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The research guarantors of scientific papers and the output counting: a promising new approach

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Abstract We propose a method for selecting the research guarantor when papers are co-authored. The method is simply based on identifying the corresponding author. The method is here applied to global scientific output based on the SCOPUS database in order to build a new output distribution by country. This new distribution is then compared with previous output distributions by country but which were based on whole or fractional counting, not only for the total output but also for the excellence output (papers belonging to the 10 % most cited papers). The comparison allows one to examine the effect of the different methodological approaches on the scientific performance indicators assigned to countries. In some cases, there was a very large variation in scientific performance between the total output (whole counting) and output as research guarantor. The research guarantor approach is especially interesting when used with the excellence output where the quantity of excellent papers is also a quality indicator. The impact of excellent papers naturally has less variability as they are all top-cited papers.

Keywords Corresponding author · Scientific excellence · Research guarantor · Output counting

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Introduction

It is generally accepted by the scientific community that scientific collaboration leads to increased visibility and impact of the results that are generated. The benefits will also depend on the different types of collaboration (Leimu and Koricheva 2005; Katz and Hicks 1997): (a) domestic in-house collaboration (all authors from the same institution); (b) domestic institutional collaboration (all authors from the same country but from more than one institution); and (c) international collaboration (authors from more than one country) (Leimu and Koricheva 2005). Although institutional collaboration leads to more visibility than domestic in-house collaboration, international collaboration is even more so in the sense that it increases the citation rates far above those of domestic national collaboration (Narin et al. 1991; Katz and Hicks 1997; Goldfinch et al. 2003; Sooryamoorthy 2009).

But not all countries get this benefit in equal measure. The benefit a country has from international collaboration may depend upon the nation(s) with which it collaborates. Countries whose research does not gain, as a rule, great citation impact profit more from collaborations, and similarly, a country will obtain greater benefit from collaborating with countries that have on average a high impact (Guerrero-Bote et al. 2013). This indicates a certain imbalance in favour of collaborating countries with lower impact at the expense of those with higher impact and leads (probably) to countries obtaining citation impact to a greater extent than their genuine scientific capabilities by collaborating with countries producing high impact.

How to share the credit of a co-authored paper?

In bibliometrics, different approaches have been introduced to share the credit of a paper co-authored by scientists from different units of analysis (institutions or countries) to each contributing unit. For overviews the reader is referred to Gauffriau et al. (2007) and Vinkler (2010). "The first is the all counting approach, which accredits each collaborator with one full credit. This approach is represented by two different counting methods: whole counting and complete counting. The former attributes one full credit to each unique collaborating country or institution; the latter attributes one credit to each author's respective country or institution, depending on the level of analysis … The second approach is straight counting. In this approach, only the most prominent collaborator receives one full credit, and the others receive none. First author counting belongs to this category … The third approach is fractional counting. In this approach, one credit is shared by all collaborators" (Huang et al. 2011, p. 2428). In the following, the difference between the counting methods is described by an example of a country-level output assessment: A paper collaborated by four institutions in three countries (two institutions in Germany, one in the USA, and one in Japan) is to be counted. Using the whole counting method, each of the three countries receives one credit. Germany receives two credits and both, the USA and Japan, each one credit in the case of complete counting. If the first author of the paper is from Japan, Japan is given one credit and the other countries none with straight counting. Using fractional counting, one credit is fractioned with 0.5 to Germany and 0.25 to both, USA and Japan, each (complete-normalized counting) or each country equally receives one-third of the credit (whole-normalized counting).

"The frequently used counting methods in most scientometric research are those that attribute equal credit to every collaborator (i.e., each collaborator gets a full credit or equal

share of one credit) or that accredit one with all or nothing (e.g., only the first author gets the credit)" (Huang et al. 2011, p. 2427). We propose in this paper a straight count approach where the corresponding author—or, more precise, the institution or country to which the corresponding author is affiliated—, receives the full credit of a paper. Man et al. (2004) give preference to this approach "because the corresponding author is usually the one primarily responsible for the study project including securing of research funding, assemblage of the research team, and preparation of the final manuscript" (p. 812). Corresponding authors "are usually the senior researcher members, who secures funding from the granting agencies and are the ones who render the final approval to a manuscript" (Man et al. 2004, p. 816). Furthermore, "the corresponding author/guarantor has primary responsibility for correspondence with the journal" (International Committee of Medical Journal Editors, 2010, p. 8) and has "to respond to readers' enquiries and requests for materials, and to coordinate the handling of any other matters arising from the published contribution, including corrections complaints" (http://www.nature.com/nature/authors/gta/index.html#a5.9).

There are some other arguments supporting the straight count approach where the corresponding author gets the full credit. The contribution of each single co-author (from the first to the last position) to a paper is difficult to assess for an evaluative study (on the country level). First, it is usually the case that certain co-authors have contributed on a paper to a different extent. For example, the first author has as a rule contributed more than the second author. Thus, corresponding authors were more likely to appear first in the byline (Mattsson et al. 2011). Second, the author positions have different meanings in the disciplines. For example, in biology the last author is the group leader in most of the papers and is responsible for the described research. But in sociology, the last author has as a rule contributed the least to a paper.

The research guarantor approach

In this paper we propose to use the term "research guarantor" referenced by the International Committee of Medical Journal Editors (2010 p. 8) to indicate the essence of corresponding co-authorship. Two important comments have to be made. Firstly, in the assessment of countries (or institutions) we do not wish to make assumptions as to which individual author in the byline of a paper has made the largest contribution to the research presented in that paper. Especially in the natural and life sciences, the research group is the base unit, typically consisting of a group leader, one or more senior staff, post-doctoral and PhD students. More and more research papers are produced by large teams in which different research groups collaborate. We do not claim that the individual indicated as the corresponding author is necessarily the research guarantor. What we do assume is that the research group to which the corresponding author belongs is the research guarantor.

Secondly, our assumption is that the research guarantor has a special status in the research team. He tends to play a leading role in the research. In the negotiations within the team as regards authorship, obtaining the corresponding authorship is an expression of the importance of that role, and a reward for the extra efforts made by the group to which the corresponding author belongs. These assumptions need to be further validated. One approach would be to study more qualitatively the processes involved in assigning corresponding authorship, for instance based on questionnaires and interviews. A second approach is to quantitatively analyze patterns in corresponding authorship, considering corresponding authorship counts, next to integer and fractional counting, as a potentially

useful method to assess publication output; one that adds an important dimension, namely research guarantor-ship, and discuss the significance of the outcomes. This approach is adopted in the current paper. To the best of our knowledge, it is the very first time that this aspect is being analyzed at a scale as large as the one presented below.

In the following, we will find an answer to the question to what extent the consideration of the research guarantor the position of specific countries changes in rankings based on citation impact. Thus, it is the purpose of this study to compare the distributions of (a) total output with (b) output as research guarantor (here, only the affiliation of the corresponding author does matter) and of (c) excellent output (papers belonging to the 10 % most cited papers, see below) with (d) excellent output as research guarantor for different countries. Our hypothesis is that the distributions of output as research guarantor and excellent output as research guarantor among countries are progressively sharper than total output and excellent output. In other words, we expect that the distribution of excellent output produced as research guarantor among countries shows the largest degree of concentration, and the distribution of all types of papers among countries (both excellent and non-excellent, and both produced as research guarantor or otherwise) the lowest. We expect high correlations between country rankings based on the different indicators, but a clearer differentiation between the countries using research guarantor indicators. Besides publication output, we compare the distributions of normalized citation impact corresponding to the different types of output (total and excellent output based on all co-authors or the research guarantor only).

Methods

The data used in this study corresponds to the citable output (articles, reviews, conference papers and short surveys) of the publication period 2003–2010 contained in the Scopus database (see Table 1). For every country we consider the indicators citable output and excellent citable output, by whole counting approach (O and EO respectively), by fractional counting whole normalized approach (OWN and EOWN) and as research guarantor (ORG and EORG). Those papers which belong to the 10 % most-cited papers in a publication year and subject area (e.g., Biochemistry, Genetics and Molecular Biology) are counted as excellent papers. "Due to ties, it is usually not possible to make an exact distinction between publications that belong to the top 10 % and publications that do not belong to the top 10 %" (Waltman et al. 2012). In case of ties in citations, we use for the sorting of the papers the SJR2 (Guerrero-Bote and Moya-Anegón 2012) of the scientific journal that has published the paper. This journal impact indicator takes into account not only the prestige of the citing scientific publication but also its closeness to the cited journal using the cosine of the angle between the vectors of the two publications' citation profiles.

As citation impact indicators we consider in this study the normalized impact of both citable output and excellent citable output (1) by the whole counting approach (NIO and NIEO respectively), (2) by the fractional counting approach using the whole normalized approach (NIOWN and NIEOWN) and as research guarantor (NIORG and NIEORG) (in Fig. 2), and (3) a counting method where only the papers with international collaboration have been considered (NIO-IC, NIEO-IC, NIORG-IC and NIEORG-IC respectively). NI compares the number of citations received by each particular paper with the number of citations that achieves an "average paper" (dividing by this number) of the same subject area, document type and publication year and then the mean over all papers

Table 1 Total number of documents and number of citable documents (absolute and in percent of total number of documents) in different publication years

	Documents	Citable documents	%
2003	1,426,562	1,312,670	92.02
2004	1,579,776	1,467,752	92.91
2005	1,749,752	1,606,708	91.82
2006	1,834,105	1,691,110	92.20
2007	1,928,797	1,774,172	91.98
2008	2,009,181	1,842,859	91.72
2009	2,082,673	1,917,823	92.08
2010	2,171,118	1,975,502	90.99

(all quotients) is computed. In case of excellent indicators (EO, EOWN and EORG), the citation impact is normalized with respect to an "average excellent paper." Instead of all papers in a subject area, document type and publication year, only the papers belonging to the top 10 % are considered.

Our procedure to determine the research guarantor is as follows. It is explained by using the papers from 2010 as an example:

1. If both the corresponding author and the affiliation institution in the record are determined, this institution is defined as the research guarantor (94.24 % in 2010).
2. If the corresponding author is determined, but the affiliation institution is not determined, the affiliation institution of this author is defined as research guarantor (4.5 % in 2010).
3. If the corresponding author is not determined, the affiliation institution of the first author is defined as the research guarantor (0.41 % in 2010).

Table 2 shows some basic authorship information for different Scopus subject areas in the year 2010. As the numbers point out in the majority of the Scopus records, the corresponding author, the affiliation country and the order of the author is determined. According to the percentages in Table 2, we can draw the following three conclusions on the material used in the generation of indicators of all types of output:

1. The percentage of records with corresponding author in each field is very high (about 99 % in most of the subject areas). The only exception is "Business, Management and Accounting" containing publications with a considerable percentage of papers without any author specified because they are attributed to the editorial staff of the publication (example: "The Economist").
2. As the percentage of documents without corresponding author is very low (in most of the subject areas less than 1 %), the columns *With corresponding author* and *Without corresponding author* are summed up to the column *With author/s*. With regard to the percentages in this column, we can say that the criteria used to assign the research guarantor domain are appropriate and do not have a high rate of missing.

In subject areas where the first or last author, respectively, has a significant position among the co-authors (e.g., biochemistry, genetics and molecular biology)—where the first author is normally the PhD student and the last author his or her supervisor—the corresponding author is mostly the first or the last author (see Table 2). In social sciences, only the first but not the last author is frequently the corresponding author. These results speak for the corresponding author approach in case of straight counting.

Table 2 Authorship information for different Scopus subject areas (in percent) (publication year: 2010)

Subject area (citable output published in 2010)	With author/s	With more than one author	With only one author	With corresponding author	Without corresponding author	More than one author and the corresponding is the first	More than one author and the corresponding is the last	Author/s from only one country	International collaboration
Multidisciplinary	99.62	82.04	17.57	98.23	1.39	44.01	25.82	73.64	26.36
Agricultural and Biological Sciences	99.67	91.44	8.24	98.97	0.7	57.62	22.09	77.84	22.16
Arts and Humanities	99.02	16.45	82.57	98.56	0.46	14.99	0.81	70.97	29.03
Biochemistry, Genetics and Molecular Biology	99.7	93.94	5.76	99.43	0.26	39.37	39.82	78.45	21.55
Business, Management and Accounting	88.32	60.69	27.63	87.62	0.7	50.35	5.41	67.07	32.93
Chemical Engineering	99.21	89.17	10.94	98.73	0.48	47.01	25.76	82.32	17.68
Chemistry	99.95	94.72	4.77	99.73	0.22	40.67	35.95	82.81	17.19
Computer Science	99.86	88.27	11.58	99.69	0.16	76.65	6.39	80.17	19.83
Earth and Planetary Sciences	99.46	87.44	12.02	98.85	0.61	75.68	4.66	70.7	29.3
Economics, Econometrics and Finance	99.21	64.58	34.63	98.01	1.2	49.72	9.33	76.14	23.86
Energy	98.43	84.05	14.38	96.95	1.48	62.22	10.6	81.69	18.31
Engineering	99.2	87.15	12.04	98.91	0.29	69.99	8.92	82.42	17.58
Environmental Science	99.6	88.76	10.84	99.15	0.46	60.62	15.81	79.22	20.78
Immunology and Microbiology	99.73	94.99	4.75	99.41	0.32	41.52	39.58	76.06	23.94

Table 2 continued

Subject area (citable output published in 2010)	With author/s	With more than one author	With only one author	With corresponding author	Without corresponding author	More than one author and the corresponding is the first	More than one author and the corresponding is the last	Author/s from only one country	International collaboration
Materials Science	99.67	91.85	7.64	99.48	0.19	54.54	21	82.19	17.81
Mathematics	99.95	77.32	22.63	99.67	0.28	63.85	8.4	77.93	22.07
Medicine	98.84	85.49	13.35	98.37	0.47	56.96	17.65	76.44	23.56
Neuroscience	99.67	92.6	7.07	99.37	0.3	47.76	32.89	79.41	20.59
Pharmacology, Toxicology and Pharmaceutics	97.56	85.64	11.92	97.19	0.37	44.69	28.84	78.51	21.49
Physics and Astronomy	99.83	88.83	10.45	99.73	0.1	66.56	12.82	77.23	22.77
Psychology	99.66	76.27	23.38	99.1	0.56	63.5	6.62	82.88	17.12
Social Sciences	98.98	47.69	51.3	98.16	0.83	41.63	3.27	81.18	18.82
Veterinary	98.26	89.3	8.96	97.7	0.56	60.28	17.12	82.44	17.56
Dentistry	99.29	89.89	9.41	98.57	0.72	58.63	15.17	74.35	25.65

Interestingly, in mathematics, and in the subset of papers with at least two co-authors, the percentage of papers in which the corresponding author is the first author is about 8 times the percentage of articles in which the corresponding author is the last author (63.7 vs. 8.4 %). This observation does not comply with an often heard claim by mathematicians that the author sequence in mathematics papers tends to be alphabetical.

Results

Figures 1, 2 visualize a ranking of the 76 countries by using different indicators (output indicators in Fig. 1 and citation impact indicators in Fig. 2). Although the different indicators are highly correlated in both figures (output indicators: >0.94; impact indicators: >0.93), we expect a sharper differentiation between the countries in terms of indicators based on the research guarantor approach in comparison to the indicators based on all co-authors.

Figure 1 shows two whole counting indicators (O and EO), two fractional counting whole normalized indicators (OWN and EOWN) and two straight counting indicators where the corresponding author receives the full credit of a paper (ORG and EORG). It is clearly visible that the three indicators based on excellent output (EO, EORG, and EOWN) are located on a lower level than the other three indicators (O, ORG, and OWN). All indicators show a behavior close to an exponential law which would be represented on this semi-log plot by a descending, although steeper, straight line. O is the indicator which has the most gradual fall, less steep than the others, with the ORG showing the sharpest decline. A similar result is visible for the EORG in comparison to the EO and EOWN. This indicates that the ORG and EORG are slightly more concentrated than the others, i.e., that there are larger differences between countries using outputs as research guarantors and also using excellent outputs than there are if countries are compared according to their total (excellent) publication output.

Figure 2 shows the Normalized Impacts values of the 76 countries with whole counting approach (O-IC and EO-IC) and with straight counting approach where the corresponding author receives the full credit of a paper (ORG-IC and EORG-IC). Only papers with international collaboration have been considered in this representation, because a large part of total production is exclusive: The only country contributor is the research guarantor. This makes it difficult to observe the effect on citation impact produced by the research guarantor approach. Similar to Fig. 1, the countries are ranked by the different indicators. All indicators point out a behavior close to linear. Normalized impact based on EO-IC and EORG-IC are the indicators which have the most gradual fall, less steep than the others. The reason is that we do not consider all the papers in the excellent output, but a selection of them having a similar (high) citation impact. Normalized impact based on ORG-IC shows a sharper decline than the other indicators. This indicates that the NI based on ORG-IC is more concentrated than the others, i.e., differences between countries become sharper visible using only research guarantors and using all instead of excellent output.

A first observation in Fig. 3 is a lower range of values for the EO than the O. As mentioned before, we do not consider all papers in the EO, but a selection of high-impact papers. Selecting the EO increases the variability of the number of papers but decreases the variability in NI.

A second observation is that for all countries the NI of articles published as research guarantor tends to be lower than that calculated for the total output published both as research guarantor or not (in the case of USA they are very similar). This phenomenon

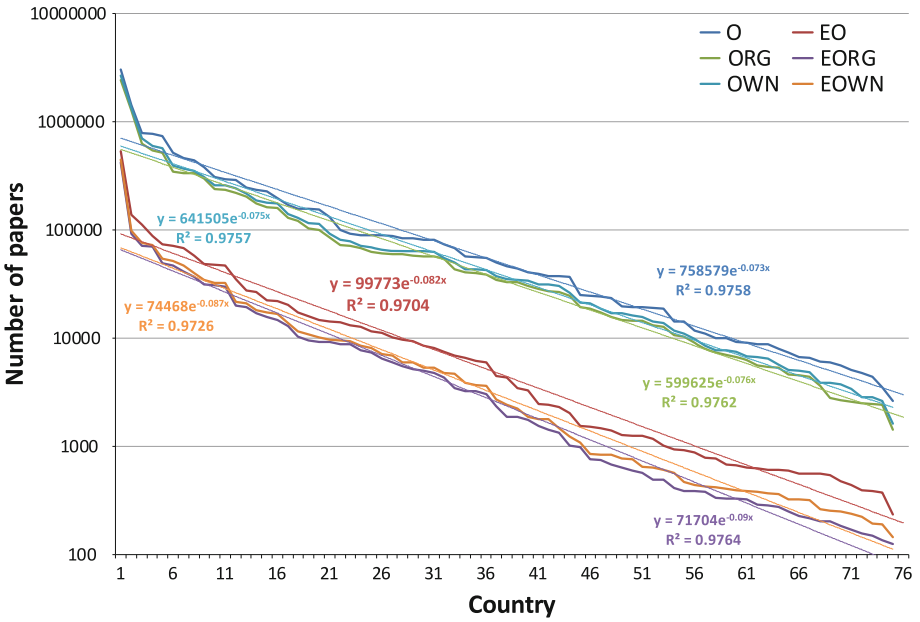

Fig. 1 Superposition of the *O* citable output, *EO* excellent citable output *ORG* citable output as research guarantor, *EORG* excellent citable output as research guarantor, *OWN* citable output whole normalized counting and *EOWN* excellent citable output whole normalized counting values versus country rank positions

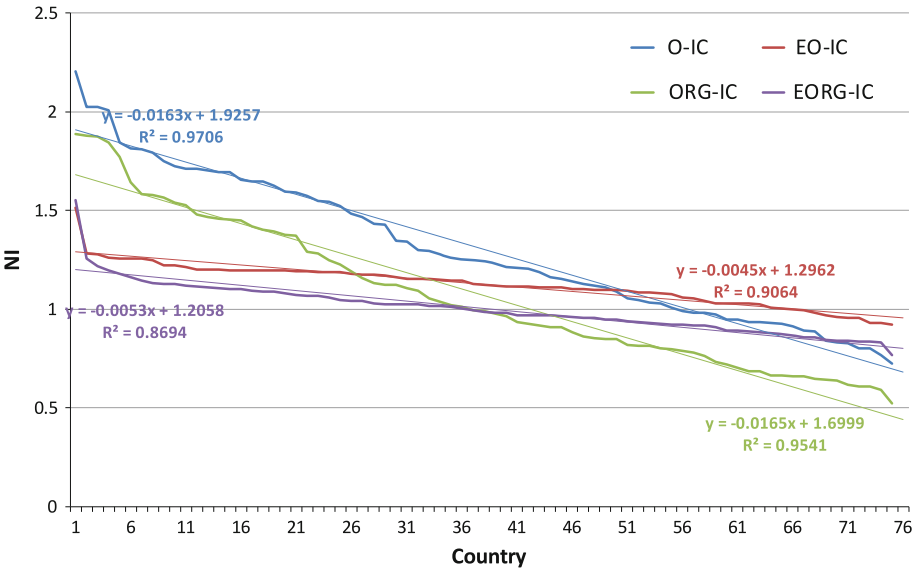

Fig. 2 Superposition of the normalized impact of *O-IC* citable output with international collaboration, normalized impact of *EO-IC* excellent citable output with international collaboration, normalized impact of *ORG-IC* citable output with international collaboration as research guarantor and normalized impact of *EORG-IC* excellent citable output with international collaboration with respect to the research guarantor values versus country rank positions

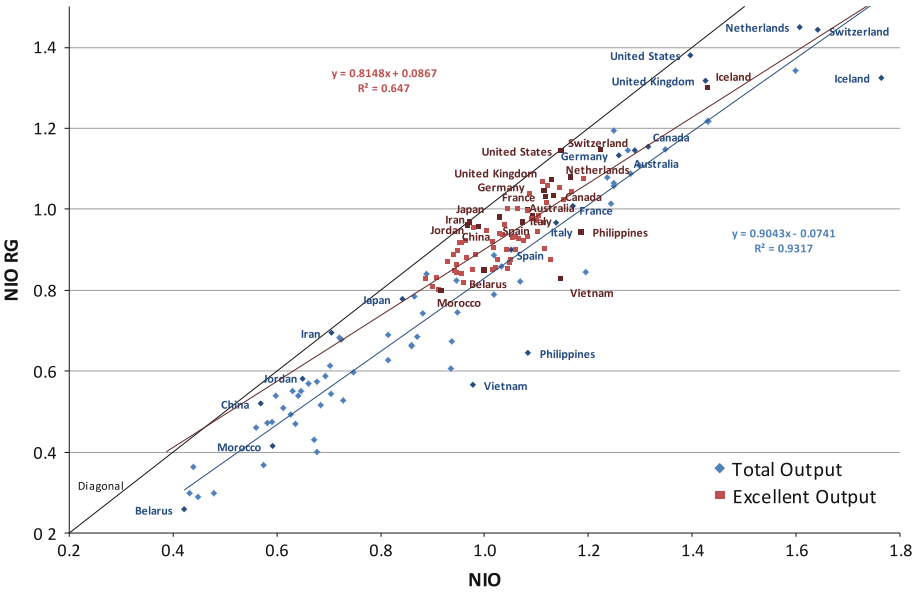

Fig. 3 Scatterplot of normalized impact average of excellent output against that for total citable output, both for the total publication output and for the output produced as research guarantor

occurs both in the analysis of excellent output and in that for all output. The degree of decline varies from one country to another.

A third observation in Fig. 3 is that the more scientifically developed countries come to be above the adjusting lines. These countries proportionally produce fewer papers involved in a non-research guarantor roll, and/or there is less impact difference between the papers as main and those secondary contributors, so that the new indicator penalizes them less. USA is the country which is more above the adjusting lines (it has decline rates of 1.43 % in total output and 0.22 % in excellent output). Developing countries come to be below the line adjustment, being penalized by the proposed indicator because they participate in fewer papers as research guarantors. However, some developing countries are above the adjusting lines and very near the diagonal (e.g., Iran and China).

Although some developing countries are above the adjusting lines and close to the diagonal (Iran has decline rates of 1.13 % in total output and 0.31 % in excellent output, or Jordan has a decline rate of 10.5 % in total output and 0.70 % in excellent output). In most of these cases, low decline rates correspond logically with high percentages of papers as research guarantor, as Fig. 5 shows, which may also be due to low rates for international collaboration (Guerrero-Bote et al. 2013). That means there are countries with a generally low citation impact.

But the overall linear correlations between the two types of impact are very high: $r = 0.97$ for total citable output and $r = 0.80$ for excellent output (Pearson product-moment correlation coefficients). The high coefficients point out that the impact values are different because they perform on a different level.

If we examine the concentric circles in Fig. 4, we see that countries like China or Brazil have very many papers where they participate as research guarantor. There are small differences visible between the two larger circles O and ORG and between the two smaller

circles EO and EORG, respectively. This is due to their low level of international collaboration. Furthermore, we see a very low production of excellent papers: There are great differences visible between the two larger circles and the two little ones. Other countries, like the United States, the United Kingdom or Germany, have a comparably great difference (compared to China or Brazil) between total output and output as research guarantor only. The two larger circles O and ORG and the two smaller circles EO and EORG, respectively, differentiate greatly. Furthermore, a higher rate of excellent papers is visible for these countries; that means small differences between the two larger circles and the two little ones.

Also, Fig. 4 shows the difference between NIO and the NIEORG. We can see a small slope in the adjusting line. This is due to the smaller variation of the citation impact of papers at the excellence level. Countries above the adjusting line improve their impact positions of excellent papers in case of the research guarantor indicator; below are the countries which do not benefit from the research guarantor approach (e.g., Brazil and Finland). However, one must distinguish between countries which get that position with a large percentage of their output such as the United States (14 %) and those which improve their positions with a small proportion of their output, such as China (5 %). Brazil, despite including a small percentage of their production (4 %), shows the lowest normalized citation impact in case of both indicators.

Figure 5 shows the percentages of EO versus EORG. The results are similar to Fig. 4. The adjusting line shows a slope lower than one but it goes near the origin. As in Fig. 4, we see the countries (above the blue line) which profit from the research guarantor approach (at the excellence level) and which do not (below the blue line). The USA is the country with the highest percentages; this country would lose comparably little citation impact if

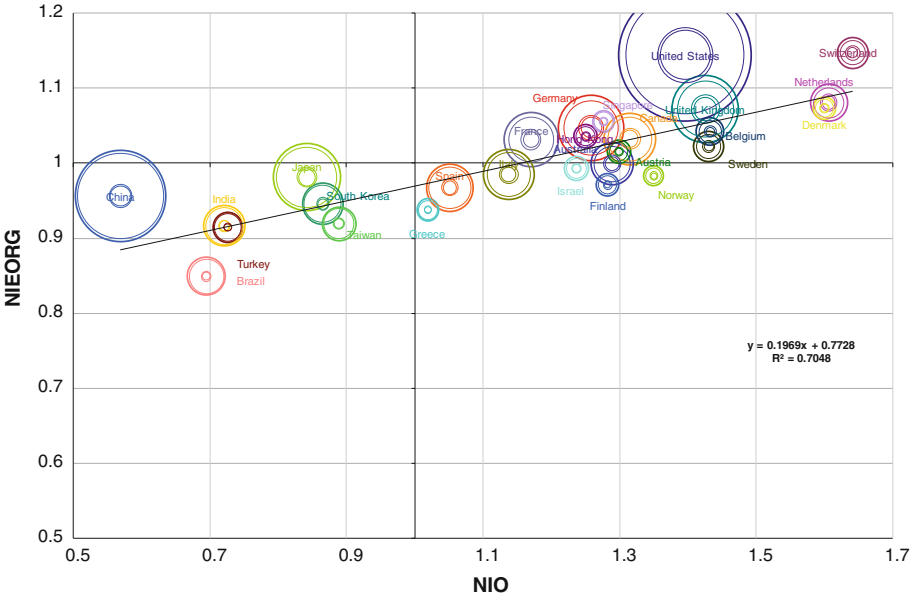

Fig. 4 Scatterplot of *NIEORG* normalized impact of excellent citable output as research guarantor versus the *NIO* normalized impact of citable output indicator. The concentric circles in each country are proportional to *EORG* excellent citable output as research guarantor, *EO* excellent citable output, *ORG* citable output as research guarantor and *O* citable output respectively

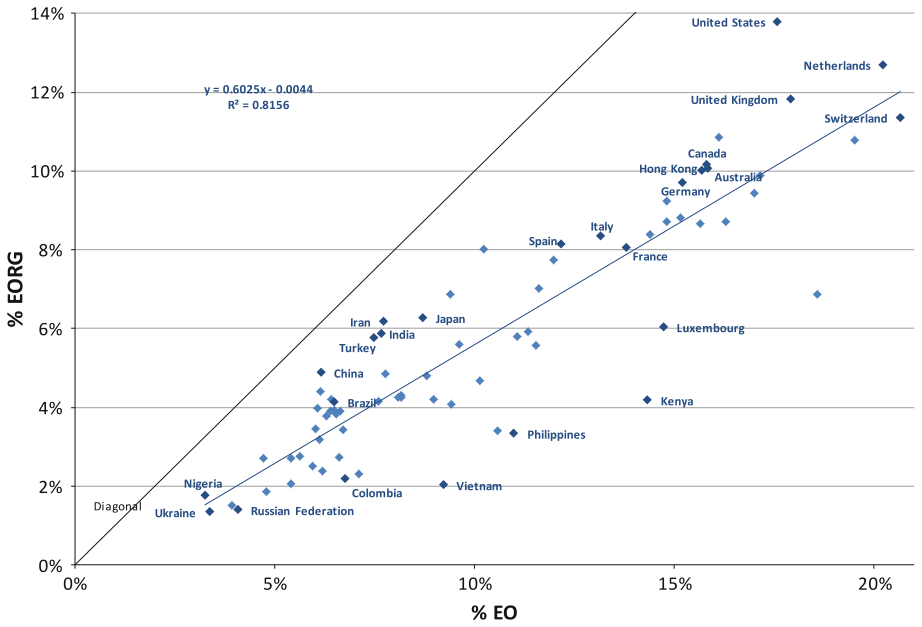

Fig. 5 Scatterplot of percentages of *EO* excellent output versus percentage of *EORG* excellent citable output as research guarantor

the research guarantor approach is applied. For Luxemburg in contrast, it would make a great difference in measuring citation impact by whole counting or the research guarantor only. The latter would lead to a loss of citation impact.

Conclusions

In this paper, the straight count approach is introduced where the corresponding author of a paper receives the full credit. This approach starts from the premise that the scientist indicated as the corresponding author is not necessarily the research guarantor. We understand the research group to which the corresponding author belongs as the research guarantor. The proposed indicator can be calculated reliably in the Scopus database. Scopus can determine the corresponding author in a significant amount of records; the small remainder can be filled with the first author.

The hypothesis examined in this paper was that distributions of (1) output as research guarantor against total output and (2) excellent output as research guarantor against excellent output are progressively more concentrated among the investigated 76 countries. Our results confirm this hypothesis. Fitting the empirical data obtained for the set of 76 major countries with an exponential distribution, and using its exponent as a measure of concentration, it was found that the excellent citable output as research guarantor (EORG) shows the largest degree of concentration among countries, and the total citable output (O, including both excellent and non-excellent papers) the lowest. With regards to the citation impact distribution of countries, it was found that the distribution of normalized impact of publications published as research guarantor shows a stronger degree of concentration than that based on the impact of all papers.

For all countries, the normalized citation impact of articles published as research guarantor tends to be lower than that calculated for the total output. This phenomenon occurs both in the analysis of excellent output and in that for all (both excellent and non-excellent) output. The degree of decline varies from one country to another and is heavily influenced by the percentage of output as the research guarantor and by international collaboration rate. The difference between the NI's total output (whole counting) and the NI output as the research guarantor in a country can be seen as a country's gain obtained through collaboration with others. If this difference is very small (below 25 %), we are in the presence of scientifically developed countries. Their NI of total output (whole counting) represents very well their scientific performance. If the difference between the two indicators is very high (above 40 %), we are talking about scientifically developing countries. Thus, we can say that this measure of profit based on scientific leadership differentiates countries scientifically dependent on scientific autonomy. Countries, like Colombia, Philippines, Vietnam, Peru, Indonesia, Costa Rica, Ghana, Moldova and Armenia, earn over 40 % of the average normalized impact when other countries are the research guarantors. By contrast, in countries, like United States, United Kingdom, Germany, China, Netherlands, South Korea, the profit of the average normalized impact is very low when others are the research guarantors (below 10 %).

Especially, the use of the research guarantor approach with the excellent output is quite promising, considering that the impact of excellent papers has less variability: The selection is made based on the impact. In this case, the amount of excellent papers is also a quality indicator of the research of a domain.

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