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A flexible bibliometric approach for the assessment of professorial appointments

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Abstract Recruitment and professorial appointment procedures are crucial for the administration and management of universities and higher education institutions in order to guarantee a certain level of performance quality and reputation. The complementary use of quantitative and objective bibliometric analyses is meant to be an enhancement for the assessment of candidates and a possible antidote for subjective, discriminatory and corrupt practices. In this paper, we present the Vienna University bibliometric approach, offering a method which relies on a variety of basicindicators and further control parameters in order to address the multidimensionality of the problem and to foster comprehensibility. Our "top counts approach" allows an appointment committee to pick and choose from a portfolio of indicators according to the actual strategic alignment. Furthermore, control and additional data help to understand disciplinary publication habits, to unveil concealed aspects and to identify individual publication strategies of the candidates. Our approach has already been applied to 14 professorial appointment procedures (PAP) in the life sciences, earth and environmental sciences and social sciences, comprising 221 candidates in all. The usefulness of the bibliometric approach was confirmed by all heads of appointment committees in the life sciences. For the earth and environmental sciences as well as the social sciences, the usefulness was less obvious and sometimes questioned due to the low coverage of the candidates' publication output in the traditional citation data sources. A retrospective assessment of all hitherto performed PAP also showed an overlap between the committees' designated top candidates and the bibliometric top candidates to a certain degree.

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Introduction and purpose

There is a worldwide growing use of bibliometrics to evaluate research performance since funding decisions in research management and science policy increasingly rely on bibliometric analyses. This is simply due to the fact that science grows exponentially and becomes more and more interdisciplinary, which results in a peer-review system that has already met its limits. Finding experienced peers across multiple disciplines is far from trivial. And even if such experts have been identified and are willing to contribute, their time is precious and limited. No one can afford to read everything to the smallest detail. This is where bibliometrics comes into play: it complements the purely subjective peer-review process by providing more objective quantitative aspects. Ideally, neither peer review nor bibliometrics should be used as stand-alone procedures in research evaluation, but rather, they should be combined to form "informed peer review", as it is called (Warner 2000; Weingart 2005; Abramo and D'Angelo 2011).

This approach can be successfully employed to expert panels like appointment committees, whose members always struggle with sifting through numerous applications for vacant professorships. Bibliometric analyses are helpful by shedding light on different aspects, which can be taken into account by the committee members according to their preferences. In so doing, it becomes easier to narrow down the list of applicants, which actually means a reduced reading effort and which therefore facilitates a faster decision-making process to identify the preferred candidate.

Successful recruitment (including professorial appointments) is one of the most important challenges for the administration and management of universities and higher education institutions because they aim to guarantee a certain level of performance quality and reputation. Competitive mechanisms for the recruitment of the best scientists and teaching professors at national and international level are less developed or implemented in German speaking countries than in English-speaking countries (van der Ploed and Veugelers 2008; Abramo et al. 2014). This might probably explain why English-speaking institutions always hold top positions in worldwide university rankings.

In Austria, academic recruitment is even regulated by law (§ 98 UnivGesetz Berufungsverfahren für Universitätsprofessorinnen und Universitätsprofessoren) in order to ensure fair competition among the applying candidates. However, this regulation does not aim at any efforts to recruit the luminaries. Furthermore, several Austrian universities provide more detailed information about their professorial appointment procedures online.[1] Like many other European countries, Austria is traditionally associated with the "Mandarin system", as it is called (Bonacorsi 2014), but major reforms have been introduced in recent times in order to support a more competitive model according to the needs of this new era. Appointment committees installed by universities consist of major representatives of the corresponding faculty. They act under the auspices of a rectorate and a senate, and they are supported by dedicated quality assurance departments or other services.

[1] For example, http://senat.univie.ac.at/berufungsverfahren/; http://www.tuwien.ac.at/akgleich/aufnahmeverfahren/berufungsverfahren/.

Nevertheless, issues of fairness—including nepotism, co-optation mechanisms and, in a more general sense, "old-boys practices"—have been reported in several countries, which are reflected extensively in the international literature (Trotman et al. 2002; Price et al. 2005; Cora-Bramble 2006; Martin 2009; Van den Brink et al. 2010; Allesina 2011; Zinovyeva and Bagues 2012; Abramo et al. 2012a; Ferlazzo and Sdoia 2012).

One of the main reasons for discriminatory and corrupt practices is obviously the use of non-transparent criteria and procedures (Combes et al. 2008). Thus, the use of quantitative and objective bibliometric analyses, supporting and enhancing the informed peer-review process, seems to be the only reasonable and possible antidote and is therefore in high demand (Holden et al. 2005; Glänzel and Debackere 2003, 2007; Van Raan 2004).

Since the implementation of the Bibliometrics Department in the Library and Archive Services of the University of Vienna in 2008, it has continuously expanded its expertise and services within and beyond university boundaries. Together with the rectorate and the Department for Quality Assurance, a scientometric triangle has formed, which is responsible for all evaluative efforts at the university. To what extent, if at all, bibliometric analyses are included in evaluations certainly varies from discipline to discipline. The Bibliometrics Department has so far regularly been involved in three different kinds of evaluations: cyclic faculty evaluations, individual evaluations for professors 5 years after their appointment, and professorial appointment procedures.

This paper will focus on the provided bibliometric input for professorial appointment procedures (PAP). It combines a thorough description of the applied bibliometric methodology, on the one hand, and a retrospective assessment of all hitherto performed appointment procedures from 2009 to 2014, on the other hand.

Many bibliometric studies prove the efficiency of recruitment processes by comparing the subsequent research performance of the recruitment "winners" with that of competition losers and pre-existing incumbents of equal academic rank (Abramo et al. 2014). However, hardly any relevant literature could be found by the authors concerning standard procedures for bibliometric analyses in order to support the assessment of the candidates' publication output (Holden et al. 2005; Gast et al. 2014).

Certainly, individual evaluation is one of the most controversial, most cumbersome and most current topics in scientometrics (Glänzel 2008; Bach 2011). This topic was also discussed at length at the previous two major scientometric conferences, namely the ISSI 2013 and the STI 2014 (e.g. Glänzel and Wouters 2013; Wouters et al. 2013) and has led to the "Leiden Manifesto for research metrics".[2] Despite an abundance of literature, established bibliometric standards are still lacking. Many indicators haven been proposed. These range from the famous h-index (Hirsch 2005) and its hundreds of variants (Alonso et al. 2009) to field-normalised citation indicators (Schubert and Braun 1986, 1996; Costas et al. 2009) or even to recently introduced indicators such as the productivity indicator FSS (Abramo et al. 2012a, b).

Indeed, bibliometric analyses should never rely on only one particular indicator, as it is normally restricted to only one aspect. In spite of the fact that composite indicators aim to combine several aspects, they complicate rather than simplify the interpretation of the results for the target group that they addressed. Therefore, our approach offers a method that relies on a variety of basic indicators and further control parameters in order to address the multidimensionality of the problem and to foster comprehensibility.

[2] Bibliometrics: The Leiden Manifesto for research metrics (http://www.nature.com/news/bibliometrics-the-leiden-manifesto-for-research-metrics-1.17351; Accessed 15.05.2015).

Without doubt recruitment and promotion are handled differently from country to country. Our described approach has already been presented at several conferences and workshops in Germany, Switzerland, Italy and Spain, and has always been deemed to be relevant and fit for the number of candidates considered. Nevertheless universities from bigger countries like USA or China with significantly higher numbers of candidates than the University of Vienna might question the feasibility of our approach. This potential restriction will be discussed later in the "Limitations" section.

General framework

Data provided by Department for Quality Assurance

The starting point for each bibliometric support that concerns PAP is a notification by the Department for Quality Assurance about the next forthcoming evaluation, about the subject of the vacant professorship and the number of already arrived applications (which might still increase after the process has started). Application letters, CVs and publication lists of all applicants are shared electronically with the Bibliometrics Department after a formal pre-selection (i.e. applications, meeting and all formal requisites). The number of applicants finally to be analysed bibliometrically per PAP can vary from <10 applicants to >30; the typical average number is 15.

Data sources for bibliometric analyses

In principle, the Web of Science (WoS)—Core Collection is used as the preferred data source for bibliometric analyses since being indexed in this database is generally perceived as a sort of quality (or at least high visibility) criterion within the scientific community. This was corroborated by all the faculties related to the natural sciences. The current subscription to WoS at the University of Vienna comprises of the following parts:

- Science Citation Index Expanded (SCI-EXPANDED)—1900—present.
- Science Citation Index Expanded (SCI-EXPANDED)—1900—present.
- Social Sciences Citation Index (SSCI)—1899—present.
- Arts & Humanities Citation Index (A&HCI)—1975—present.
- Conference Proceedings Citation Index—Science (CPCI-S)—1994—present.
- Conference Proceedings Citation Index—Social Science & Humanities (CPCI-SSH)—1994—present.
- Book Citation Index—Science (BKCI-S)—2005—present.
- Book Citation Index—Social Sciences & Humanities (BKCI-SSH)—2005—present.

Due to the fact that not all disciplines are equally well covered in WoS, alternative data sources such as Scopus or Google Scholar are used for complementary analyses. In order to assess the activity or productivity, some other subject specific databases were occasionally considered (Chemical Abstracts, Mathematical Reviews, etc.).

Publication and document types

All publication types that appear in the list of publications delivered by the candidates are considered in the central part of the bibliometric analysis or at least in the complementary section. Document types used by the authors in their list of publications are manually

reassigned to the following standard groups: monographs (books), book chapters, journal articles, proceedings papers, conferences (including meeting abstracts and talks), reports (working papers), book reviews, edited books and journal issues, and other publications (or miscellaneous). A clear distinction between "proceedings papers" and "conferences" is not always possible when one relies on the publication lists.

Data automation is desirable, but currently no automation can deliver the same results. Therefore we attach special importance to the degree of coverage in the databases used for our analyses and match them with provided publication lists whenever possible. Automation will gain momentum once critical mass of permanent individual identifiers (like ORCID) has been implemented within the scientific community (see "Lessons learned" section).

Furthermore, all bibliometric indicators added to the publication lists by the authors themselves, such as citation counts, impact factor or h-index, are checked or recalculated in order to guarantee a correct and comparable analysis. Some analyses are restricted to peer-reviewed documents. Finally, citation analyses are performed for citable items [articles, reviews and proceedings papers (A/R/PP)] and "non-citable" items (other document types).

Normally, "non-citable" items (like editorials, book reviews, etc.) remain uncited and will negatively influence some parameters, such as the number of citations per publication (Moed 2005). However, in some special cases or in some areas, these document types can also be strongly cited. In order to consider these special cases and not to penalise any candidate, the citation standard analysis was performed for citable items (articles, reviews and proceedings) and for all the items. If considerable changes were detected, it was suggested to also consider the responsible "non-citable" items that attract a considerable number of citations.

Citation analyses for monographs are performed separately in order to avoid inconsistencies by mixing different metrics (Gorraiz et al. 2013). If appropriate and desired by the commission, further document types such as patents, e-publications, articles in newspapers and so on are also taken into account.

Publication and citation window

In general, the last ten complete years constitute the standard publication window. This decision has been taken in agreement with the commission and ensures that young scientists are not discriminated against, in favour of senior scientists. Additionally, the complete retrospective publication record as well as any submitted or "in press" material is considered in the complementary analyses (additional data). And citations are taken into account until the date of analysis, which guarantees the same citation window for all candidates.

Methodology

General approach

The Bibliometrics Department of the University of Vienna regularly provides its PAP-related input for stakeholders, who normally have no scientometric background and therefore desire to grasp the outcome of the undertaken analyses as quickly as possible. In

order to comply with this requirement and to increase the willingness to deal with the bibliometric data, the Bibliometrics Department avoids using composite indicators and instead prefers very basic ones, which are easily understood.

Furthermore, in order to consider the skewness of most of the citation distributions (Seglen 1992), three indicators are used to describe the distribution of journal impact measures and citations: the total sum, the arithmetic mean and the maximum.[3] Moreover, bibliometric standard analyses are always complemented by additional analyses, which rely on control data and additional data. "Additional data" help us to get a broader picture (extension of the publication years, consideration of a broader number of document types, etc.) whereas "control data" are helpful to make correct comparisons and to provide more accurate interpretation of the standard analyses.

The number of co-authors is a good example for control data. It is useful to assess the productivity or activity of each candidate. If candidate x has published twice as many articles than candidate y, but x has also twice as many co-authors than y, this latter information certainly puts productivity into perspective again and helps to get a more meaningful interpretation. On the other hand, the extension of the citation analysis from the last 10 years to the overall career time rather qualifies as additional data.

Finally, three further sections, containing "special comments", comparisons between different data sources, and network analysis of the candidates, are added to the report.

The bibliometric standard analyses are all performed in due consideration of the agreed 10 years publication window and differentiate between citable (articles, reviews and proceedings papers) and non-citable items. As it is already a well-established practice at the University of Vienna (Gumpenberger et al. 2012), the bibliometric standard analyses are meant to shine a light on three different main aspects:

- Activity: the number of publications along a timeline and with differentiation of document types to reflect the productivity (Lotka 1926; Shockley 1957).
- Visibility: prestige and impact of the journals where the candidates have published in, according to their impact factor (Garfield 2005; Glänzel and Moed 2002) or other alternative journal impact measures such as SCImago journal rank (SJR) (Gonzalez-Pereira et al. 2009) and source normalised impact per paper (SNIP) (Moed 2010, 2011) in order to reflect the editorial barrier and to unveil publication strategies.
- Impact: the number of citations, including several citation indicators to reflect the significance in the scientific community (Cronin 1984; Moed 2005; de Bellis 2009; Vinkler 2010).

In many bibliometric and scientometric analyses, visibility and impact are indistinctly used, even often as synonyms, leading to misunderstandings and interpretation errors. Visibility and impact are the two faces of the coin that represent the "value" of a publication.

The visibility of a document is determined by the reputation or the impact of the source where it was published. It reflects the editorial barrier and unveils publication strategies. For a journal article, the visibility can be determined by the impact measures of the journal it was published in. The most commonly used impact measure is the journal impact factor (IF). Thus, a document has a high visibility in one research field if it was published in a journal with an IF bigger than the aggregate or the median IF of the corresponding subject category or field. Therefore, visibility can be quantified by the IF of the source in relation to the aggregated or median IF assigned to the corresponding subject category.

[3] The standard deviation is provided only upon request.

The IF is an appropriate measure for the visibility but only for journals indexed in journal citation reports (JCR). Other recent alternatives are based on the widely known PageRank algorithm of the Google search engine—for example the article influence score or the SJR indicator. SJR and SNIP refer to journals indexed in Scopus, which results in an enlargement of the "visible" journals to almost 19,000 journals.

The impact of the document itself is not determined by its visibility (or the impact factor of the journal—a very common error) but instead by the number of citations received—that is, the resonance that this publication has obtained in the scientific community. The number of citations being an absolute value means nothing if they are not related to a predefined environment (for example, a subject, a group of publications or a journal set). The most appropriate way to normalise citation counts is on a disciplinary basis. Web of Knowledge (WoK) offers within its analytical tool "essential science indicators", a special section named "baselines by averages or percentiles", which provides a quick overview of how to measure the impact of a publication by taking into account the publication year and the varying citation rates across fields. "Baselines by average" gives the number of times an average paper is being cited depending on its publication year (for the last 10 years) and on its subject field. In contrast, the table of percentiles shows how many citations a paper requires to belong in the top 0.01, 0.10, 1.00 and 10.00 % percentiles, respectively.

Citation counts are an accepted proxy for impact; however, normalisation is needed according to discipline and per publication year. Our multifaceted approach is based on the usual indicators (citations, citations per publication, maximum of citations, h-index and i-index) and also incorporates normalised citation counts in the form of percentiles top 10 % and top 1 % (Adams et al. 2007; Gorraiz et al. 2011, 2012a; Bornmann et al. 2012). Top 10 % is used in order to assess the degree of excellence and top 1 % allows a further differentiation between highly cited ("excellent") and extremely high—cited publications ("edgy" *publications).*

Collaboration analyses were only reported in the special comments section if the committees explicitly required them. They aim to inform about the degree of internationalisation and are performed by analysing the number and percentage of countries in the affiliation field.

Table 1 Publication spectrum based on publication lists for three PAP candidates (WoS coverage in parentheses)

Candidate no.	1	2	3
1st pub year	1996	1990	2002
Books	13	2	0
Edited books/issues	7	4 (2)	0
Book chapters	12 (4)	25 (6)	5 (1)
Proceedings & conference papers	26 (1)	17	70
Book reviews	0	0	0
Miscellaneous	0	29	0
Journal articles (JA)	35	19	19
A-R-PP	32	14	19
% WoS coverage (only peer review JA)	73.81 %	64.71 %	63.33 %

Table 2 Data collected for each candidate in order to assess the WoS publication activity

Standard analysis								
Activity								
Year of the first publication in WoS	Last 10 complete publication years							
	Document type (DT)							A/R/PP per year
	Total	A	R	PP	EM	MA	other	A/R/PP
	Control data							
	Mean # co-authors/paper			% single, 1st, last or corresponding author			% WoS coverage	
	Additional data							
	(# in press not yet in WoS, or most recently in WoS)			# publications (all years, all document types)			# A/R/PP (all years)	

All the results from the standard analyses including control and additional data were delivered to the committees in the form of a report and corresponding Excel-tables. The candidates were primarily ranked according our recommendations (see "The "top counts approach"" section) but committees always had the possibility to sort and rank them by their own criteria or even by each indicator.

The report itself painted a clear picture using different figures for each candidate according to different aspects.

The main aspects will now be described in more detail.

Activity

Initially, a general analysis is performed based on the provided publication list in order to get an idea of the publication spectrum. This is compared to the coverage in WoS for each candidate and all publication years. Table 1 provides one example. The activity or productivity is measured by absolute output values—that is, normal counts. The percentage of WoS coverage for all articles in peer-reviewed journals is also calculated (see the last column of Table 1).

The following publication types can generally be included depending on disciplinary characteristics or the spectrum given in the provided publication lists: journal articles, monographs or books, book chapters, edited books or journal issues, proceedings papers and conference papers (including meeting abstracts and talks), book reviews or any other publication types (combined under miscellaneous).

Reports or working papers and patents are included whenever appropriate, mostly for disciplines related to physics, the life sciences or technology. Some other publication types receive special attention according to their disciplinary importance, such as proceedings papers in computer sciences or book reviews in the social sciences.

Once all relevant document types have been determined, the WoS activity of each candidate is analysed in more detail for the last 10 complete years (see Table 2). The following document types were counted separately: articles (A), reviews (R), proceedings papers (PP), editorial material (EM), meeting abstracts (MA) and other. Book chapters were considered as articles. Books or monographs and edited books were considered separately (see Table 1). The counts for A, R and PP are summed up to build the "A/R/PP activity indicator" (# A/R/PP = number of citable items). Additionally, the "number of citable items per year" was calculated for the last 10 complete years. The calculation of the indicator A/R/PP per year considers only the time period after the first publishing year.

Table 2 shows the indicators and parameters used for the standard analysis as well as additional and control data, all of which were used in the assessment of the activity or productivity of each candidate. The standard analysis was performed for an agreed-upon 10-year publication window The number of current publications (most recent year = last incomplete year), the number of publications either in press or not yet indexed in WoS and the total number of publications and citable publications during the overall academic life are included as additional data. The first publication year is always considered in the standard analysis in order to quickly distinguish between junior and senior scientists.

The WoS coverage percentage, the number of co-authors per paper and the percentage of single/first/last/corresponding authorship are both included as control data. The number of co-authors per paper is deemed to be a better alternative to fractional author counting (simple vs composite indicators and normal vs fractional counts) and allows a better understanding of the publication habits in the given discipline (see Table 2) (Laudel 2002; Persson et al. 2004).

Table 3 Data collected for each candidate in order to assess visibility

Standard analysis				
Visibility				
JIF			JIF quartiles	
A/R/PP only			A/R/PP only	
Sum	Per A/R/PP	Max	#Q1	% Q1
Control data				
First research field				Second research field
WoS category	JIF median	JIF aggregate	WoS category	
Additional data				
JIF				
All DT				
Sum		per publ		Max

The relevance of the percentage of first/last/corresponding authorship was illustrated by one of our case studies. The candidate with the highest activity, visibility and impact was in <15 % of his or her publications first/last/corresponding author. This information was well appraised by the commission.

Concerning the activity, an additional analysis was provided, hinting at an extremely high rate of co-authorship with the same author (>75 %). Co-authorship with the same author provides information about an author's publication style and co-authorship behaviour. If a candidate tends to always publish with the same co-author, this could probably keep him/her from either becoming a successful single author or from finding new collaborators. This supplementary information, which revealed the "co-author" dependence (Glänzel 2014), was supplied in the section "comments".

Furthermore, timelines of the activity in the last 10 years (increasing, decreasing and constant) in WoS are supplied as supplementary information in order to identify fluctuating trends. This information could reveal affiliation changes, sabbatical leave or other changes influencing the activity of the candidates.

Visibility

Visibility analyses are performed for publications in journals indexed at least in Thomson Reuters' JCRs with a journal impact factor (JIF) or in Scopus with an SJR or SNIP for the last 10 complete years. The JIF of the most recent JCR edition is used for all analysed publications as an accepted compromise since applying the corresponding JIF to each publication year is not completely correct either[4] (delay of the JCR edition + delay of 2 years in the calculation of the IF) (Gorraiz et al. 2012b).

Visibility analyses are generally performed for citable items in the standard analysis (see Table 3), but they can be further expanded by applying the indicators "JIF sum", "JIF

[4] Alternatively, one could use the mean JIF value of the last 10 JCR—Editions.

per publication" and "JIF max" to all document types instead of to only A/R/PP. This serves the purpose of obtaining additional data for the remaining document types (see "Additional Data" in Table 3). Whenever considerable differences between the results in "all document types" and "citable items only" are observed, the responsible document types need to be analysed in more detail and are further explained in a special comments section.

Moreover the number of publications is determined for JIF quartile Q1 (top 25 %) according to the corresponding WoS category. The percentage of Q1 publications is then calculated.[5] All obtained Q1-related data are included in the standard analysis (see Table 3).

Last but not least, the visibility analysis is complemented by "control data" informing about the candidate's first and secondary research field (see "Control Data" in Table 3) in order to consider significant differences in the candidates' research fields. This approach is based on the WoS classification system and is applied to the agreed-upon 10-year publication window. For the first research field, the JIF median and the JIF aggregate values are provided for the corresponding category.

In disciplines where the coverage in WoS and Scopus is known to be low, such as in the social sciences, mathematics and the computer sciences, committees and faculties have the possibility to provide self-compiled lists of "highly" reputed journals in their discipline. In such cases, the number of publications in these selected journals is calculated.

Visibility analyses for publication types like edited books or monographs are highly controversial. None of the so-far suggested alternative approaches (e.g. use of highly reputable editorials as visibility criterion) has proven to be suitable for PAPs.

Impact

Impact finally relies on citations as proofs of recognition within the scientific community. Citation analyses for publications in journals are commonly performed in the source part of WoS. In the humanities and the social sciences, the "cited reference search" is also used in order to collect citations to other document types that are not indexed in the source part of WoS. Citation analyses for non-A/R/PP document types depend on a meaningful number of such available publications. For example, citation analyses for monographs that use the book citation index and the "cited reference search" in WoS are performed separately and presented as "Additional Data".[6] Google Scholar (via "publish or perish" and/or Google Scholar Citations Profiles) can also be considered if requested by the commission. Google Scholar has so far been used in an exploratory way for the humanities and the social sciences.[7]

Comparable to the previous approach explained for the visibility aspect, again a sum value, a value per publication and a maximum value of the citations received are determined in the standard analysis. "Citations sum" is the total number of all citations received for the analysed A/R/PP record. "Citations per publication" is calculated by dividing

[5] Q1 publications are publications in journals that are ranked in the top 25 % of the assigned category or categories in JCR according to the JIF.

[6] A paper dealing with these aspects and summarizing the results has been accepted for the forthcoming edition of the ISSI Conference 2015 in Istanbul "Exploration of the bibliometric coordinates for the field of 'Geography'.

[7] Ibid.

Table 4 Data collected for each candidate in order to assess impact

Standard analysis									
Impact									
# A/R/PP last 10 publication years (PY)								All DT last 10 PY	
Received citations			# top 10 %	% top 10%	# top 1 %	% top 1%	h-index		
Sum	Per publ	Max							
Control data									
All DT last 10 publication years % Self-citations									
Additional data									
All DT last 10 publication years			All DT all publication years						
Received citations			Total # citations	h-index	i-50	i-100			
Sum	Per publ	Max							

"citations sum" by "# A/R/PP". "Citations maximum" reflects the value for the publication which has attracted the most citations.

The impact aspect can as well be expanded by applying "Citations sum", "Citations per publication" and "Citations maximum" to "All DT" instead of the restricted "A/R/PP" set (see Additional Data in Table 4). In case considerable differences between the results in "A/R/PP" and "All DT" are observed, the responsible document types are analysed in more detail and the findings are presented in a "Selected Comments" section.

Moreover, the h-index is determined for all document types and the agreed-upon 10-year publication window as well as the number and the percentage of the top 10 % (10 % percentile) and of the top 1 % (1 % percentile) of the most cited papers in the corresponding essential science indicators (ESIs) category and publication year (see "Standard Analysis" in Table 4).[8]

In order to also reflect a candidate's complete publication record (total output, all publication years) and its resulting impact, the total number of citations and the total h-index of all publications types for all publication years are included as "Additional Data". Furthermore, in this case we are using as additional data the number of publications with at least 50 or 100 citations (i50-index and i100-index, Google Scholar Blog 2011). This is done in order to assess the excellence and to consider the skewness of the citation distribution, which is not sufficiently reflected in the h-index. Last but not least publications with at least 500 and 1000 citations are mentioned in the special comments.

It should also be considered that the "i-index" thresholds are determined according to the expected number of citations for each discipline. Therefore, in the social sciences, the i10-index and the i50-index are common instead.

[8] The same analysis can also be performed by using the percentile values from Incites (WoS Category, fractional count) with no considerable differences. Nevertheless, the suggested approach above guarantees the same thresholds for all applying candidates within a specific PAP. Distorting field differences are considered in Table 3 (Additional Data).

slightly decreasing but very high WoS activity (8 per year); one publication with > 1000 citations; 13 publications with > 100, high degree of internationalisation; top productivity, top visibility and top impact; highest number of co-authors; however, single, first, last or corrresponding author (no alphabetical order) in only 14% of the publications; focus on "XXX" (Research Field)
increasing and high WoS activity (6 per year),1 publication with > 400 citations; four with > 100, highest visibility, top impact, low number of co-authors (~4) in comparison with other top candidates, singlefirst, last or corrresponding author in ~50% of the publications, high degree of internationalisation
steadily increasing WoS activity due to high average of citable documents per year (~10), ~40 publications in 2013!; two publications with > 500 citations; four publications with > 100 citations, lower visibility in comparison to other top candidates; top impact; large number of co-authors (>7); single, first, last or corrresponding author in ~50% of the publications; high degree of internationalisation
longest activity in WoS (since 1985); steadily increasing WoS activity due to highest average of citable documents per year (~14); two publications with > 500 citations; 5 publications with > 100 citations; lower visibility in comparison to other top candidates; large number of co-authors (almost 9); single, first, last or corrresponding author in ~34% of the publications, high degree of internationalisation
constant activity in WoS (2-3 citable items per year); one publication with > 400 citations; seven publications with > 100 citations; high visibility, high percentage of top 10% publications; highest i50-index; low number of co-authors (~2); single, first, last or corresp. author in 80 % of the publications; low degree of internationalisation
sharply increasing activity in WoS (7 citable items per year); one publication with > 200 citations; six publications with > 100 citations; highest number of publications in Q1 journals; high impact (h-index); large number of co-authors (almost 9); in ~40% of the publications single, first, last or corrresponding author in ~40% of the publications; high degree of internationalisation

Fig. 1 Example for the section "Selected Comments"

Finally, the percentage of self-citations (Glänzel et al. 2004, 2006) for the agreed-upon 10-year publication window is calculated and included as "Control Data" (see Table 4).

Selected comments

Our analysis also comprises the "Selected Comments" section, which is intended to provide information about any observed peculiarities in the main or additional analysis. Such comments would address the following, among other things:

- Deviations or discrepancies resulting from the control or additional data (e.g. self-citations, different main focus with lower or higher aggregate IF, document type with an expected high number of citations, etc.).
- Activity trend lines for the last 10 years.
- Degree of internationalisation (considering the number of countries in the affiliations).
- Co-authorship with the same author (>70 %).

Figure 1 shows a few examples for such selected comments.

Comparison between data sources

Furthermore, the total number of publications, total number of citations, citations per publication and h-index are compared at least in WoS and Scopus. Pearson correlations are calculated and major discrepancies are both analysed in order to avoid significant omissions or incorrect information in the data sources for all candidates for each appointment procedure. Our results have so far shown a very high correlation (>0.9) between WoS and Scopus and a moderate correlation between WoS and Google Scholar as well as between Scopus and Google Scholar.

The "top counts approach"

The Bibliometrics Department pursues the "top counts approach", as it is called: first, it is assessed for who is among the top five values for each applied indicator per analysed aspect; second, the number of top five counts is determined for each applicant and used in an overall comparison of the candidates. In the cases of PAP with fewer than ten candidates, only the top three values are determined.

The following indicators are taken into account for the "top counts":

- Sum of citable items (# A/R/PP) in the agreed-upon 10-year publication window.
- Mean value of citable items per year (# A/R/PP per year) as shown in Table 2 (in red font).
- All the data collected in the standard analyses that considered the visibility and impact aspects (see Tables 3 and 4).
- All additional data collected for the impact analysis referring to all the publications years (complete output for each candidate). This should avoid disadvantaging junior researchers in comparison to senior colleagues.

Our approach enables to rank the candidates according to our recommended top counts, which results in a list of top candidates based on bibliometric criteria.

If the number of candidates is big, a hypothetical "average" candidate (mean values of each indicator or parameter) or the standard deviation can of course be calculated easily, but neither option was ever requested by any commission.

The obtained results are always discussed with the commission. According to the committee's preferences, it is possible to pick and choose from the spectrum of indicators. These should finally be used for the "top counts" calculation. For example, if monographs or patents are considered important document types, the corresponding indicators will definitely be considered for the "top counts".

Network analysis of the candidates

All publications are exported from the corresponding database for all candidates. Hence, an author network is produced in order to get a quick picture of the cooperation intensity between the candidates (see Fig. 2 for an example). For this purpose, BibExcel (Persson et al. 2009) and Pajek (De Nooy et al. 2005) are used as visualisation tools. The strong point of BibExcel's is the high flexibility regarding data management and data analysis: (1) the ability to work with different data sources, such as WoS and Scopus; and (2) the ability to produce output that can be further processed by other tools, such as Excel, SPSS, Pajek, etc.

Further advantages are: open source, easy operability, many interesting applications and additional features and, finally, optional data cleaning at different stages. The resulting cluster maps (see Fig. 2) can help the commission in selecting the top three interviewees (either central or cluster connecting candidates).

Data and figures for Vienna University PAP

From 2009 until the date of this publication, the Bibliometrics Department has contributed to 14 PAPs: 2 PAPs led to no appointment, 1 PAP was never completed and 1 PAP resulted in a new one. For privacy reasons, all data can be reported in only an anonymous form.

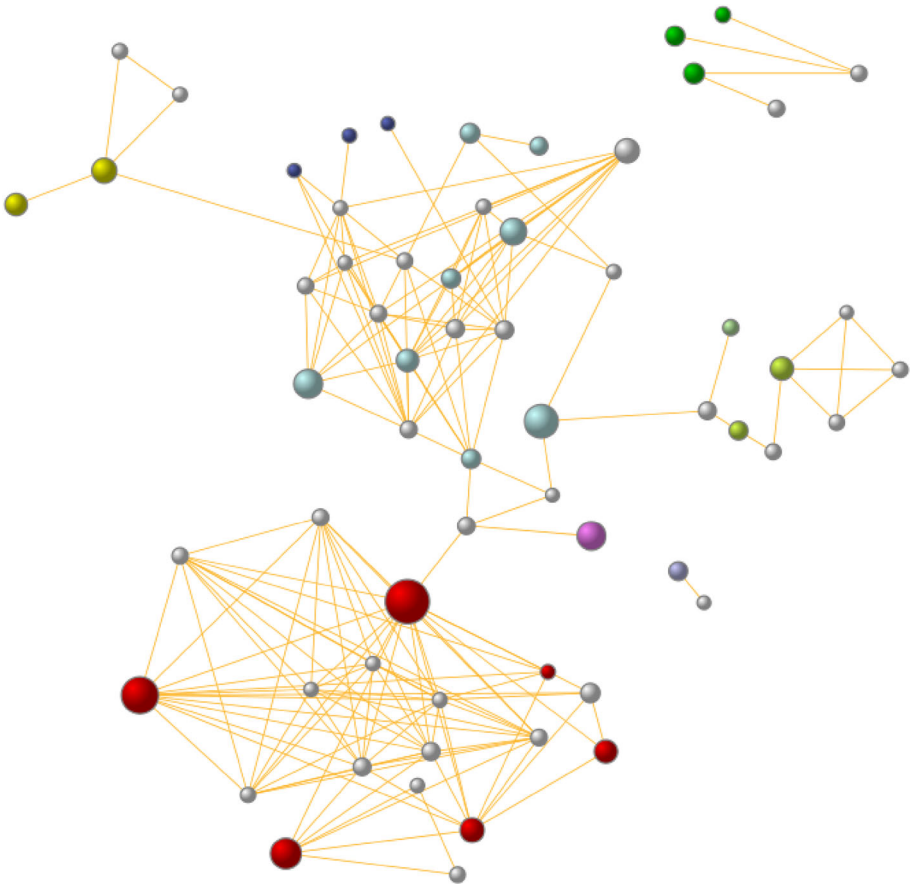

Fig. 2 Example of a candidate network. Different clusters in *different colours* can easily be identified, which allows the assessment of the candidates' cooperative interaction. Co-authors of candidates are indicated in *grey*. (Colour figure online)

Therefore, it is also not possible to disclose the detailed subjects of the vacant professorships, but instead, it is possible to assign them to high-level categories such as the life sciences ($n = 9$), the earth and environmental sciences ($n = 4$) and the social sciences ($n = 1$). Overall, 221 candidates were analysed bibliometrically. Top candidates were finally available for only 12 PAP.

The bibliometric analyses were generally performed within two or three weeks by two colleagues from the Bibliometrics Department, depending on the number of candidates (from nine to 33). Most of this time was spent on thorough data disambiguation and data cleaning. Candidates with implemented personal identifiers such as ORCID (Open Researcher and Contributor ID) or Thomson Reuters ResearcherID were definitely quicker to assess, as long as these profiles were regularly updated. Five PAP were still ongoing while this study was completed.

Retrospective PAP analysis

In order to judge the usefulness of the bibliometric support provided for PAPs, a retrospective analysis was done in two steps. First, the head of each professorial appointment committee was surveyed to gain insight into its usefulness. For life sciences, all respondents agreed that the provided bibliometric expertise was not only useful for the overall decision process but also helpful for understanding the publication habits in the given discipline. For earth and environmental sciences as well as social sciences, the usefulness was less obvious and sometimes questioned due to the low coverage of the candidates' publication output in the traditional citation data sources (Web of Science and Scopus). The Bibliometrics Department was then encouraged to explore complementary data sources (such as Google Scholar) and metrics (such as usage metrics and altmetrics).

Second, the overlap of the short-listed top candidates by appointment commissions with the bibliometrically identified top candidates was analysed. For all 12 PAPs with available short-listed top candidates, there was at least one identical candidate in the top three; for six PAPs, the overlap was even bigger, with two identical candidates. For six PAPs, two short-listed candidates were not among the bibliometric tops, whereas for the other six PAPs, the same was true for only one candidate. For three PAPs, the first ranked short-listed candidate was also the first ranked bibliometric top candidate, and for five PAPs, the first ranked short-listed candidate was either ranked second or third as a bibliometric top candidate. However, for six PAPs, the first ranked short-listed candidate was not even among the bibliometric tops.

Regarding final appointments, for only one PAP, the first ranked short-listed candidate was also the first ranked bibliometric top candidate and was finally appointed. In contrast, for another PAP, the first ranked short-listed candidate was not among the bibliometric top candidates and was still finally appointed.

Lessons learned

This study shows the benefits but also the limitations of bibliometrics as an evaluative method. Quantitative aspects were measured, which are for themselves certainly objective but are never meant to be taken out of context. Each person has a particular history and individual skills. Thus, it is impossible and inappropriate to simply base decisions on measureable objective aspects. This should always be taken into account whenever peers are responsible for deciding on the future career path of scientists.

Professorial appointment decisions ultimately depend on who fits best in the vacant position. Sometimes committees favour a highly respected and well-experienced senior scientist with high visibility and impact, but sometimes they are looking for quite the opposite, specifically a productive, visionary newcomer with the ability to implement new approaches. Who is "best" depends on the strategic alignment of the hiring research group, department or faculty.

Bibliometrics is helpful to identify desired strengths and undesired weaknesses within the candidate portfolio, provided that these analyses are carried out by experts.

Self-reported bibliometric data in candidates' applications are perhaps not useless, but they need to be controlled due to their subjective nature. And such control mechanism normally requires as much time and effort as self-calculation. Reliable bibliometric

analyses can only be performed based on objective data, following the same standards and conditions.

However, it can never be assumed that all candidates have access to the same databases. Nor will they use the same windows and standards (see for example, Bar-Ilan 2008). Therefore, calculations occur in different data sources using different citation and publication windows and consequently do not allow sound comparisons between candidates.

It is of course true that self-assessments of academics are a usual practice all around the world, including top universities and also still including the University of Vienna. Candidates submit their applications and CVs with self-appraisals, which often also include self-reported bibliometric information. However, they would probably refrain from doing so if standard bibliometric analyses or reports were implemented at the universities of application.

These data cannot be used, and candidates should definitely be discouraged from these practices in the application guidelines. They should also refrain from the self-distinction of peer-reviewed vs. non-peer-reviewed publication output since experience has shown that candidates do not or cannot always use the same criteria, standards or data sources. Aim of this publication is also to launch a discussion in the community in order to avoid subjective and wrong bibliometric practices.

Instead, application guidelines should require the strict assignment of the candidate's publication output to given document types, which would be highly appreciated by all bibliometricians, who generally spend a considerable amount of time on this task. It is advisable to clearly differentiate between the following publication types: books or monographs, edited books and journal issues, chapters in books, articles in journals, proceedings papers, patents, book reviews, reports and workings papers, meeting abstracts, talks and other publications (in newspapers, on the Internet, etc.).

Finally, application guidelines should encourage and recommend the use of a correctly updated personal identifiers such as ORCID or ResearcherID.

Conclusions

The suggested bibliometric approach offers several advantages:

- It avoids complicated composite indicators and instead relies on single indicators, which are particularly easy to understand for peers in appointment committees.
- Its multidimensional approach sheds light on various aspects, such as coverage, activity, visibility and impact, and it thus paints a diverse picture of an assessed candidate.
- The top counts give the peers some flexibility in placing their preferred focus.
- The standard analysis is always performed for the last 10 complete years. This ensures that young scientists are not discriminated against, in favour of senior scientists.
- Occasionally used control and additional data foster a better understanding of disciplinary publication habits and help to reveal concealed aspects (degree of co-authorship; percentage of first, last or corresponding authorship; activity time lines; degree of collaboration; degree of internationalisation; individual publication strategies; etc.).
- The practised comparison of different data sources is definitely helpful to identify and correct indexing and coverage errors.

- Finally, candidate network maps help the commission to quickly grasp the interconnectedness of the candidates and to identify relevant clusters.

In the event of a much higher number of applicants, concise descriptive statistics, including at least average and standard deviation values, should be added in order to foster data interpretation by the appointment committee.

Bibliometric support was highly appreciated by all appointment committees and usefulness was confirmed in the life sciences in particular. It is difficult to tell to what extent bibliometric input has finally influenced the decision-making process in the explored Vienna University PAP, but there certainly is an undeniable overlap between the committees' designated top candidates and the bibliometric top candidates.

Bibliometrics can and should be used only to complement peer review. Neither bibliometrics alone nor peer review alone can paint a complete picture. This is possible only if both are combined into the "informed peer review", as it is called. Routine bibliometric analyses provided by experts should become a standard in application procedures in order to avoid amateurish bibliometric practices by peers as well as final decisions based on solely subjective criteria and processes.

Limitations

One possible limitation of our approach is a restricted applicability to countries, which handle recruitment and promotion in a similar way as Austria. In bigger countries, like for example USA or China, where the number of applicants can be significantly larger than in our approach, its feasibility could be questioned.

However, if the number of candidates remains too large, the commission will be obliged to consider more selective application criteria that allow pre-selection, e.g. minimum number of academic activity, minimum number of peer-reviewed publications, focus on a more specific research field, etc.

Once again it is stressed that the bibliometric report can only be part of the overall informed peer review process; nonetheless it is an essential one. Certainly no commission will have the resources to analyse such large numbers of candidates solely based on a qualitative approach.

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