sufficient' conditions to attribute a causal relationship, and the results may therefore be seen in this light.

The third limitation is that this work only explores the relationship between NCJ and its research output and does not take into account other factors that are likely to affect the research output volume of the country. These factors may include GERD, FTE, collaboration networks etc. Different countries vary significantly on these aspects and hence merely looking at relationship between number of journals and research output of the country does not present the full picture. For example, China has grown from 850 researchers per million in 2005 to 1,350 researchers per million in 2018, which is a significant increase and would definitely be an important factor behind the phenomenal growth in China's research output. Similarly, the research funding volume of different countries also vary a lot, with US, UK, Germany spending higher proportion of their GDP on R & D activities, whereas many developing countries, such as India, continue to spend less than 1% of its GDP on R & D activities. The collaboration networks of different countries also vary a lot. Therefore, a detailed analysis of all these factors together, possibly as a multivariate regression model, can be taken up as a future work to understand the complex interplay of multiple factors determining research output of a country.

The study in spite of these limitations, has shown the changing profile of journals indexed from different countries; has examined in a granular level which enriches the understanding of the how journals are indexed in the Scopus database. The study also provided a more critical introspection of the relationship that is observed in a journal indexed from a country and its research output. In the process, it has identified many salient aspects of different countries' research outputs and journals indexed.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

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