Qualitative and Quantitative Methods in Libraries (QQML) 3: 231 – 244, 2013

Analysis of journal usage by Wageningen UR staff members via article references

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Abstract. The research activities of Wageningen University and Research (or Wageningen UR) are concentrated around food and food production, living environment and health, lifestyle and livelihood. To facilitate the scientific information access of Wageningen UR staff members, the library strives to provide a balanced collection of relevant journals. For such a balanced collection, appropriate collection management is a necessity.

For information on journal usage by staff members of Wageningen UR, the library has developed an alternative analysis based upon information from article references. An inventory is made on a yearly basis of the journals from which articles are listed in the references of articles published by Wageningen UR staff in the three previous years. For each of the inventoried journals the number of times (abundance) articles from this journal are included in the references of the published articles is counted. The published articles are collected from Wageningen UR's institutional repository, which contains updated affiliation information for the authors of the articles. The institutional repository also contains, for each published article, a link to its corresponding Web of Science record for collecting information on the articles' references.

The use of the institutional repository, in combination with Web of Science, as input for this alternative analysis enables customized, evidence-based measures of journal usage by Wageningen UR as a whole or parts thereof (e.g. research groups). Customized lists of accessed journals can be used by staff members to select journals that are relevant for their research. The library uses the lists to evaluate its journal collections and allocate costs to organizational units of Wageningen UR.

Customized lists of used journals also can be applied in a similarity analysis of journal usage by different research groups. Via cluster analysis and mapping this similarity in journal usage by research groups can be visualized over time.

Keywords. Collection management, Article references, Journal usage, Research groups, Cost allocation, Similarity, Mapping

Received: 1.3.2013 / Accepted: 19.9.2013 ISSN 2241-1925

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1. Introduction

Wageningen UR (University & Research Centre) is an international research and knowledge centre which is located in the Netherlands. The hybrid character of Wageningen UR is reflected in the combination of a university (with more than 80 chair groups) and 10 different research institutes in one organization. Research activities and educational programs of Wageningen UR focus around the domain of 'healthy food and living conditions'. Within this domain there are three core areas that are studied and explored by students and staff of Wageningen UR (Working Group Annual Report Wageningen UR, 2012): health, lifestyle and living conditions; food and food production; and living environments.

For about 10,000 BSc and MSc students and 6,500 staff members (Wageningen UR, 2013), Wageningen UR Library provides access to both digital and hardcopy versions of scientific literature, especially in the fields of agrotechnology, food sciences, plant and animal sciences, soil science, geo-information, landscape and spatial planning, water and climate, ecosystem studies and social sciences. The services of the library are not restricted to staff and students. All locations of Wageningen UR Library are also open to the general public.

In addition to the physical collection of (e.g.) books, journals and reports, Wageningen UR Library also holds a digital library with access to online resources such as research reports, MSc or PhD theses, websites, databases (mostly bibliographies), electronic books and online journals. The online journals provide an important source of information, especially to Wageningen UR staff members, that is used in their research. It is for this reason that the library strives to provide a balanced collection of relevant journals for the scientific disciplines in which Wageningen UR researchers are active. For such a balanced collection appropriate collection management is a necessity.

Typically, collection management for journal subscriptions at university libraries is often based upon annual measurements of journal usage at the university (see e.g. Boukacem-Zeghmouri & Schöpfel, 2012; Bucknell et al., 2011; Suseela, 2011). For this purpose, statistics on article downloads per journal are obtained from COUNTER reports (Project Counter, 2012) provided by the publishers or aggregators where the subscription to the journals are arranged. Download statistics of journals are also annually collected and aggregated for collection management on journals at Wageningen UR Library (Veller & Spikman, 2010). Unfortunately, however, these download statistics only provide information on the usage of journals by staff for Wageningen UR as a whole. As a result, collection management on journals that are relevant for certain parts of Wageningen UR (e.g. research groups, institutes or chair groups) cannot be based on these statistics.

In addition to the lack of information on journal usage by parts of Wageningen UR, download statistics may provide inaccurate information on journal usage. The reason for this is that a user may download an article (even multiple times) without actually reading or using it. As a result the analysis of download statistics to assess journal usage may result in over-estimation of 'real` usage.

In order to obtain more accurate estimations of journal usage for both Wageningen UR as a whole or parts of it, the library has applied an alternative measure of journal usage that is based upon the abundance of journals in reference lists of articles published by Wageningen UR staff. This paper describes the methodology for obtaining this information and discusses some applications of this new method in the collection management and presentation of journals by Wageningen UR Library.

2. Methodology

The alternative analysis of journal usage is based upon information from the references in research articles that are published by Wageningen UR staff. Wageningen UR Library uses a time frame of three years for the analysis of the reference lists. This means that in year t articles published by Wageningen UR staff in years t-1, t-2 and t-3 are analyzed. The methodology for the alternative analysis is schematically represented in figure 1.

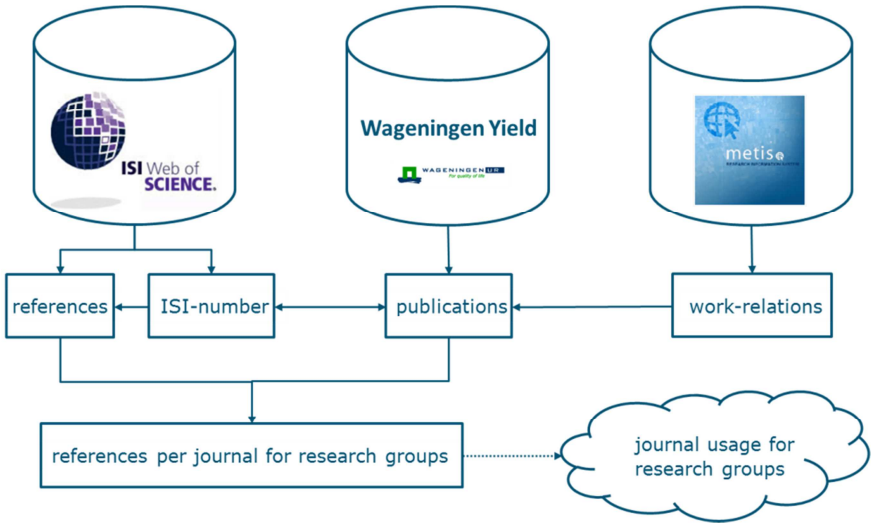

Figure 1: Sources and methodology for the alternative analysis of journal usage by (parts of) Wageningen UR based upon references.

The published articles are collected from Wageningen UR institutional repository (Wageningen Yield: WaY). The repository contains all scientific output by Wageningen UR staff and is maintained by the library. Via a connection with a Current Research Information System (Metis), the repository contains updated information on work relations (affiliation data) for the authors (i.e. Wageningen UR staff) of the scientific output. For articles published in ISI-journals (i.e. journals covered by Web of Science) the unique identifier to the corresponding record with bibliographic information in Web of Science is also stored in the repository.

From the articles published by Wageningen UR staff in years t-1, t-2 and t-3 a selection comprising articles published in ISI-journals is made. For each of these articles, via the unique identifier to the corresponding bibliographic record in Web of Science, all references are collected. These references represent the information sources used by Wageningen UR staff in the writing of articles published in ISI-journals in years t-1, t-2 and t-3.
The collected references are subject to further analysis. A subsequent selection is made for references that represent journal articles. Criteria for the identification of these references are journal titles, indications of volume and issue data or listings of DOIs. For the references that represent journal articles an inventory is made of the journals in which they are published. For each of these inventoried journals its abundance in the references of articles published by Wageningen UR staff is determined. The abundance of an inventoried journal is measured by counting the number of times articles from this journal have been included in all reference lists of the articles published in years t-1, t-2 and t-3 by Wageningen UR staff.
Along the whole analysis, for each reference the identifier (to the corresponding bibliographic record in Web of Science) of the published article in which it was listed is saved. Based upon this identifier, and the information stored in the repository, customized lists of articles published by specific parts of Wageningen UR (e.g. research groups) can be selected and related to measures of journal abundance in the references of these articles. As a result, this analysis enables the listing of the number of article references per journal in articles that have been published by a particular research group. This listings provides an evidence-based estimation of usage per journal for this research group.

3. Results

In 2012, the alternative analysis of journal usage was based upon 7,278 articles in ISI-journals that were published by Wageningen UR staff in 2009, 2010 or 2011. These articles represent 57% of the total scientific output (academic publications) for Wageningen UR in these three years. From the articles published in ISI-journals, in total 349,344 references were selected, 80% of which were references representing articles in 8,201 journals.
Figure 2 shows the counts of article references (abundance) for each of the 8,201 journals in the reference lists of Wageningen UR published ISI-journal articles in 2009, 2010 or 2011. The journals on the horizontal axis are sorted in descending order by the number of article references.
In figure 2 an arrow indicates the position of the *Journal of Business Logistics*, from which 20 articles were included in the reference lists of the Wageningen UR published articles. In order to cover 90% of all article references in the 8,201 journals, 1,814 journals (which were counted 20 or more times in the article references) need to be selected. As a result, from this analysis, a core collection of 22% of all journals that have been inventoried from the reference lists would be responsible for 90% of all article references in Wageningen UR published articles.

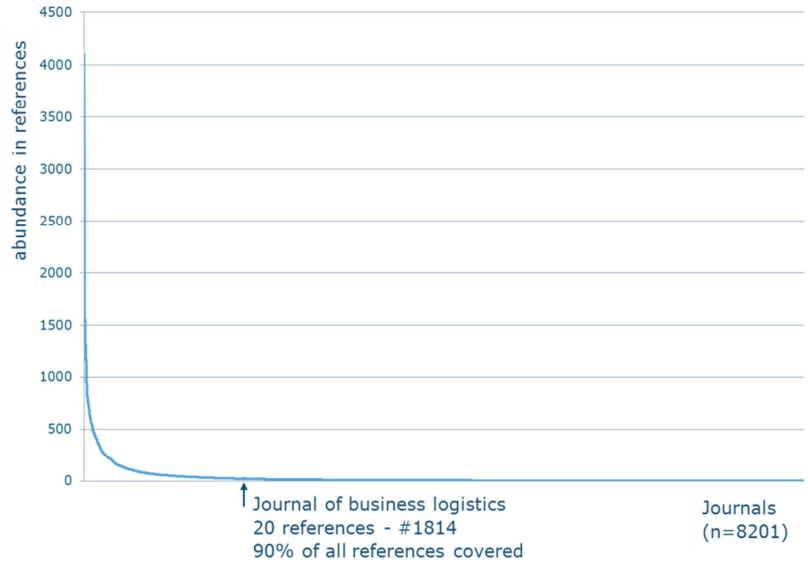

Figure 2: Abundance of 8201 journals in reference lists of ISI-journal articles published by Wageningen UR staff in 2009, 2010 or 2011.

Table 1 shows the top-10 journals that are the most abundant in references listed in ISI-journal articles published in 2009, 2010 and 2011 for the whole of Wageningen UR. Journals referred to most are *Proceedings of the National Academy of Sciences*, *Nature*, *Science*, *Applied and Environmental Microbiology* and the *Journal of Dairy Science*.

Table 1: Top-10 journals that are most abundant in reference list of articles published by Wageningen UR staff in 2009, 2010 or 2011.

Journal title	Number of references
Proceedings of the National Academy of Sciences of the United States of America	4,106
Nature	4,065
Science (New York, N.Y.)	3,890
Applied and Environmental Microbiology	2,810
Journal of Dairy Science	2,142
Plant Physiology	1,877
Ecology : a Publication of the Ecological Society of America	1,857
The journal of Biological Chemistry	1,764
Environmental Science & Technology	1,684
Remote Sensing of Environment	1,564

The lists of journals for specific research groups can differ considerably from the listing for the Wageningen UR as a whole. Table 2 displays the top-10

journals , listed in 669 ISI-journal articles, published by the Crop and Weed Ecology group in 2009, 2010 and 2011. For this research group the journals that were referred to most are *Field Crops Research*, *Annals of Botany*, *Plant, Cell & Environment*, *Journal of Experimental Botany* and *Plant Physiology*.

Table 2: Top-10 journals that are most abundant in reference list of articles published by the Crop and Weed Ecology group in 2009, 2010 or 2011.

Journal title	Number of references
Field Crops Research	154
Annals of Botany	110
Plant, Cell & Environment	101
Journal of Experimental Botany	95
Plant Physiology	94
Agricultural Systems	74
Agriculture Ecosystems & Environment	65
Crop Science	54
Weed Research	54
The New Phytologist	51

The differences between tables 1 and 2 demonstrate that the journals important to Wageningen UR as a whole may not be important for the staff of a particular research group. These differences reflect the relative importance of journals for the research fields in which the researchers of various groups of Wageningen UR are active.
Rather than COUNTER statistics on article downloads per journal, the alternative analysis described above provides a direct estimation of the usage of scholarly journals by WUR staff in the preparation of their articles. Comparison between COUNTER statistics and analyses on the abundance of journals in reference lists shows that both measures are correlated. Table 3 below displays correlations between both metrics. Journals with low counts of article downloads are excluded from the calculations of the correlations.

Table 3: Correlations between article downloads per journal and abundance of the journal in the references of published articles in years 2007-2011.

		Abundance in references from published articles				
		2007	2008	2009	2010	2011
Number of article downloads*	2007	0.597	0.603	0.610	0.602	0.594
	2008		0.543	0.553	0.552	0.550
	2009			0.775	0.802	0.795
	2010				0.796	0.804
	2011					0.712

*Only the journals that cover in total 90% of all downloads per year are used to calculate correlations between the number of article downloads and abundance in the references.

Table 3 shows a correlation of about 0.8 between the number of article downloads per journal and the abundance of this journal in references of Wageningen UR publications for the years 2009, 2010 and 2011. A perfect correlation between both measures for journal usage is not expected because not all article downloads will result in the inclusion of those articles in the references of published articles. This may be the result of not using downloaded articles in the writing process or multiple downloads of the same article by a user and only inclusion of this article only in a single publication.
For the article downloads that were collected in 2007, 2008 and 2009 table 3 indicates that the correlation with the abundance in reference lists tends to be higher one to two years after downloading. For example the correlation between the number of article downloads collected over 2007 increases to a maximum of 0.610 with the abundance in references from article published in 2009 and decreases again with the abundance in references from articles published in 2010 and 2011. This indication of a (weak) trend may correspond with the time that a user needs for the preparation, review and publication of articles as well as additional time that is needed for the inclusion of these articles in Web of Science. The differences between the correlations in table 3, however, are not very large and to confirm a trend correlations should be determined over a longer period of time.

4. Applications

The alternative measurement of journal usage described above enables direct comparison of journal usage in Wageningen UR published articles. Also, customized lists of journals used can be made and compared for (any part of) Wageningen UR. Wageningen UR Library uses these comparisons and lists to make decisions on the continuation of subscriptions to journals (journal collection management) with publishers or aggregators. Also, frequently it is checked whether journals that are included in reference lists make part of the collections of journals to which Wageningen UR is subscribed and are included in the library catalogue. This measurement also enables regular evaluation of composition of the journal collections to confirm that they still include journals most often referenced. In addition, allocation of the journal subscription costs of these collections can be based upon the same methodology.
For its services the library has financial agreements with various (aggregations of) research groups at Wageningen UR. With the methodology described above it is possible to analyse which journals have been included in the references of articles published by the staff of each research group over a period of three years. The abundance of journals in these references is used to distribute costs[1] involved in the subscription to these journals over the research groups. Summation of the allocated costs per group results in a total amount of costs for

[1] For most journals the list price is allocated over the different research groups. The reason for using the list price is that for the majority of (paid) journal subscriptions package deals have been arranged with publishers or aggregators.

each group. Per research group these costs are fractionized to the total costs for all journals. What follows from this fractionation is a factor per research group that is used (in combination with other data) to allocate costs of collections and services by the library to the different (aggregations of) research groups of Wageningen UR. The factor for allocation of costs over the science groups is known, at Wageningen UR, as the Spikman factor[2]. The calculation of the Spikman factor based upon the abundance of journals in the references of groups' published articles is described in the appendix.
In addition to collection management and cost allocation, the 'journal reference abundance list' is also used to present journals in the catalogue browser of the digital library of Wageningen UR. Users of the digital library can sort selections of journals (e.g. journals that have been categorized under molecular biology; see for an example figure 3) according to importance of these journals to Wageningen UR staff. Hereby 'importance' is measured by the abundance of the journal in the references of articles published by Wageningen UR in the last three years.

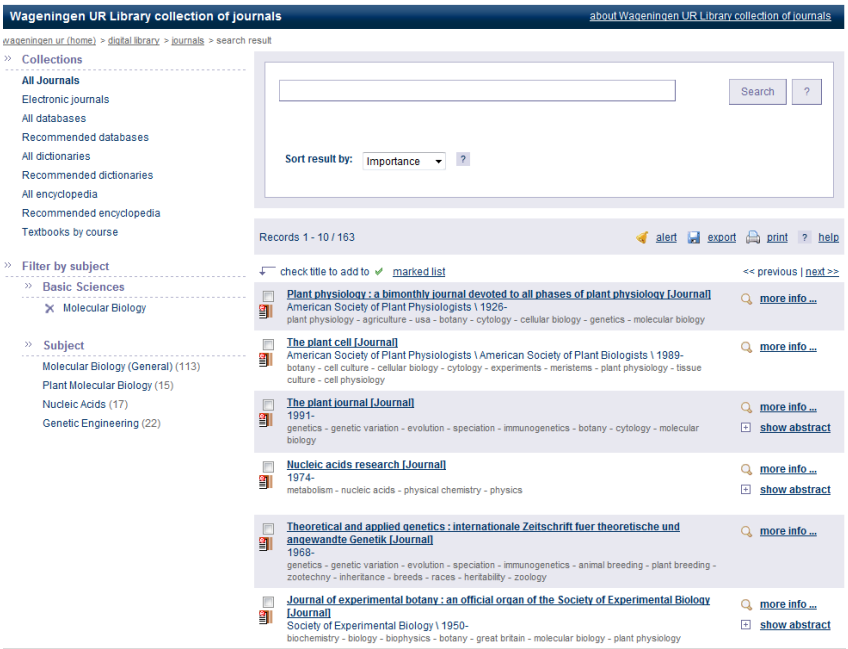

Figure 3: Sorting of molecular biology journals in the catalogue browser of the digital library of Wageningen UR according to their importance.

As described above this alternative analysis makes it possible to obtain journal lists with counts of article references per research group. These lists provide an

[2] G. Spikman was librarian for Wageningen UR from 2010-2013 and applied virtual collections of journals per research group to allocate subscription costs.

estimation of usage per journal per research group in their published articles over the last three years. Based upon the lists it is possible to make comparisons between research groups according to similar usage of journals. For this comparative analysis a similarity matrix is calculated from journal abundances in the references of published articles per research group; in order to correct for differences in group size and research output per group, the abundance per journal is fractionized to the total number of article references in the published articles of each research group. The similarity matrix is calculated based upon the Jaccard similarity coefficient (Jaccard, 1901).
Via cluster analysis on the calculated similarity matrix and mapping of the number of article publications per research group with VOSviewer (Van Eck & Waltman, 2011) a network can be created (see figure 4).

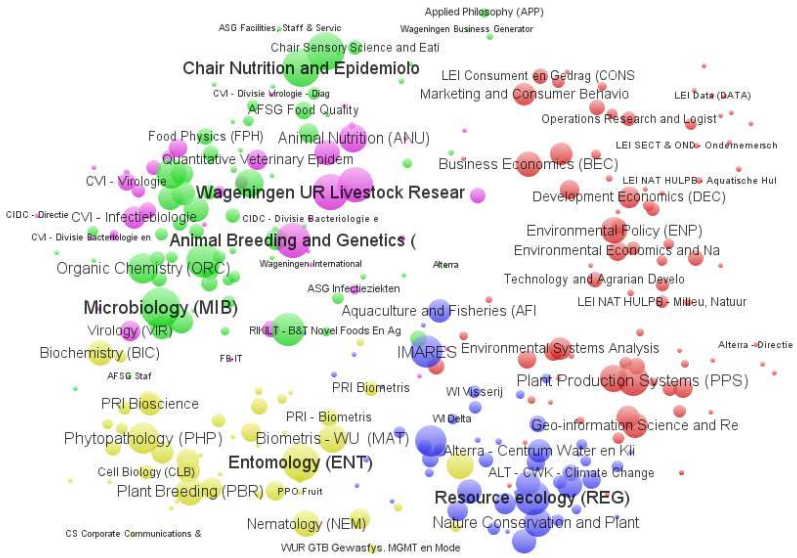

Figure 4: Network of 290 Wageningen UR research groups based upon a similarity analysis on shared use of journals in articles published by these groups in 2009, 2010 and 2011.

The network in figure 4 visualizes similarity in journal usage by the 290 research groups of Wageningen UR based upon their published articles in 2009, 2010 and 2011. The size of the bubbles corresponds with the size of the article output in 2009, 2010 and 2011 for each group. Research groups that are placed closely together in the network have more similar usage of journals in the reference lists of their published articles. Also, from the clustering with the VOSviewer (Van Eck & Waltman, 2011) it follows that the research groups can be clustered in five clusters, represented by five different colours in figure 4. In majority, the five clusters correspond with the five aggregations of research groups under which the research groups are organized at Wageningen UR:

- yellow: Plant Sciences group
- green: Agrotechnology and Food Sciences group
- purple: Animal Sciences group
- red: Social Sciences group
- blue: Environmental Sciences group

By creating networks (such as the one represented in figure 4) from analysis of articles published in consecutive years it is possible to follow the similarity in journal usage by research groups over time. It is also possible to compare and visualize journal usage of research groups with the journals that have been included in publications of individual (internal or external) researchers.

5. Discussion and conclusions

Also other authors describe the analysis of the abundance of journals in the reference lists of faculty publications to evaluate journal usage. Mattos & Dias (2009) describe an application of citation analysis from academic dissertations to support decision making in the collection development of the library.

Despite the fact that analysing references from dissertations may indeed support collection management decisions, the analysis described here for Wageningen UR is based only on the analysis of reference lists from journal articles. The reason for this is that journal articles represent the largest part (on average 65% in 2009, 2010 and 2011) in the yearly published scientific output of Wageningen UR and therefore are the best source to base analysis of journal usage on.

In another paper, Chung (2009) proposes an alternative model for the selection of a set of journals that can be considered most important for an academic library (i.e. a core collection). In the model, besides journal citation scores also other scores like number of article downloads, impact factors and subscription prices are included per journal. The combination of the scores results in a ranked list of journals from which collection management decisions can be taken. The analysis described here for Wageningen UR only takes the number of citations each journal received from staff publications into consideration. The reason for this is that this number directly can be related to usage of the journal by the Wageningen UR staff. The same does not necessarily hold for download statistics (see the remarks made on download statistics to assess journal usage in the introduction of this paper) and neither impact factors nor subscription prices give information on journal usage (and thereby relative importance of the journal to the user).

Salisbury & Smith (2010) provide in their paper a method that resembles the method described in this paper for evidence based collection management. In their study, they analysed references from faculty publications of the University of Arkansas. Based upon the total number of citations each journal received, ranked listings of journals are presented. The analysis by Salisbury & Smith (2010) represents an analysis at the macro-level; i.e. for the whole university.

Recently, Tucker (2013) published a paper on the analysis of literature citations by faculty of the University of Nevada, Las Vegas. By starting with the publication output of the nine colleges of the university, Tucker is able to

identify most cited journals per college. This enables custom made journal selection at the meso-level; i.e. for each college.

The analysis described in this paper makes it possible to obtain estimations of journal usage by Wageningen UR staff members over defined periods of time. As input for the analysis, articles published by (parts of) Wageningen UR are selected from the institutional repository of Wageningen UR. Since this repository also contains updated affiliation information as well as identifiers to Web of Science records (with meta information such as articles included in the references) customized analyses of journal usage (measured by journal citations) per (selectable) organizational part of Wageningen UR is possible. Thereby, it is possible to perform analyses at the macro (whole university), meso (science groups or institutes) or micro (chairs and chair groups) level.

From the analyses lists of journals, sorted on the abundance of each journal in the references of published articles (i.e. number of received citations per journal), can be made. These lists are used in journal collection management by the library as well as for presenting relevant journals to researchers that may be active in different scientific fields. Additionally, the estimation of journal usage per group can be used to calculate the Spikman factor, used by the library to allocate costs over different research groups of Wageningen UR. Based upon additional similarity analyses, the library applies the outcomes of the alternative analysis on journal usage per research group in order to visualize comparability between research groups of Wageningen UR based upon usage of the same journals.

Acknowledgments

The author thanks Ger Spikman, Wouter Gerritsma and Corrie van Zeist for helpful discussions, Peter van der Togt for help with establishing database connections and Rebecca Stellato for corrections on the English. Also, the author wishes to thank Saava Favour Jacob for inspiration on the writing of this paper.

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Appendix: Calculation of the Spikman factor for allocation of costs over (aggregations of) research groups based upon the abundance of journals in the references of groups' published articles

The calculation of the Spikman factor starts with a table of the abundance of journals in the references of articles published per group. The abundance is measured by counting article references per journal in the articles published by the group.

The total number of groups is n_g and the total number of journals is n_j. Each cell in the table below contains the abundance r of a journal j in the references of articles published by a particular group g.

	Group 1	Group 2	...	Group n_g
Journal 1	r_{11}	r_{12}	...	r_{1n_g}
Journal 2	r_{21}	r_{22}	...	r_{2n_g}
...	...	...	...	
Journal n_j	r_{n_j1}	r_{n_j2}	...	$r_{n_jn_g}$

In the next step the abundance of a journal in the publications of all groups is allocated to the different groups. This is done by the calculation of fractions: the abundance of a journal per group is divided by the summation on the abundances of the same journal over all groups. The results of this fractionation is shown in the next table.

	Group 1	Group 2	...	Group n_g
Journal 1	$\frac{r_{11}}{\sum_{g=1}^{n_g} r_{1g}}$	$\frac{r_{12}}{\sum_{g=1}^{n_g} r_{1g}}$	...	$\frac{r_{1n_g}}{\sum_{g=1}^{n_g} r_{1n_g}}$
Journal 2	$\frac{r_{21}}{\sum_{g=1}^{n_g} r_{2g}}$	$\frac{r_{22}}{\sum_{g=1}^{n_g} r_{2g}}$	...	$\frac{r_{2n_g}}{\sum_{g=1}^{n_g} r_{2n_g}}$
...	...	...	...	...
Journal n_j	$\frac{r_{n_j1}}{\sum_{g=1}^{n_g} r_{n_jg}}$	$\frac{r_{n_j2}}{\sum_{g=1}^{n_g} r_{n_jg}}$	...	$\frac{r_{n_jn_g}}{\sum_{g=1}^{n_g} r_{n_jn_g}}$

In general, the calculation of the fractionized abundance of journal j for group g can be represented as follows:

$$\frac{r_{jg}}{\sum_{g=1}^{n_g} r_{jg}}$$

In additon to abundances of journals in reference lists a table is needed with the list price l for each journal j.

	List price
Journal 1	l_1
Journal 2	l_2
...	...
Journal n_j	l_{n_j}

The list prices of journals are allocated to the groups by calculation of the product of the fractionized abundances with the list prices.

	Group 1	Group 2	...	Group n_g
Journal 1	$\frac{r_{11}}{\sum_{g=1}^{n_g} r_{1g}} * l_1$	$\frac{r_{12}}{\sum_{g=1}^{n_g} r_{1g}} * l_1$	...	$\frac{r_{1n_g}}{\sum_{g=1}^{n_g} r_{1n_g}} * l_1$
Journal 2	$\frac{r_{21}}{\sum_{g=1}^{n_g} r_{2g}} * l_2$	$\frac{r_{22}}{\sum_{g=1}^{n_g} r_{2g}} * l_2$	...	$\frac{r_{2n_g}}{\sum_{g=1}^{n_g} r_{2n_g}} * l_2$
...	...	...	...	...
Journal n_j	$\frac{r_{n_j1}}{\sum_{g=1}^{n_g} r_{n_jg}} * l_{n_j}$	$\frac{r_{n_j2}}{\sum_{g=1}^{n_g} r_{n_jg}} * l_{n_j}$	...	$\frac{r_{n_jn_g}}{\sum_{g=1}^{n_g} r_{n_jn_g}} * l_{n_j}$

In general, the allocation of the list price of a journal j to the groups can be represented as follows:

$$\frac{r_{jg}}{\sum_{g=1}^{n_g} r_{jg}} * l_j$$

For the groups the total share in the list prices of the journals is calculated by summation over the journals for each group.

	Group 1	Group 2	...	Group n_g
All journals	$\sum_{j=1}^{n_j}\left(\frac{r_{j1}}{\sum_{g=1}^{n_g} r_{jg}} * l_j\right)$	$\sum_{j=1}^{n_j}\left(\frac{r_{j2}}{\sum_{g=1}^{n_g} r_{jg}} * l_j\right)$	...	$\sum_{j=1}^{n_j}\left(\frac{r_{jn_g}}{\sum_{g=1}^{n_g} r_{jg}} * l_j\right)$

The Spikman factor per group follows from the fractionizing of the total share in the list prices for all journals per group over the summation of all list prices.

	Group 1	Group 2	...	Group n_g
All journals	$\frac{\sum_{j=1}^{n_j}\left(\frac{r_{j1}}{\sum_{g=1}^{n_g} r_{jg}} * l_j\right)}{\sum_{j=1}^{n_j} l_j}$	$\frac{\sum_{j=1}^{n_j}\left(\frac{r_{j2}}{\sum_{g=1}^{n_g} r_{jg}} * l_j\right)}{\sum_{j=1}^{n_j} l_j}$	...	$\frac{\sum_{j=1}^{n_j}\left(\frac{r_{jn_g}}{\sum_{g=1}^{n_g} r_{jg}} * l_j\right)}{\sum_{j=1}^{n_j} l_j}$

In general terms the Spikman factor per group g based upon abundance of n_j journals (with list prices) that have been included in the references of the groups published articles can be represented as follows:

$$\frac{\sum_{j=1}^{n_j}\left(\frac{r_{jg}}{\sum_{g=1}^{n_g} r_{jg}} * l_j\right)}{\sum_{j=1}^{n_j} l_j}$$