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THE INFLUENCE OF INTERNATIONAL COLLABORATION ON THE IMPACT OF RESEARCH RESULTS

Some simple mathematical considerations concerning the role of self-citations

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There is an ongoing discussion on the influence of international collaboration on impact as measured by citation-based indicators. Collaboration generally involves more authors than 'no collaboration' work and it is obvious that the phenomenon of self-citation will be stronger (there are more authors to cite themselves). Thus it can be seen as an important 'amplifier' of measured impact. Although this effect is certainly possible and already demonstrated recently, it should not be considered as the only or even major explanation of higher impact in the comparison between 'no collaboration' and international collaboration. Using data of an extensive bibliometric study of astronomical research in the Netherlands, we prove that higher rates of self-citation in international collaboration do not play any significant role as 'impact amplifier'. The central point is that proper impact measurement must involve corrections for self-citations.

Introduction

In a recent paper (*Van Raan*[1]) we discussed the *strategy to increase international visibility* of an institute's or country's research work, not by international collaboration in the first place, but by changes of publication behavior of one's own work. A decisive step in this strategy is the choice of international journals for publication, and in particular for Citation Index-covered journals. We argued that this strategy is already a major aspect of the 'internationalization' of science, regardless of collaboration.

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Then, next, we have the phenomenon of international scientific collaboration. This is the type of 'internationality' usually considered in science policy discussions. Collaboration is possible in many ways: exchange of researchers and students, joint research facilities and work meetings, organization of international conferences, division of tasks in a larger and broadly defined research program, or, almost the opposite, close cooperation in a well-defined project. All these types of collaboration may range in a wide spectrum between typical individual and informal relations on one hand, and very formal, politically dominated relations on the other.

This whole spectrum of collaboration may yield internationally co-authored publications, or co-publications. Such co-publications also function as symbols or evidence of collaboration. It is clear that an analysis of co-publications will never provide a complete picture of international scientific collaborations (*Moed* et al.[2]). But at least it gives an interesting representation of important aspects of international collaboration, such as the results in terms of concrete output.

Pioneering work on international collaboration was done by Narin's group in the USA in the 1970's. Based on these experiences, *Frame* and *Carpenter*[3] formulated the three following 'rules':

1. the *more basic* the field, the *more international* collaboration;
2. the *larger the national* research system, the *smaller the international* collaboration;
3. *'external'* factors play a *major role* in international collaboration.

We think that these rules are still valid after almost 30 years (a detailed discussion is given in *Van Raan*[1]).

More precisely, *Narin* and *Whitlow*[4] found that, generally, internationally co-authored papers are cited more than 'single-country' papers. We may call this the 'fourth rule' of international collaboration. Indeed, we have strong evidences that generally the internationally co-authored publications are the ones with the higher impact. To illustrate this, we discuss recent work of our group on astronomy research in The Netherlands. Some authors (*Herbertz*[5]) have different opinions based on their empirical work. Particularly higher rates of *self*-citation, which are characteristic and in fact almost unavoidable in international co-publication, are brought forward as explanation for higher citation scores in international co-publication. In this discussion, we show how 'tricky' it is to draw too fast conclusions from higher self-citation rates. Even *if* self-citation rates are *significantly* higher in international co-publications, then still a considerably higher 'real', i.e., self-citation corrected impact is possible for these international co-publications as compared to 'no collaboration' work.

For a discussion on the practice of self-citation we refer to earlier literature on this topic, see for instance *Bonzi* and *Snyder*[6].

Impact and international collaboration

Table 1 presents our results on international collaboration in a recent 'real life' evaluation study of astronomy in The Netherlands (publications: 1980–1991; citations: 1980–1993, for more details see *Van Raan* and *Van Leeuwen*[7]). These results are based on a bibliometric analysis of 2,090 publications and 35,780 citations in a period of about ten years.

Table 1
Bibliometric indicators of output and impact for different types of scientific collaboration, Netherlands (1980–1993)

Type of collab.	P(%)	C	CPP	CPPex	%Pnc	CPP/ FCSm	%Self cit
No collaboration	691(33)	9515	13.8	11.7	11.9	1.12	15.09
National collab.	173 (8)	2014	11.6	9.3	6.9	1.07	19.76
Internat. collab.	1226(59)	24251	19.8	15.5	6.8	1.67	21.64

P: Number of articles (normal articles, letters, notes, and reviews) published in journals covered by the Science Citation Index (SCI). C: Number of citations recorded in SCI journals to all articles involved, self-citations included. CPP(ex): Average number of citations per publication, self citations in(ex)cluded. %Pnc: Percentage of articles not cited during the time period considered. FCSm: Average citation rate of all articles in the fields in which the subject group is active (i.e., world citation average based on the relevant research fields). Fields are defined by means of SCI journal categories. CPP/FCSm: Impact of the subject group's publications, compared to the world citation average in the fields in which the institute is active. %Self cit: Percentage of self-citations; a self-citation is a citation in which the citing and the cited paper have at least one author (any co-author) in common.

The table shows that 33% of all Dutch astronomy articles has been published by authors with only *one* institutional address in the heading of their articles, i.e., no collaboration was involved with other research groups. About 8% of the articles originates from collaboration between two or more groups located in the Netherlands. The majority however (almost 60%) is the result of a collaboration between Dutch groups and one or more groups from abroad: this is research in international collaboration.

The crucial point now is to analyse *impact* as a function of the type of collaboration. We developed standard software-routines in our data-system to carry out such a breakdown of output and impact to type of collaboration. We refer for details to our

recent publications (*Moed* et al.,[8] *Van Raan*[9]). We here focus on our 'crown indicator', impact normalized to the world-wide average impact of the field concerned: CPP/FCSm. So we calculated the impact of all Netherlands astronomy papers in a long period (1980–1993) and compared this impact to the world astronomy average (*Van Raan* and *Van Leeuwen*[7]). The table shows clearly that papers in international collaboration obtain the highest (field-normalized) impact. The overall value for *all* Dutch astronomy articles (more than 2,000) is 1.44, so we observe that the impact of papers co-published with foreign groups is by far the highest (CPP/FCSm = 1.67). Thus, international collaboration indeed contributes to a considerable extent to the international impact of Dutch astronomy. These findings are consistent with the general conclusion of the *strong international position* of astronomy in the Netherlands.

Now we focus on the rates of *self*-citation, and we find that the percentage of self-citations in the case of 'no collaboration' is 15.1, and in the case of international collaboration it is 21.6. The ratio is 1.43. If we now look at the impact per publication (CPP) in both cases (13.8 and 19.8, respectively), we find a ratio of 1.44. For the field-normalized impact (CPP/FCSm, 1.12 and 1.67, respectively) the ratio is somewhat larger, 1.49. Thus, at first sight, a 'surplus' of self-citations seems to explain the higher impact for work in international collaboration.

This impression is, however, wrong. For we also observe that the ratio of the impact per publication *corrected for self-citations*, *CPPex*, is 1.33, so a considerable part of the difference remains.

Simple mathematical relations between self-citations and impact

If we denote the percentage of self-citations by s, then the absolute number of citations corrected for self-citations Cex can be written as

Cex = (1–s)C (with C as given above, the absolute number of citations uncorrected for self-citations), which simply yields

s = (C–Cex)/C, thus

s = {C/P–Cex/P}/{C/P}, which is, given the standard-notation of our indicators as used in the table

s = (CPP–CPPex)/CPP.

If we now denote the percentage of self-citations for the 'no collaboration' work by s(n) and for international collaboration by s(i) we have, using the same notation for the other indicators:

$$s(n)/s(i) = \frac{\{CPP(n) - CPPex(n)\}CPP(i)}{\{CPP(i) - CPPex(i)\}CPP(n)}$$

which now clearly indicates that a difference in self-citations (expressed in ratio) does not fully determine the difference in observed impact (expressed in the ratio CPP(i)/CPP(n)).

Conclusions

Self-citations are certainly a non-negligible phenomenon in bibliometric analysis. Collaboration generally involves more authors than 'no collaboration' work and it is obvious that the phenomenon of self-citation will be stronger (more authors to cite themselves) and thus it can be seen as an 'amplifier' of the measured impact. Although this effect is certainly possible and already demonstrated recently, it should not be considered as the only or even major explanation of higher impact in the comparison between 'no collaboration' and international collaboration. The central point is of course that proper impact measurement must involve corrections for self-citations. Therefore, the percentage of self-citations is one of the 'standard' indicators in all our bibliometric studies (*Van Raan*[9]).

This case study on astronomy shows that differences in impact between 'no collaboration' work and work based on international publication cannot be explained by differences in self-citation rates although at first sight the data suggest an obvious relation. Normalization to field-specific citation characteristics – as performed by us by – does not change the situation.

International collaboration often implies a considerable 'broadening' of the audiences around the authors, enhanced by more intensive 'networking' which is characteristic for 'internationality' of research. Therefore it is reasonable that a 'genuine' increase of impact , i.e., not based on self-citing strategies alone, will occur. And it does, at least in the case we presented here. As this case concerns a nation-wide and coherent activity in an important, highly internationally oriented discipline, on a high level of scientific quality, we think that our findings are a significant prove of 'impact-strengthening' by international collaboration.

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