Creation of Journal-Based Publication Profiles of Scientific Institutions – A Methodology for the Interdisciplinary Comparison of Scientific Research Based on the J Factor

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Abstract

A form of normalisation is presented for the evaluation of citation data on multidisciplinary research. This method is not based on the classification of output according to ISI subject categories but rather on the existing classification according to the publishing journals. A publication profile is created for each institution to be investigated. This profile accounts for the weight of publications in a journal, represented by the number of publications as a proportion of the total output of the institution. In accordance with this weight, the citation rate of each journal is compared to a qualified benchmark. The final result is a relative citation rate *J*, which is the relative perception of an institution accounting for its publication and citation habits and makes a transdisciplinary comparison possible.

1 Introduction

The widespread use of the performance-oriented allocation of funds and excellence initiatives in science and research has led to questions concerning fair national and international bibliometric benchmarks for comparing scientific institutions becoming a hot topic.

"Every enterprise and almost every organisation or corporation is confronted with the task to monitor and evaluate the performance [...] of its teams, or of the whole unit" (Wagner-Döbler, 2003, p. 145).

The focus is on research institutions as creators of a steadily growing, multidisciplinary scientific output (Price, 1963). These compete with each other to rank among the leading institutions in their disciplines internationally and also to document their position through the perception of their publications. Since the range of publications is continuously increasing worldwide, a global competition has come into being (see Mervis, 2007, p. 582; Broad, 2004, p. 1) with the scientific institutions as its main actors. The aim is to achieve a high international visibility for institutions and countries. "The increasing significance of science and research, and the key role played by research institutions in the global competition for innovation are giving rise to an increasing need for both comprehensive and differentiated information. […] This information need cannot be met with simple one-dimensional rankings nor can it be met with selected opinions or impressions alone" (translation of Da Pozzo et al., 2001, p. 15). It

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should also be noted that no individual indicator is capable of providing a compact ultimate answer to the question of the quality of scientific research.

2 Aspects and Methods of Bibliometric Evaluations

When using bibliometrics to evaluate scientific work, the central questions posed are always similar:

1. *In what journals does an institution predominantly publish?*
2. *What thematic focus is pursued by an institution?*
3. *What journals promise above-average citation success?*
4. *What perception does a certain institution receive compared to a selected benchmark on a national or international level?*
5. *How can different institutions working in the same field of research be compared with each other?*
6. *How can institutions working in different fields of research be compared with each other?*
7. *What information can be gained by a changed or unchanged positioning of an institution in a ranking in the form of regular monitoring?*

(See: Da Pozzo et al., 2001, p. 18)

In answering these questions, a careful approach is required, particularly for multidisciplinary institutions (research campuses and universities) as it is not easy to evaluate how the institution as a whole is positioned in comparison with a benchmark (Adam, 2002). When comparing on an interdisciplinary basis a normalisation must be carried out in any case: "Citation (and publication) practices vary between fields and over time" (Garfield, 1989, p. 96) because disciplines fall back on different methods to identify problems and to tackle them. Here, different communication methods also come into play. Mathematics, for example, is considered to be a field with a lower impact than biology or medicine (Zitt et al., 2005, p. 374 and Adam, 2002, p. 727). "As citation practices strongly depend on fields, field normalisation is recognised as necessary for fair comparison of figures in bibliometrics and evaluation studies" (Zitt et al., 2005, p. 373).

Van Raan describes the creation of research profiles (van Raan, 2004, p. 34): "A further important step is the breakdown of the institute's output into research fields. This provides a clear impression of the research scope or 'profile' of the institute" (van Raan, 2004, pp. 33f). The literature describing this type of output profile is already quite extensive, comparing for example individual countries, disciplines or institutions and mapping their focused research activities and the resulting changes (See: Garg et al., 2006, pp. 151 - 166; Mittermaier et al., 2007; Tijssen et al., 2002, etc.).

In order to achieve a pure output profile for a field-normalised perception analysis, van Raan investigates "the field-normalised impact values of the institute's research in [...] different fields [...]" (van Raan, 2004, p. 33). He uses this method to gain a comprehensive insight into scientific research in Germany (see Tijssen et al.; 2002, etc.). Van Raan termed the requisite indicator that estimates the field-normalised perception the field citation score (FCS) or FCSm "in the case in which more fields are involved" (van Raan, 2004, p. 30).

It should be noted that field normalisation is based on the classification of journals as one of the 230 total ISI subject categories. Each journal is assigned to at least one of the categories and multiple classifications are often found. A journal can therefore be assigned to up to five different fields. This means that a single article can be taken into account more or less often depending on the number of subject categories in the journals in which it has been published. Objectively, this is in no way justified and it leads to avoidable distortions. Further distortions are caused by non-uniform distribution of multiple classifications and the different size of the individual disciplines. "As a result, field-normalised indicators are not only, trivially, dependent on the delineation of fields, but also, for a given multi-level classification, dependent on the

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hierarchical level of observation in a particular classification. An article may exhibit very different citation scores, or rankings when compared within a narrow speciality or a large academic discipline" (Zitt et al., 2005, p. 391).

3 The J Factor

In the following, a recently introduced method (Ball et al., 2008) is presented that works separately from the disciplines, in other words field-normalised, and simultaneously takes each article into account once only. It is based on the fact that every scientific institution has an individual publication profile characterised by the specific distribution of publications among the total number of journals. The perception of each institution (citation rate of articles) is compared for each journal with the benchmark. Each journal as a proportion of the total output is taken into account when calculating the total value for perception. This value is what we call the J factor. This means that for publications in all of the journals, in which the institution under analysis publishes, a perception ratio is ascertained in comparison with the identical journal of the benchmark and calculated with a weighting factor.

$$J(I,B) = \sum_S \frac{cpp_I(S)}{cpp_B(S)} \bullet \frac{p_I(S)}{p_{I,ges}} \qquad (1)$$

where

J(I,B): J factor of institution I, in relation to benchmark B
S: serial
$cpp_I(S)$: average citation rate of publications by institution I in journal S
$cpp_B(S)$: average citation rate of publications of benchmark B I in journal S
$p_I(S)$: number of publications by institution I in journal S
$p_{I,ges}$: total number of publications by institution I

As a result of the relationship cpp = c / p, we can rewrite the formula as

$$J(I,B) = \frac{1}{p_{I,ges}} \sum_S \frac{c_I(S)}{cpp_B(S)} \qquad (2)$$

where

$c_I(S)$: number of publications by institution I in journal S

Benchmark B can be defined on a national scale (institution as against the nation-state to which it belongs), on a multistate scale (e.g. EU-27, ASEAN) or on an international scale. For a comparison of a group of institutions with each other (e.g. Ivy League universities), the total number of publications by the group can be used as a benchmark.

Only those publications by institution I in journals S can be taken into account, for which the corresponding information is also available for benchmark B (number of publications and citations). This is the case for example in the cover-to-cover indexed databases such as Science Citation Index, Social Sciences Citation Index and Arts & Humanities Citation Index (Thomson Scientific). The analyses outlined in Chapter 4 were conducted with the aid of these databases.

The J factor therefore describes the relative perception J of an institution I in comparison with a defined benchmark B. Through summation over the perception quotients for each individual journal, weighted with the number of publications in each of the journals as a proportion of all publications.

A result that can be compared to that generated by the J factor is generated by the JCSm indicator (mean Journal Citation Score), which is described in the literature (see van Raan, 2004, p. 29). The quotient CPP/JCSm must first be determined and related to the weight of publications in a set. In other places in the literature, a similar indicator is also discussed, namely the journal-based relative citation rate (RCR; see Schubert et al., 1993): "In general, sets of papers under investigation are published in various journals. In that case, the mean expected citation rate (MECR[4]) can be defined as the weighted average citation rate of the journals, the papers

[4] MECR equals JCSm

in question were published in. (The weights are, of course, the publication frequencies in the respective journals.) The mean observed citation rate (MOCR[5]), i.e. the average citation rate per paper can again be related to the MECR to result in the relative citation rate (RCR[6]), indicating the relative impact of the papers in question among the average papers of the publishing journals as reference standard" (Schubert & Braun, 1993, p. 23).

In our opinion, the J factor is more suitable than methods of field normalisation used in the past as a new standard for a journal-based distortion-free ranking of multidisciplinary research institutions.

4 Examples and Applications

The J factor will be applied to three fictive institutions by way of example in order to explain the method more precisely. Profiles will therefore be created for the three different fictive institutions and their publication and citation data will be compared with the corresponding benchmark.

Each of the three profiles represents one institution whose impact compared to the benchmark is:

1. *identical,*
2. *half as high,*
3. *twice as high.*

The composition of the benchmark is defined individually according to the journals selected by the institution. The proportion of publications in a journal is calculated in relation to the institution's total output with the citation rate of the institution being related to this journal in relation to the benchmark. The benchmark consists of all journals in which the institution being analysed has published. This is used to compare the impact of publications by an institution in a journal (according to the weight of the journal in terms of the total output of an institution) with the impact of all publications in this journal, which belong to the benchmark (e.g. country, world, etc.). The comparison is conducted journal-by-journal and produces a cumulative value as the final result of perception as a percentage (relative citation rate).

For the sake of overview, the number of journals used is deliberately kept to a minimum for the fictive institutions (Table 1 – 3).

Table 1: Examples of an institution with a J factor of 100 % (sum of incremental citation rates), which is equivalent to an identical perception of I1 and B1.

Table 2: Examples of an institution with a J factor of 50 % (sum of incremental citation rates), which is equivalent to a perception half as high for I2 compared to B2.

Table 3: Examples of an institution with a J factor of 200 % (sum of incremental citation rates), which is equivalent to a perception twice as high for I3 compared to B3.

Every institution is assessed according to their individual publication output. This means that the calculated benchmark is customised for each institution. This does not mean that it is chosen at random. It directly reflects the publication habits of an institution.

With the data generated, it is possible to come to a conclusion with regard to which institution has the highest perception in relation to their research environment. The journals in which the institution under analysis surpasses the benchmark perception can be identified, as can the journals in which the institution has not. "If we find a smaller field with a relatively low impact (i.e. a field in the lower part, the 'tail' of the profile), this does not necessarily mean that the (few) publications of the institute in this particular field are 'bad'. Often these small fields in a profile are those that are quite 'remote' from the institute's core fields" (van Raan, 2004, p. 33). What van Raan implements here as subject categories also holds for journal-based profiles. A small number of publications in a journal and a simultaneously low impact indicate a journal

[5] MOCR equals CPP
[6] RCR equals CPP/JCSm

in which scientists from other disciplines predominantly publish.

The method outlined can be compared to the field normalisation method used by van Raan (van Raan, 2004). In order to determine the J factor, however, the classification according to ISI subject categories is replaced by the basic classification in the journals.

A clear advantage of normalisation using the J factor on a journal basis compared to a field normalisation based on subject categories is that the heavily discussed assignment of journals to categories does not come into play: "Taking into consideration that journals are often not devoted to a single topic, the delimitation of subject areas based on journal assignment is neccessarily less precise [...]" (Glänzel et al., 1999, p. 428). Although the composition of categories is documented in the Journal Citation Report, the different sizes of the individual categories can lead to distortions depending on the aggregation level of the underlying classification (see Zitt, 2005, p. 391).

The origin of this type of distortion is demonstrated in the following using the three institutions as an example. Journals A-E are assigned to four subject categories (Table 4).

Table 4: Assignment of the fictive subject categories to the journals listed above.

Based on the assignment of the journals to the subject categories in Table 4, the perception of institutions I1 - I3 is compared to a benchmark with this changed configuration (Table 5 - 7):

Table 5: Institution I1 achieves a total perception of 104.2 % with a field normalisation according to subject categories compared to the benchmark (with the journal method: 100 %).

Table 6: Institution I2 achieves a total perception of 55.7 % with a field normalisation according to subject categories compared to the benchmark (with the journal method: 50 %).

Table 7: Institution I3 achieves a total perception of 160.4 % with a field normalisation according to subject categories compared to the benchmark (with the journal method: 200 %).

The results varied for the perception of institutions I1 - I3 calculated according to subject categories, based on identical journal publications of the three fictive institutions and the benchmarks from Tables 1 - 3. This deviation can be either very small amounting to a few percent or it can amount to 20 % or more. Rankings that were created for an institution with an identical set of reference data can deviate strongly from each other. Depending on the subject categories to which the journal is assigned and their configuration, this can be either better or worse for an institution. An institution fares worse in a ranking based on subject categories than in the journal method presented above if it generally publishes in low-impact journals. Even if these articles top the perception of the journal in which they were published, they can still give rise to an under-average rating compared to an entire discipline. Furthermore, the multiple registration of articles can also have a generally cumulative effect, particularly for articles that lie well below or well above the respective average for that discipline, and it also often slips into calculations through the multiple classification of journals.

The model presented will now be explained in more detail using a concrete example.

We compare the scientific publications of individual institutes in non-academic research institutions located in Germany (Table 8). The institutes belong to the following research bodies: Max Planck (MPI), Fraunhofer (FhG), and Leibniz. Each one of the institutes is characterised by its own scientific profile and each of the scientific profiles are different. Four German universities were also analysed, each with different research priorities. The bibliometric problem arises when one institution simultaneously occupies different disciplines. This is where the different communication habits come into play and prevent a comparison of multidisciplinary institutions on the basis of the citation rate.

The J factor is used to present a method that allows a multidisciplinary bibliometric comparison to be conducted on the basis of all types of documents listed in the Science Citation Index. Since it has been shown that opinion columns, for example, are also cited, it would be biased to exclude this group of documents from the beginning from this type of evaluation.

For every institution, the J factor is listed along with the other standard indicators P, C and CPP in order to make a dimensional comparison possible. For the present investigation, the benchmark for an institution was taken as all of the publications from Germany that were published in the journals in which the specific institution published during the period under investigation from 2003 to 2007. The citation rate of the institution was compared to the benchmark on a journal-by-journal basis in order to be able to estimate the difference between the citation rate of an institution in relation to the benchmark as a percentage in the J factor. When J was calculated, it was taken into account that an identical number of articles are not published in every journal and that every journal therefore has its own weight which is proportional to its proportion of the total output.

Table 8: Results of the investigation on the J factor (2003-2007)

The three bodies chosen represent the top research institutions in Germany, and together with the Helmholtz Association, they belong to the most important research bodies in Germany, alongside the universities. It is therefore not surprising that almost all of the institutes lie above the benchmark and that only two lie well below it. All four universities, including RWTH Aachen University, which was assessed as an elite university in a competition amongst German universities, lie above the benchmark. With 108.9 %, the University of Düsseldorf is the best of the universities investigated. The three Max Planck Institutes and the two Leibniz Institutes are the best amongst the non-academic institutions. The Leibniz IAP, which has the fourth highest average citation rate of all of the institutions investigated, clearly has the best J factor. This reflects the fact that lower citation rates tend to be produced in atmospheric physics than in the life sciences, for example, but that the Leibniz IAP is one of the most highly cited institutions within atmospheric physics.

5 Summary

The journal-based normalisation method presented here has two advantages over normalisation on a subject-category level:

1. *Each article is counted once only, which means that all types of distortion caused by assigning the same article to several subject categories are therefore avoided.*
2. *A field-normalised ranking according to subject categories does not consider whether a publication was positioned in a low- or high-impact journal in the corresponding subject category. Therefore, this ranking does not take into account the fact that the impact factors of journals in the same subject category can differ by two to three orders of magnitude. The subject category "multidisciplinary science", for example, includes the "Kuwait Journal of Science & Engineering" as well as "Science" and "Nature". This is not important for the journal-based normalisation presented here. An institution is compared to a constructed specialist community and only the exact composition of this community determines its journal-based publication profile.*

For the bibliometric evaluation of institutions, this means that the underlying comparison becomes more transparent and comprehensible when the journal method is applied because the benchmark composition is easier to understand. For institutions that would like to or need to document their scientific performance using publication and citation data, the method presented here represents another step towards more transparent benchmarks and ranking methods.

The results of bibliometric analyses provide greater transparency and clarity, thus giving researchers the opportunity to accept these results more easily, to identify their strengths and weaknesses of their own publication behaviour, and consequently to change this behaviour accordingly in the future. Such opportunities to change their own communication behaviour must be provided for internationally competitive scientific institutions, because after all they are also partly economically dependent on the worldwide response to their research.

Not only is the more targeted communication behaviour of scientific institutions of benefit to the institutions themselves, but it also leads to more purposeful communication in science. In this way, bibliometrics does not only contribute to the evaluation of science; it also supports the targeted optimisation of scholarly communication.

The increasing application of the journal-based method will optimise rather than replace the method of field normalisation according to subject categories. Multidisciplinary scientific institutions in particular will profit from the journal-based ranking method.

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6 Appendix

Table 1: Examples of an institution with a J factor of 100 % (sum of incremental citation rates), which is equivalent to an identical perception of I1 and B1.

	Benchmark B1			Institution I1					
	P	C	CPP	P	C	CPP	Relative citation rate (CPP rel)	Weight of the journals	Incremental relative citation rate
Journal A	10	100	10	1	10	10	100%	33%	33.3%
Journal B	5	20	4	1	4	4	100%	33%	33.3%
Journal C	20	400	20	1	20	20	100%	33%	33.3%

Table 2: Examples of an institution with a J factor of 50 % (sum of incremental citation rates), which is equivalent to a perception half as high for I2 compared to B2.

	Benchmark B2			Institution I2					
	P	C	CPP	P	C	CPP	Relative citation rate (CPP rel)	Weight of the journals	Incremental relative citation rate
Journal A	10	100	10	2	10	5	50%	40%	20.0%
Journal B	5	20	4	1	4	4	100%	20%	20.0%
Journal C	20	400	20	2	10	5	25%	40%	10.0%

Table 3: Examples of an institution with a J factor of 200 % (sum of incremental citation rates), which is equivalent to a perception twice as high for I3 compared to B3.

	Benchmark B3			Institution I3					
	P	C	CPP	P	C	CPP	Relative citation rate (CPP rel)	Weight of the journals	Incremental relative citation rate
Journal C	20	400	20	3	180	60	300%	50%	150.0%
Journal D	10	40	4	2	4	2	50%	33%	16.7%
Journal E	25	250	10	1	20	20	200%	17%	33.3%

Table 4: Assignment of the fictive subject categories to the journals listed above.

Subject category 1	Subject category 2	Subject category 3	Subject category 4
Journal A	Journal A	Journal A	Journal C
Journal D	Journal B	Journal B	Journal D
	Journal D		
	Journal E		

Table 5: Institution I1 achieves a total perception of 104.2 % with a field normalisation according to subject categories compared to the benchmark (with the journal method: 100 %).

	Benchmark B1			Institution I1					
	P	C	CPP	P	C	CPP	Relative citation rate (CPP rel)	Weight of the journals	Incremental relative citation rate
SC 1	20	140	7.0	1	10	10.0	143%	17%	23.8 %
SC 2	50	410	8.2	2	14	7.0	85%	33%	28.5 %
SC 3	15	120	8.0	2	14	7.0	88%	33%	29.2 %
SC 4	30	440	14.7	1	20	20.0	136%	17%	22.7 %

Table 6: Institution I2 achieves a total perception of 55.7 % with a field normalisation according to subject categories compared to the benchmark (with the journal method: 50 %).

	Benchmark B2			Institution I2					
	P	C	CPP	P	C	CPP	Relative citation rate (CPP rel)	Weight of the journals	Incremental relative citation rate
SC 1	20	140	7.0	2	10	5.0	71%	20%	14.3%
SC 2	50	410	8.2	3	14	4.7	57%	30%	17.1%
SC 3	15	120	8.0	3	14	4.7	58%	30%	17.5%
SC 4	30	440	14.7	2	10	5.0	34%	20%	6.8%

Table 7: Institution I3 achieves a total perception of 160.4 % with a field normalisation according to subject categories compared to the benchmark (with the journal method: 200 %).

	Benchmark B3			Institution I3					
	P	C	CPP	P	C	CPP	Relative citation rate (CPP rel)	Weight of the journals	Incremental relative citation rate
SC 1	20	140	7.0	2	4	2.0	29%	20%	5.7 %
SC 2	50	410	8.2	3	24	8.0	98%	30%	29.3 %
SC 4	30	440	14.7	5	184	36.8	251%	50%	125.5 %

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Institution	P	C	CPP	**J**
Fraunhofer Institute for Applied Solid-State Physics	166	539	3.2	**72.7%**
Leibniz Forschungszentrum Dresden Rossendorf	1509	5393	3.6	**84.3%**
Fraunhofer Institute for Surface Engineering and Thin Films	98	446	4.6	**99.4%**
- Benchmark: Germany -				**100.0%**
University of Cologne	10032	52515	5.2	**100.8%**
RWTH Aachen University	10050	49957	5.0	**103.4%**
University of Bonn	12205	68532	5.6	**104.5%**
Fraunhofer Institute for Interfacial Engineering and Biotechnology	137	792	5.8	**106.8%**
Heinrich Heine University of Düs-seldorf	8562	54391	6.4	**108.9%**
Max Planck Institute of Plasma Physics	1648	8235	5.0	**109.5%**
Max Planck Institute for Terrestrial Microbiology	371	4393	11.8	**115.3%**
Leibniz Institute for Neurobiology	309	2575	8.3	**117.3%**
Max Planck Institute for Polymer Research	1635	15035	9.2	**117.7%**
Leibniz Institute of Atmospheric Physics (IAP)	181	1172	6.5	**123.9%**