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Expert-based versus citation-based ranking of scholarly and scientific publication channels

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ABSTRACT

The Finnish publication channel quality ranking system was established in 2010. The system is expert-based, where separate panels decide and update the rankings of a set of publications channels allocated to them. The aggregated rankings have a notable role in the allocation of public resources into universities. The purpose of this article is to analyze this national ranking system. The analysis is mainly based on two publicly available databases containing the publication source information and the actual national publication activity information. Using citation-based indicators and other available information with association rule mining, decision trees, and confusion matrices, it is shown that most of the expert-based rankings can be predicted and explained using automatically constructed reference models. Publication channels, for which the Finnish expert-based rank is higher than the estimated one, are mainly characterized by higher publication activity or recent upgrade of the rank. Such findings emphasize the importance of openness of information on a ranking system, with its multifaceted evaluation.

1. Introduction

The quality or impact of a publication channel (i.e., source of publications) can be used for many purposes. Traditionally, the impact of a serial has been used to determine the most important sources of disciplinary knowledge to be acquired for the university libraries – nowadays in digital form. Another, more recent function is to use the research output of universities to evaluate their operational performance through a Performance-based Research Funding System (PRFS). Currently, in many countries, PRFSs have a prominent role in national resource allocation (Abramo & D'Angelo, 2015; Auranen & Nieminen, 2010; Fairclough & Thelwall, 2015). According to Hicks (2012), a PRFS can utilize either an evaluation-based (peer-review) or an indicator-based (bibliometric) model. The prime example of the evaluation-based model was the emergence of the *Research Assessment Exercise* in 1986 and its transformation to *Research Excellence Framework* in England (Wilsdon et al., 2015). For indicator-based models, which are of the main interest here, one has witnessed a transition from the raw numbers of different kinds of publications (e.g., books, articles, and reports) towards their aggregated quality indicators (Haustein & Larivière, 2015). Here an important lesson comes from the *Composite Index* (CI) that was implemented in Australia in 1995, where university funding was based only on the number of publications. However, as shown by Butler (2003), this mostly led to a higher publishing activity in lower quality journals so that the overall impact of the publications dropped. As a

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result, the national PRFS (*Excellence for Research in Australia 2012*) uses both indicators and peer evaluation by an evaluation committee (Vanclay & Bornmann, 2012).

National allocation of research funding using solely an indicator-based model is not common (Hicks, 2012). The PRFS in Flanders (Belgium), as depicted in Verleysen, Ghesquière, and Engels (2014), provides one example, where one of the four pillars of funding for the Flemish universities is based on publications and citations. The Italian research assessment exercise (*Valutazione della Qualita' della Ricerca*) first applied a hybrid peer-review/bibliometrics method during 2004–2010 (Giovanni, Tindaro, & D'Angelo, 2014), and in 2011, introduced a model in which universities were free to choose between peer-reviews and bibliometric indicators as their research evaluation method (Cattaneo, Meoli, & Signori, 2014). The research funding evaluation methodology in Czech (*Metodika hodnocení*) counts all research outputs – among them publications – and then uses aggregated research output points as the basis for the university funding (Good, Vermeulen, Tiefenthaler, & Arnold, 2015). Generally in Europe, as recently summarized by Pruvot, Claeys-Kulik, and Estermann (2015), an output-oriented funding formula as the primary mechanism for research funding is used in England, Finland, Flanders, Ireland, and Poland.

The Nordic system, together with that of Flanders, is distinguished from the other indicator-based PRFS models by the development of open, full coverage national databases in order to record and validate academic publication activity (Verleysen et al., 2014). These databases provide the first basic element of the so-called *Norwegian Model* (NM) that has been described by Ahlgren, Colliander, and Persson (2012), Sivertsen (2010), and Schneider (2009). The main purpose of the NM is to combine (assess) production and quality of publications, without directly using citations. The purpose of the other main components of the model is to create a unified ranking system among various academic disciplines. Finally, the publication points counted using the aggregated ranks determine the university's share in annual government research funding. According to a recent evaluation by Schneider, Aagaard, and Bloch (2015), the NM has proved to serve its purposes in Norway. In particular, in comparison with the above mentioned CI in Australia, the quantity of publications has grown, while the overall quality of publications remained basically the same (Ahlgren et al., 2012; Schneider et al., 2015).

The other two Nordic countries – first Denmark (Schneider, 2009) in 2009, and then Finland (Puuska, 2014, pp. 81–83) in 2010 – have introduced their national PRFSs that follow the NM. Similarly to Norway, the main reason to creating a unified national ranking system in Finland for all relevant publication channels was the difficulty in using available quality indicators to compare the various research and publication cultures of different disciplines (e.g., comparing humanities or social science (SSH) to technology or natural science). The purpose of the Finnish database, *JuFo*[1] is to highlight for the national scientific community the characteristics of all relevant publication channels. Currently, 13% of public university funding in Finland is based on the average weighted sum of quality ranks of all the publications that were produced over a period of three years. The national goal is to target research activity in prestigious international forums, and to enable national evaluation and management of research activities and quality over the years. Hence, *JuFo* serves in Finland both as an available indicator of the quality of publication channels and as a guideline for allocating funding to its national research institutions.

Generally, the quality of a publication channel can be evaluated by an expert in that channel's area of academia (expert-based), or by citation-based indicators of scientific impact (Ahlgren et al., 2012; Ahlgren & Waltman, 2014). The classifications of publication channels in *JuFo* – i.e. the Finnish ranks – are expert-based, like they generally are in the NM as well. Though citation-based indicators can be used as an aid in the NM, the final decisions about the ranks should be made by experts (Sivertsen, 2010). In February 2015, *JuFo* incorporated 29,443 different publication channels, assigning every journal and conference proceeding publication channel to one of 24 expert panels. Each of these 24 panels is composed of experienced and respected Finnish researchers in different scientific fields (all fields can be found in Table A.12). A steering committee allocates publication channels to the panels and provides common ranking rules.

Although the PRFSs of the three Nordic countries following the NM are fairly similar, some crucial differences exist. The Danish and Norwegian PRFSs have the same number of quality ranks: 0 (non-scientific publication channel), 1 (scientific publication channel), and 2 (publication channel with especially great scientific prestige). In both countries, the ranks are updated annually. Publication channels at rank 2 can, at most, account for 20% of the world's publications in a discipline. In Finland, each expert panel must classify all assigned publication channels to one quality category. However, unlike the Norwegian and Danish PRFSs, in Finland, the number of publication channels (not the number of publications) is used to define the quality ranks percentages. Moreover, the Finnish *JuFo* system has one additional rank, (3), which is reserved for the top (at most 5%) of the rank 2 publication channels from each discipline. An additional difference is that in Finland, the ranks of all publication channels in the list are reevaluated only every fourth year. The last reevaluation of all publication channels took place during 2014, and were available in the *JuFo* list in early 2015.

The purpose of this paper is to analyze the expert-based ranks in the *JuFo* list. At the moment, the state covers all costs associated with the publication forum, its management, and the evaluating panels. Furthermore, as argued by the Danish Centre for Studies in Research and Research Policy (2014), one weakness of an indicator like the *JuFo*-rank is the lack of transparency in the nomination process of the steering committee and the panels. As Serenko and Dohan (2011) discovered, an expert's current research interest can strongly influence his or her ranking of publication channels. Therefore, our basic research questions are:

[1] *JuFo* is the abbreviation of "Julkaisusfoorumi", which means "publication forum" in Finnish.

(*i*) Do we need the system in its current form, or can the ranks be automated by rules using available information?
(*ii*) Can possible deficiencies in rankings be linked to certain characteristics of the decision-making process or the decision makers?

The similarity of the Finnish system to that of Norway and Denmark implies that the present study compares expert judgment on the individual publication channel level across three countries, which involves, as far as we know, a novel research setting. As a result, the main question of the present study – following the research track of the previous studies by Ahlgren et al. (2012), Ahlgren and Waltman (2014), and the Danish Centre for Studies in Research and Research Policy (2014) – is to address the two basic approaches for evaluating publication quality: expert-based versus citation-based publication channel ranking.

We propose to answer the research questions by linking two publicly available national datasets to external reference measures retrieved from Thomson Reuters' Journal Citation Reports® and Scopus®. We argue that repeatable patterns and rules, based on available relevant information, can be used to modify the entire ranking system, using central decision making to improve ranking efficiency and transparency. Thus, automatic and repeatable rules would help to open up the nomination process, assist panel members in their decision-making, and possibly save work and costs related to the system. Notably, studies that discuss automatization of expert judgment in research evaluation on the basis of advanced methodology and large datasets presently have a broad interest in research policy (Wilsdon et al., 2015).

In the existing quantitative evaluations of expert-based rankings (e.g., Ahlgren et al., 2012; Ahlgren & Waltman, 2014; Vanclay, 2011), typically a small set of citation-based indicators are linked to the expert-based rankings. This means that only those publication channels that have a reference citation-based indicator can be assessed. Here, our goal is to enlarge (even maximize) the coverage of each expert-rank evaluation by incorporating into it more explanatory variables (metadata) and involved data analysis techniques than existing studies do. For instance, the binary information concerning whether or not certain citation-based indicators are available has clear relationship to the ranking, as will be evident later on. Therefore, our contributions are two-fold: First, we address the broad international relevance concerning the question of expert-based versus citation-based publication channel rankings. Second, we use a novel methodological approach combined with available data from large datasets to analyze the expert-based decisions.

The structure of this paper is as follows: First, we describe the *JuFo* data and its available attributes (Section 2). Second, we present our overall analysis method (Section 3), which is based on triangulated (Bryman, 2004) machine learning techniques. Third, we present how well the rules we identified can predict the Finnish expert-based ranking (Section 4). Moreover, we characterize the publication channels that are misclassified when the aforementioned rules are used. Finally, overall patterns and findings are presented in Section 5.

2. Data

The data for this study comes from three sources:

1. *JuFoDB*: Database of the Finnish publication forum, *JuFo*[2], which contains all nationally evaluated publication channels. Data was retrieved from this database in February 2015.
2. *JuuliDB*: The publicly accessible database of *Juuli*[3] that contains all publications of Finnish researchers. Each publication channel in *JuFoDB* has a unique *Juuli* ID, through which all Finnish publications in that particular channel can be found. Data was retrieved from this database in September 2015.
3. The *Journal Citation Reports*® (JCR): Published by Thomson Reuters, there is no direct link available from *JuFoDB* to the JCR. However, 8178 of all the 8539 observations from the Thomson Reuters database were linked to publication channels in *JuFoDB* by using the ISSN available in both databases. Data from this database was retrieved in September 2014.

Altogether, 29,443 different publication channels with 33 attributes were retrieved from *JuFoDB*. The example in Table 1 shows available attributes for the *Journal of Informetrics*. As can be seen from the table, the *Journal of Informetrics* has been evaluated as one of the most prestigious journals in its field (rank 3). The Finnish expert-based rank (i.e., the *JuFo*-level) of each publication channel as well as the Norwegian and Danish expert-based rankings can be obtained directly through the *JuFoDB*. Moreover, as can be seen in Table 1, the three indicators from the bibliographic database Scopus®, that is the SJR, the SNIP and the IPP, are featured. Furthermore, by using the ISSN linkage to Thomson Reuters' JCR, we can, for the common publication channels, access the six original JCR variables (*Total Cites*, *Articles*, *Impact Factor*, *Cited Halflife*, *Immediacy Index*, and *5-Year Impact Factor*), as well as the two Eigenfactor metrics (*Eigenfactor Score* and *Article Influence Score*).

In addition to some more general data, such as the unique identifier (*ID*), *ISSN*, and *publisher*, the *JuFoDB* also provides the information on the panel (see Table A.12) responsible for evaluating a publication channel. Moreover, through the link to *JuuliDB* (the last attribute in Table 1), one can directly access the information of all researchers in Finland who have published in the particular channel. Additional information such as *abbreviation*, *ISBN*, *end year*, *continued under the name* and *continued JuFo-rank* are available for some publication channels, but were not included in Table 1 because they were not available for

[2] Available at: http://www.tsv.fi/julkaisufoorumi/haku.php.
[3] Available at: http://www.juuli.fi/?&lng=en.

Table 1
Information available in *JuFoDB* with the example of the Journal of Informetrics.

Attribute	Value
Level	3
JuFo ID	60692
Title	Journal of Informetrics
Parallel title or subtitle	
Title details	
Website	http://www.journals.elsevier.com/journal-of-informetrics/
Type	Serial
ISSN (print)	1751-1577
ISSN (online)	1875-5879
Starting year	2007
Country of publication	NETHERLANDS
Publisher	Elsevier BV
Language	English
Norway level	1
Denmark level	2
ERIH field	
SJR	2.541
SNIP	2.018
IPP	3.51
DOAJ	No
Sherpa/Romeo	Green
Evaluating panel	17
Field	;1 Natural Science;5 Social Science;
MinEdu field	111 Mathematics 112 Statistics 113 Computer and information sciences 512 Business and management 518 518 Media and communications
Web of Science fields	INFORMATION SCIENCE &LIBRARY SCIENCE (SSCI)
Scopus fields	Modelling and Simulation Management Science
Evaluation history	Level 2015: 3 Level 2014: 2 Level 2013: 2 Level 2012: 2
Juuli	60692

Table 2
Comparison of the discipline-wise rankings in *JuFo*.

Discipline	ID	Rank 0	Rank 1	Rank 2	Rank 3	Total occurrences
Natural science	1	1243 (14%)	6628 (75%)	733 (8%)	248 (3%)	8852 (100%)
Technology	2	1294 (26%)	3300 (65%)	348 (7%)	100 (2%)	5042 (100%)
Medical and health	3	250 (5%)	4615 (85%)	430 (8%)	113 (2%)	5408 (100%)
Agriculture and forestry	4	106 (10%)	904 (83%)	61 (6%)	24 (2%)	1095 (100%)
Social science	5	1521 (18%)	5777 (69%)	865 (10%)	267 (3%)	8430 (100%)
Humanities	6	652 (9%)	5196 (75%)	837 (12%)	219 (3%)	6904 (100%)
Other	9	22 (27%)	52 (64%)	1 (1%)	6 (7%)	81 (100%)
All disciplines	–	5088 (14%)	26,472 (74%)	3275 (9%)	977 (3%)	35,812 (100%)

the *Journal of Informetrics*. None of the observations in the database is complete, meaning that all of the publication channels have missing values for at least some of the 33 total attributes. Hence, for utilizing all of available data in the analysis, one faces a significant sparsity problem (see, e.g., Saarela & Kärkkä inen, 2015, and articles therein).

Each publication channel in *JuFoDB* is assigned to at least one discipline. Rankings are presented according to discipline in Table 2, in which most of the publication channels have been evaluated as basic, or rank 1. We can see from the table that the percentages do not differ much between the disciplines. However, Natural Science has more than ten times more rank 2 and 3 publication channels than Agriculture and Forestry. Even if this should reflect the size of the overall publication channel population, it probably better reflects the size of the national researcher population in a discipline. From both a discipline and panel perspective, the more publication channels can be brought under evaluation, the more high ranks can be given in absolute terms.

Table A.12 provides information about the distribution of the different ranks according to the panels. Although a discipline may have multiple possible linkings, each publication channel is attached to only one panel. As can be seen in the table, some differences exist when it comes to the percentage of the highest classified publication channels across the panels. However, all panels adhere to the rule (see Section 1) that 20% of the publication channels at most are allowed to be classified as rank 2, and 5% at most as rank 3. There is no panel information available in *JuFoDB* for 6562 observations (see the first column

Table 3
Overview of used variables, their availabilities in percentages, and preprocessings.

Variable	Availability	Preprocessing
rank	100%	The categorical (0–3) Finnish expert-based rank (*JuFo*-rank).
panel	100%	The categorical indicator which panel (1–24) was responsible for evaluating the channel.
type	100%	3 for journals, 2 for conferences, 1 for book publishers.
inJCR	100%	1 if the publication channel can be found in Thomson Reuters' JCR, 0 otherwise.
nrOfPub	100%	The total number of publication in this channel as retrieved from *JuuliDB*.
rankChange	100%	0 if there was no change compared to the rank in the previous year, 1 if the current rank is lower, and 2 if the current rank is higher than in the previous year.
language	94.76%	3 for English, 2 for Finnish or Swedish, 1 for other languages. NaN if not available.
age	91.12%	Current year (2015) minus the start year of the channel. NaN if start year cannot be found.
NORrank	76.56%	The categorical (0–2) Norwegian expert-based rank. NaN if not available.
DNKrank	71.0%	The categorical (0–2) Danish expert-based rank. NaN if not available.
SJR	67.81%	The continuous SJR value. NaN if not available.
SNIP	65.06%	The continuous SNIP value. NaN if not available.
IPP	64.69%	The continuous IPP value. NaN if not available.
sherpaCode[1]	60.10%	5 for green, 4 for blue, 3 for gray, 2 for yellow, 1 for white. NaN if not available.

[1] Definitions and terms of Sherpa are provided at http://www.sherpa.ac.uk/romeoinfo.html.

in Table A.12). The publication channels that have not been assigned to any panel have a special profile: they are all book publishers and have mostly been evaluated as rank 0 (see Table A.12). What is not clear, based on the general description of the ranking system as described in Section 1, is who could update the ranking of the non-panel-allocated publication channels?

2.1. Observations and variables used for the study

For further analysis, we selected all 22,881 observations from *JuFoDB* that were assigned to a panel. Moreover, we utilized all available variables that might affect the expert rank of a publication channel. Table 3 provides an overview of all the used variables, their preprocessings, and their availability with respect to the 22,881 observations under study. It is important to note that the distribution of ranks (0–3) of our observations is very imbalanced: 2.01% are rank 0, 2.87% are rank 3, 9.85% are rank 2, and 85.27% are rank 1. Hence, for example a trivial classifier returning always 'rank 1' would be more than 85% correct. As will be seen below, by using the proposed methods and techniques, we only obtain slightly better overall classification accuracies than this. However, compared to the trivial classifier, the advantage of these methods and techniques is their explicit construction allowing one to identify and discuss salient variables of the models.

3. Method

Our analysis was based on a combination of different machine learning techniques (e.g., Alpaydin, 2010) with a unified analysis pattern: We first generated an automatic indication of ranks and, then, studied the deviations from this to analyze their characteristics. All computations were performed using Matlab 2015b. The applied techniques and deviations used are as follows:

- Association rules to determine patterns in the data based on the availability of variables (deviations are defined as publication channels for which the rules do not apply)
- Decision tree with stratified cross-validation to construct a classification model for the ranks, using the through association rules detected patterns in data (deviations are defined as misclassified publication channels)
- Reference indicator detection using triangulated PCA for Thomson Reuters' JCR (confusion matrices are used to define deviations from the baseline)

3.1. Decision tree

We aim to predict the Finnish expert-based ranking by automatic rules. Decision tree is a supervised machine learning technique that can predict the categorical output (rank) from given categorical and continuous predictor variables. It is very suitable in our case because we are interested in a prediction model that provides explicit rules with respect to the predictor variables used. A decision tree presents the rules in a tree-like structure, whose nodes provide readable and easily accessible rules on the so-called splitting variable for human interpretation. We use the CART (Breiman, Friedman, Stone, & Olshen, 1984) decision tree induction algorithm (default in Matlab), in which the splitting is based on Gini's diversity index.

However, one problem with using a decision tree (explicitly visible in Table 3) is the high percentage of missing values in data. Observations that have a missing value for a splitting variable are automatically assigned to the most frequent class. This is especially unsuitable in our case, since we have (as already discussed in Section 2.1) very imbalanced class sizes. If we use a decision tree for the whole data, we receive an almost perfect classifier. However, this is not because the classifier

Table 4
Confusion matrix to identify highly deviating publication channels.

Ref. rank	*JuFo*-rank			
	Rank 0	Rank 1	Rank 2	Rank 3
Rank 0	+	+	–	–
Rank 1	+	+	+	–
Rank 2	–	+	+	+
Rank 3	–	–	+	+

itself has built a valuable model that captures the data very well. Instead, every time a variable with missing values is used as the splitting attribute, the classifier can assign all observations with missing values for this variable to the most common class (i.e., rank 1, which by default is in more than 85% of the cases correct).

We solve this sparsity problem by using association rules indicating for each variable whether the value is missing or not (see Section 3.2). Furthermore, we solve the problem of the imbalanced class sizes in the decision tree by assigning the inverse of its class frequency to each observation as a weight. This technique is called oversampling (He & Garcia, 2009).

3.2. Association rules

The goal of association rule mining (Agrawal, Imieliński, & Swami, 1993) is to automatically find patterns that describe strongly associated attributes in data. The discovered patterns are usually represented in the form of implication rules or attribute subsets. If I is the set of all items and S_1 a subset of the set of items ($S_1 \subseteq I$), a transaction $t_i \in T$, where T denotes the set of all transactions, is said to contain itemset S_1 if S_1 is a subset of t_i. The support count, $\sigma(S_1)$, for an itemset S_1 is defined as $\sigma(S_1) = |\{t_i \mid S_1 \subseteq t_i, t_i \in T\}|$, where $|\cdot|$ stands for the cardinality, i.e., the number of elements in a set.

An association rule is then an implication expression of the form $S_1 \rightarrow S_2$, where $S_1, S_2 \subseteq I$ and $S_1 \cap S_2 = \emptyset$. The support, $s(S_1 \rightarrow S_2) = \frac{\sigma(S_1 \cup S_2)}{|T|}$, determines how often a rule is applicable to a given data set. Furthermore, the confidence, $c(S_1 \rightarrow S_2) = \frac{\sigma(S_1 \cup S_2)}{\sigma(S_1)}$, determines how frequently items in S_2 appear in the transactions that contain S_1.

Association rule mining is applied to the whole data set, i.e., to all 22,881 observations under study. Our itemsets consist of binary representation (encoding) of all the variables presented in Table 3, except the number of publications and the rank change, as those should not have an effect on the expert-based rank. Hereby, we use for all categorical variables in each case one variable for each category, and, if there can be missing values, one additional variable indicating whether the value is missing. For example, with this strategy we have for language the binary indications *isEnglish*, *isFinnishOrSwedish*, *otherLanguage*, and *languageNaN*, while for rank (which is available for all observations), we only have the binary indications *rank 0*, *rank 1*, *rank 2*, and *rank 3*. Furthermore, for our three continuous variables (SJR, SNIP and IPP) and one discrete variable (age), we use two variables (e.g., *SJRavail*, and *SJRnan*) in each case to indicate whether these variables are available or not. Altogether, that gives us 59 binary variables for each observation.

We are interested in association rules with high confidence, as confidence represents the reliability and accuracy of a rule. On the other hand, support can be relatively small, since we are interested in all rules that contain rank information. For example, a transaction that contains the item *rank 0* can by construction be supported by at most 2.01% (see Section 2.1) of all transactions in the itemset.

3.3. Confusion matrix using a reference metric

The idea for our third analysis technique is to compare the existing *JuFo*-rank of each observation in the database to an overall reference indicator, using a simple confusion matrix (Alpaydin, 2010). Thus, the (continuous) reference indicator is categorized to have the same number of ranks as present in *JuFo*. Hereby, we accept small deviations from perfect matches. We entitle the *JuFo*-rank of a publication channel to be in accordance with the reference indicator (denoted as + in Table 4) if the reference indicator rank is either equal to or at most one rank higher or lower than the *JuFo*-rank. Furthermore, we characterize the *JuFo*-rank as highly deviating (denoted as −) if the *JuFo*-rank is at least two ranks higher (or lower, respectively) than the reference indicator. We study further those observations that deviate greatly from the reference indicator, asking, “Which publication channels have been evaluated very differently by the Finnish panels compared to a constructed reference indicator, and can they be summarized by a general profile?”

Defining one overall reference indicator is challenging. Traditionally, the impact factor (IF) published by Thomson Reuters in the JCR (see Section 2) has been the most well-established ranking for the evaluation of publication channels. However, as discussed by numerous scholars before (Archambault & Larivière, 2009; Falagas, Kouranos, Arencibia-Jorge, & Karageorgopoulos, 2008; Moed, 2010; Seiler & Wohlrabe, 2014; Vanclay, 2012), the IF has several limitations, such as the lack of quality assessment of the citations and the influence of journal self-citations. Due to its simple formula (the IF is computed by dividing the number of citations in the JCR yearly by the total number of articles published in the two previous years), a journal can easily boost its IF by accepting only articles that cite a certain percentage of recent articles from the same journal. Furthermore, citation practices differ between disciplines (Moed, 2010) and, as a consequence, the likeliness of being cited depends also on the research field. Reference lists in mathematical articles, for example, tend to be much shorter than those in biology. More precisely, as shown in (Moed, 2005, Chapter 5), the top journals in large disciplines typically have higher citation impact than the top journals of smaller disciplines. Therefore, especially because we intend to evaluate the *JuFo*-rank across different scientific fields using the same indicator, the IF alone cannot serve as our external reference quality indicator.

With the exception of considering another yearly time interval (and for IPP, another database), the *5-Year Impact Factor* (five years), *Immediacy Index* (current year), and IPP (three years) are fairly similar in construction to the traditional IF (two years). Although we cannot use these metrics because of the aforementioned reasons, we note that these still seem to be the most established external citation-based metrics. This is evidenced by the fact that usually, when a new indicator is introduced, it is compared against the IF of some yearly time interval. For example, Moed (2010) compared the SNIP indicator against the three-year IF (IPP[4]), Guerrero-Bote and Moya-Anegón (2012) compared the SJR2 against the three-year IF (IPP), and González-Pereira, Guerrero-Bote, and Moya-Anegón (2010) compared the SJR against the three-year IF (IPP). Furthermore, after the two Eigenfactor® metrics had been introduced by Bergstrom, West, and Wiseman (2008), Franceschet (2010) compared both to the two-year IF, and the five-year IF.

To sum up, despite the fact that all recent studies seem to agree that the IF of some yearly time interval is outdated and not adequate for a fair comparison across disciplines, no other external citation-based metric seems to have reached the same status yet. Bollen, Van de Sompel, Hagberg, and Chute (2009) point out that there is not even a “workable definition of the notion of ‘scientific impact’ itself.” The general conclusion is that no single indicator alone “captures all the criteria that are needed for a rigorous and comprehensive measure of scientific output” (Kreiman & Maunsell, 2011). Instead, the quality of scientific publication channels is a “multi-dimensional concept that cannot be expressed in any single measure” (Moed, 2010).

3.3.1. *Finding an overall reference quality indicator*

Based on our conclusion that the quality of scientific publication channels must be described by multiple features (and possibly several metrics), we used the different quality indicators published by Thomson Reuters as our starting point. Six different JCR metrics were available, plus the two Eigenfactor® metrics (see Section 2). However, two of these eight measures, namely *Cited Halflife* and *Articles* were not directly connected to the quality of a publication channel. Hence, we left out the *Cited Halflife* as “a higher or lower cited half-life does not imply any particular value for a journal”[5]. Furthermore, we decided to omit the *Articles* indicator since it does not necessarily increase the quality of a journal if more articles are published, and does not correlate as strongly with the other variables.

All remaining six indicators in the Thomson Reuters database are positively correlated (see Fig. 1). Hereby, we observe immediately two groups that have especially strong metric correlations with each other. The first group (composed of *Total Cites* and *Eigenfactor Score*) represent the not-normalized metrics (see also Table A.13). The second group (*Impact Factor*, *5-Year Impact Factor*, *Immediacy Index*, *Article Influence Score*) is composed of metrics that normalize the influence of a journal with regard to its publishing volume, i.e., they measure the average influence of an article in the journal. A high correlation between different variables of the JCR data has been observed by other scholars, as well. In Chang, McAleer, and Oxley (2013), a table can be found that provides an overview of which correlation between which variables have been observed by which researchers. Since these six indicators all measure the same concept, i.e., the quality of a publication channel, and our intention was to describe this concept in a compact way (ideally at once), we scaled all six variables to the interval [0, 1] using min-max scaling to prepare them for dimension reduction. Then, we applied *Principal Component Analysis* (PCA). Because we had missing values (see Table A.14, which summarizes the availability for each indicator in the JCR), we had to use PCA for sparse data. To strengthen the result using methodological triangulation (Bryman, 2004), we used three different approaches.

The classical PCA for sparse data, the robust PCA for sparse data (see both Kärkkäinen & Saarela, 2015) and the ALS algorithm (Kuroda, Mori, Masaya, & Sakakihara, 2013) all suggest that the first two principal components explain more than 90% of the variance in the data and that the first three components account for nearly 90% of the geometric variability, respectively. Moreover, the angles between the three principal derived subspaces are very small, which means that the results of the three different PCA variants coincide in practice (cf. Kärkkäinen & Saarela, 2015). Hence, we use the projection of data into the most significant principal (major) component to summarize the six different quality measures in the JCR data.

3.3.2. *Relation of the combined JCR data to the three Scopus indicators*

Next, we study the relation of the SJR, SNIP and IPP indicators to the major component just defined. The three indicators from Scopus offer two main advantages over the quality indicators offered by Thomson Reuters: First of all, the SJR, SNIP and IPP indicators are open-access resources, while access to the JCR data requires a paid subscription. Furthermore, possibly as a consequence of the accessibility, the three indicators can also be obtained directly from the public *JuFoDB*, while the connection to the Thomson Reuters data requires substantially more action (see Section 2). Second, considerably more

[4] Back then, the IPP was known as “Raw Impact per Paper.”

[5] See http://admin-apps.webofknowledge.com/JCR/help/h_ctdhl.htm.

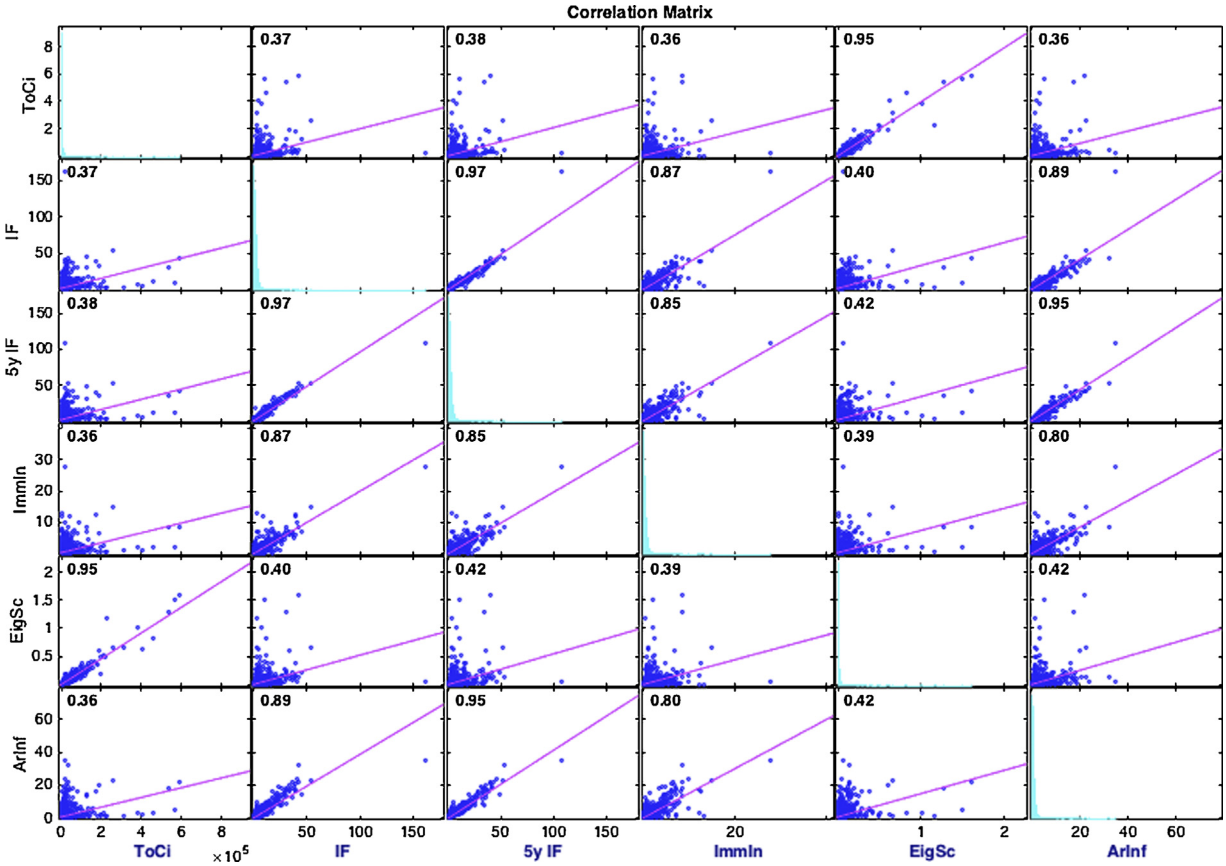

Fig. 1. Spearman correlations of Thomson Reuter measures of quality.

publication channels published in a wider variety of countries and languages are listed in the Scopus database (with SJR, SNIP and IPP values available) than can be found in the Thomson Reuters database (Bornmann et al., 2009; Falagas et al., 2008; Guerrero-Bote & Moya-Anegón, 2012). In our case, only within *JuFo*, 8178 publication channels can be linked to Thomson Reuters JCR, but 17,355 readily have an SJR indicator available.

The correlation between the SJR, SNIP and IPP and each available quality indicator in Thomson Reuters' JCR for those 8178 publication channels that are stored in both databases can be found in Table A.14. As the table shows, the highest correlation ($r = 0.97411$) is observed between the IPP and Thomson Reuters' IF. The second highest correlation ($r = 0.941$) is observed between the SJR and Thomson Reuters' *Article Influence Score* (AI). The very strong correlation of these two metrics is not surprising, given that the SJR is very similar in construction to AI. Both indicators take into account not only the quantity but also (by giving each citation a weight) the quality of the citations using Google's PageRank algorithm. Besides being computed over different databases (Scopus versus JCR), the SJR differs in three additional respects from the AI. First, the SJR is computed over a three-year-window while the AI is computed over a five-year-window. Second, journal self-citations are only limited so that they count for not more than one third of the total citations, while they are totally excluded in the AI. Third, the AI is normalized only by the number of identified references in the citing journals (i.e., those in the JCR data), while the SJR is normalized by the number of all references in the citing journals.

The correlation of SJR with the representation of the Thomson Reuters data spanned by the first principal component using robust PCA is very strong ($r = 0.913$). Likewise, the correlation of the first principal component to SNIP is $r = 0.7398$, and the correlation to IPP is $r = 0.9191$. We conclude that the three Scopus indicators are, with reference to the Thomson Reuters data and with respect to their availability, the most appropriate choices as the citation-based indicators of publication channel quality.

4. Results

4.1. Association rules

We applied association rule mining for the variables and observations, as explained in Section 3.2. Our main interest was in those rules that contained Finnish expert-based rank information. Since we wanted to have rules for all ranks and only

Table 5
Association rules for the whole *JuFo* data.

Rule	Support	Confidence	Rule	Support	Confidence
rank 3 → isJournal	2.87%	100%	SherpaNaN → rank 1	36.77%	92.17%
rank 3 → SJRavail	2.85%	99.24%	SNIPnan → rank 1	32.1%	91.86%
rank 3 → SNIPavail	2.85%	99.24%	IPPnan → rank 1	32.39%	91.73%
rank 0 → notInJCR	1.99%	99.13%	SJRnan → rank 1	29.45%	91.5%
rank 3 → IPPavail	2.84%	98.93%	NOR 1 → rank 1	59.75%	91.43%
rank 0 → IPPnan	1.96%	97.39%	rank 3 → DNK 2	2.62%	91.31%
rank 2 → isJournal	9.57%	97.07%	rank 2 → SJRavail	9%	91.31%
rank 1 → isJournal	80.31%	94.18%	DNKnan → rank 1	26.71%	90.96%
rank 3 → isEnglish	2.67%	93.29%	rank 2 → SNIPavail	8.96%	90.91%
DNK 1 → rank 1	54.69%	93.21%	NORnan → rank 1	21.59%	90.68%
otherLanguage → rank 1	19.77%	92.29%	rank 2 → IPPavail	8.92%	90.55%

a bit more than 2% of all the publication channels under study were *rank 0*, we set the minimal support to 1.95. When the confidence was set to 90% and we explicitly searched for the rules that included the rank information, we obtained the set of rules as presented in Table 5.

As can be seen from Table 5, only one rule is supported 100%. All publication channels evaluated as 3 in *JuFo* were journals. However, also 97% of the publication channels evaluated as 2 in *JuFo*, and 94% of the publication channels evaluated as 1 in *JuFo* were journals. Therefore, the type of publication channel did not seem to be a very useful indicator of the Finnish expert-based rank.

The most interesting subset of the obtained rules was the one that included the availability of reference indicators. We see from Table 5 that if a publication channel has been highly evaluated (i.e., as rank 3 or 2), then the three indicators from Scopus are available with a very high percentage. If the Finnish expert rank is 3, SJR and SNIP are available for more than 99% of all the publication channels, and IPP is available for almost 99% of all the publication channels. If the Finnish expert rank is 2, SJR, SNIP and IPP are available for more than 90% of all publication channels. Vice versa, for more than 97% of those publication channels that have been evaluated as 0, the IPP value is missing. Moreover, we see from the table that of those publication channels missing SNIP, IPP, and SJR, more than 91% have been ranked as 1 in Finland. Hence, it can be concluded that the availability of the three Scopus metrics already provides a very good prediction of the Finnish expert-based rank.

Table 6
Characteristics of misclassified publication channels with association rules.

	SJR, SNIP or IPP missing		SJR, SNIP and IPP missing	
	Rank 3	Rank 2	Rank 3	Rank 2
total sum	7 (0.03%)	214 (0.94%)	5 (0.02%)	196 (0.86%)
in JCR	2 (28.57%)	11 (5.14%)	2 (40%)	9 (4.59%)
mean number of publications	13.29	13.44	14.2	14.32
rank now higher	2 (28.57%)	64 (29.91%)	1 (20%)	55 (28.06%)
no rankChange	5 (71.43%)	138 (64.49%)	4 (80%)	130 (66.33%)
rank now lower	0 (0%)	12 (5.61%)	0 (0%)	11 (5.61%)
Language NaN	0 (0%)	29 (13.55%)	0 (0%)	29 (14.8%)
English	4 (57.14%)	115 (53.74%)	3 (60%)	99 (50.51%)
Finnish or Swedish	0 (0%)	16 (7.48%)	0 (0%)	16 (8.16%)
other Language	3 (42.86%)	54 (25.23%)	2 (40%)	52 (26.53%)
Journal	7 (100%)	148 (69.16%)	5 (100%)	137 (69.9%)
Conference	0 (0%)	66 (30.84%)	0 (0%)	59 (30.1%)
Age NaN	0 (0%)	37 (17.29%)	0 (0%)	37 (18.88%)
Age (mean of avail)	49.57	41.5	39.4	41.41
NOR rank NaN	2 (28.57%)	84 (39.25%)	2 (40%)	82 (41.84%)
NOR rank equals FI rank	5 (71.43%)	52 (24.3%)	3 (60%)	46 (23.47%)
NOR rank higher FI rank	0 (0%)	0 (0%)	0 (0%)	0 (0%)
NOR rank lower FI rank	0 (0%)	78 (36.45%)	0 (0%)	68 (34.69%)
DNK rank NaN	2 (28.57%)	103 (48.13%)	2 (40%)	99 (50.51%)
DNK rank equals FI rank	5 (71.43%)	60 (28.04%)	3 (60%)	57 (29.08%)
DNK rank higher FI rank	0 (0%)	0 (0%)	0 (0%)	0 (0%)
DNK rank lower FI rank	0 (0%)	51 (23.83%)	0 (0%)	40 (20.41%)

Table 7
Characteristics of publication channels that are *JuFo*-rank 2 but have no other available reference indicator.

total sum	73
in JCR	0 (0%)
mean number of publications	15.22
rank now higher	22 (30.14%)
no rankChange	50 (68.49%)
rank now lower	1 (1.37%)
Language NaN	29 (39.73%)
English	30 (41.10%)
Finnish or Swedish	5 (6.85%)
other Language	9 (12.33%)
Journal	23 (31.51%)
Conference	50 (68.49%)
NOR rank NaN	73 (100%)
DNK rank NaN	73 (100%)

4.1.1. Deviations

In Table 6, we summarized the characteristics of those publication channels in which (i) SJR, SNIP or IPP were not available but the Finnish expert-based rank was still 3 or 2 (columns 2 and 3), and (ii) SJR, SNIP and IPP were not available but the Finnish expert-based rank was still 3 or 2 (columns 4 and 5).

As can be seen from the fourth column in Table 6, five publication channels are classified as *JuFo*-rank 3, although SJR, SNIP and IPP are not available. However, three of these have been classified as the highest rank in Norway and Denmark, and for the other two publication channels (namely *British Medical Journal* and *Light: Science & Applications*), the SJR, SNIP and IPP indicators seem to have been incorrectly not included in *JuFoDB*. They can be found by manually using the *Browse Sources* search function in Scopus,[6] and in both cases, the values are so high that rank 3 seems appropriate.

As can be seen from the fifth column in Table 6, 196 publication channels have been classified as *JuFo*-rank 2 but no SJR, SNIP or IPP value is available. However, again for most of these channels, a Norwegian or Danish rank is available and in each case, at least one is classified as rank 1 or higher. Only 73 publication channels remain that are *JuFo*-rank 2 but have no SJR, IPP or SNIP, nor is a Norwegian or Danish expert-based rank available. All of these publication channels are explicitly listed in Table A.15, and a summary is provided in Table 7.

From Table 7, we see already that in the subgroup of those 73 publication channels that have a Finnish expert-based ranking of 2 but no other reference indicator available, a high percentage of conference series exists (68.49%). It is interesting that the number of publications for these channels is very high, with an average of more than 15 per channel. Moreover, for more than one third of the publication channels in this subgroup, the *JuFo*-rank was upgraded during the last evaluation round.

Then, just as above for the *JuFo*-rank 3 publication channels, we tried to manually find SJR, SNIP and IPP values using the search interface in Scopus. Indeed, for 15 publication channels, SJR, SNIP and IPP values were detected, and for 14 others, the coverage discontinued in Scopus (both are reported in Table A.15). If we subtract these 15 + 14 from the 73 publication channels that are *JuFo*-rank 2 but have no other reference indicator available, 44 publication channels remain.

These 44 publication channels show a clear profile: most of them (precisely 26) are conference proceedings evaluated by the *Computer and Information Sciences* panel. The remaining publication channels that do not belong to the *Computer and Information Sciences* panel are journals, mostly published in another language than English. They belong to five different panels: 17,18, 19, 22 and 23. To this end, we also scanned manually through these 44 publication channels and their links to *JuuliDB*. Then, two slightly alarming cases were noticed, in which the highly deviating *JuFo*-rank 2 of a publication channel could be linked to an active publication profile of a panel member responsible for deciding the rank.

However, these results must be interpreted cautiously. As discussed in Section 1, one of the main reasons for establishing the expert-based *JuFo*-ranks instead of using citation-based indicators to measure the quality of a publication channel was to include the SSH and engineering sciences on the same terms as the other major areas. For example, it is known that publication channels belonging to the SSH are less covered in the international citation databases (although there has been a positive trend towards broader coverage, especially in Scopus) than other disciplines (Sivertsen, 2014). Table 8 summarizes for all panels the number and percentages of journals (*JuFo*-rank 0 publication channels as well as book publishers and conference series are excluded) and articles, i.e. publications in *JuuliDB*, within these journals that are covered in Scopus. The table clearly shows the disciplinary differences. While the journals that belong to the panels of the so so-called hard sciences are covered very well in Scopus, the journals that belong to SSH panels are covered relatively less in Scopus. This trend is even more visible when looking at the number and percentages of articles. On average, almost 78% of the total

[6] See http://www.scopus.com/source/browse.url?zone=TopNavBar&origin=searchbasic.

Table 8
Disciplinary differences of journal coverage in Scopus and Finnish publication activity within those (*JuFo*-ranks 0 as well as book publishers and conference series are excluded).

Panel name	Journals			Publications in journals		
	All	In Scopus (% of all)	Not in Scopus (% in FI/SWE)	All	In Scopus (% of all)	Not in Scopus (% in FI/SWE)
Mathematics and statistics	804	644 (80.1%)	160 (0%)	1438	1345 (93.53%)	93 (0%)
Computer and information scis.	652	518 (79.45%)	134 (0.75%)	1874	1705 (90.98%)	169 (1.18%)
Physical scis., space scis. & Astronomy	486	424 (87.24%)	62 (0%)	5136	5023 (97.8%)	113 (0%)
Chemical scis.	444	404 (90.99%)	40 (0%)	2459	2427 (98.7%)	32 (0%)
Geosciences & environmental scis.	624	545 (87.34%)	79 (1.27%)	2028	1967 (96.99%)	61 (0%)
Biosciences I	621	573 (92.27%)	48 (4.17%)	2839	2744 (96.65%)	95 (49.47%)
Biosciences II	622	567 (91.16%)	55 (0%)	2496	2435 (97.56%)	61 (0%)
Civil engr. and mechanical engr.	502	461 (91.83%)	41 (2.44%)	825	754 (91.39%)	71 (53.52%)
Electrical & electronic engr., information engr.	356	312 (87.64%)	44 (0%)	1730	1695 (97.98%)	35 (0%)
Chemical, materials, & Environmental engr.	734	630 (85.83%)	104 (0%)	2804	2738 (97.65%)	66 (0%)
Medical engr., biotechnology & Basic medicine	1121	1016 (90.63%)	105 (0.95%)	4433	4236 (95.56%)	197 (43.65%)
Clinical medicine I	893	833 (93.28%)	60 (5%)	5450	4633 (85.01%)	817 (90.7%)
Clinical medicine II & Dentistry	1196	1120 (93.65%)	76 (3.95%)	4988	4798 (96.19%)	190 (45.26%)
Health scis. and other medical scis.	863	751 (87.02%)	112 (10.71%)	3441	2679 (77.86%)	762 (78.61%)
Agricultural sciences	795	706 (88.81%)	89 (1.12%)	1987	1818 (91.49%)	169 (25.44%)
Economics and business	1242	904 (72.79%)	338 (0.89%)	2858	2244 (78.52%)	614 (21.82%)
(Interdisc.) social scis., media & Comm.	1575	1045 (66.35%)	530 (6.6%)	4008	1883 (46.98%)	2125 (74.35%)
Psychology and educational scis.	1230	893 (72.6%)	337 (4.75%)	3402	2054 (60.38%)	1348 (45.4%)
Political scis., public administration & Law	1080	590 (54.63%)	490 (4.69%)	2219	485 (21.86%)	1734 (73.41%)
Philosophy & theology	1144	588 (51.4%)	556 (3.78%)	1880	752 (40%)	1128 (41.13%)
Languages	974	401 (41.17%)	573 (1.92%)	1772	861 (48.59%)	911 (21.95%)
Literature, arts & architecture	1685	736 (43.68%)	949 (2.85%)	1622	535 (32.98%)	1087 (58.97%)
History, archaeology & cultural studies	1815	777 (42.81%)	1038 (5.01%)	4036	1102 (27.3%)	2934 (69.67%)
Multidisciplinary journals	34	26 (76.47%)	8 (50%)	1883	1656 (87.94%)	227 (87.67%)
Total	21,492	15,464 (71.95%)	6028 (3.6%)	67,608	52,569 (77.76)	15,039 (58.44%)

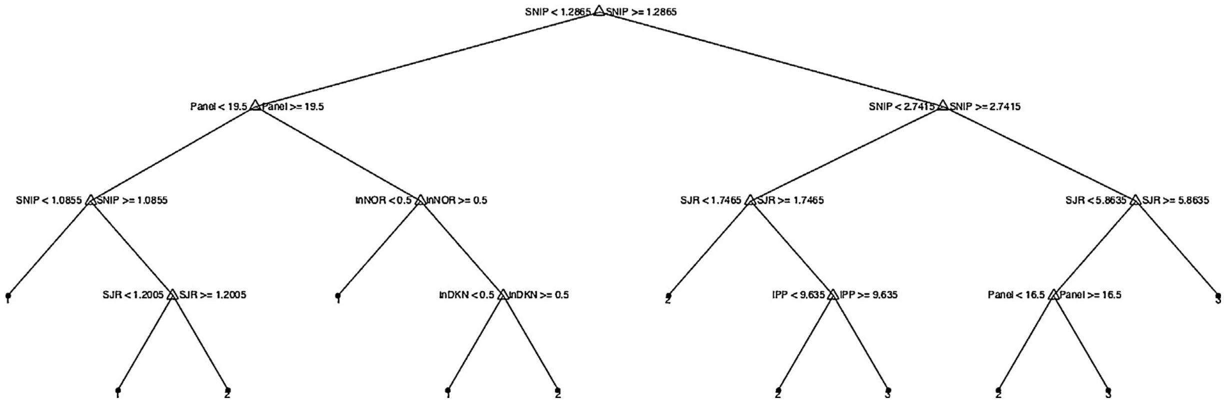

Fig. 2. Pruned decision tree.

Finnish journal publications (see last row in the table) are in journals that are covered in Scopus. However, for the journals assigned to the *Political Science and Public Administration* panel, less than 22% of the journal publications are in journals that are covered in Scopus. Similar observations have been made by Sivertsen (2014), who compared the coverage of journals and articles in the SSH to the other major disciplines from Norway's research institutions.

Table 8 also illustrates the language differences across disciplines. Altogether, the percentage of the not-covered-by-Scopus journals that are in Finnish and Swedish language is very small (see the fourth column in the table). However, for many disciplines (especially medicine and SSH) most of the not-covered-in-Scopus publications are articles in Finnish or Swedish language journals (see last column in the table). Again, this situation is comparable to that in Norway where only a few journals in the national language exist but a high percentage of the national articles from the SSH are concentrated in them (Sivertsen & Larsen, 2012). Actually, as described in (Puuska, 2014, pp.82–83), in both Norway and Finland groups of scholars and scientific societies had an effect of the higher rankings of publications with native languages.

4.2. *Decision tree*

Next, we built a decision tree for all 14,798 publication channels with the three indicators from Scopus (i.e. SJR, SNIP and IPP) available. 12,096 of these publication channels are rank 1, i.e. a trivial classifier predicting always 'rank 1' (compare Section 2.1) for this subset would be 81.74% correct. For our decision tree model, we used all variables that could have an effect on the expert-based rank decision in such a way that we utilized each variable from Table 3, either as it is if the variable had available values for all observations, or as a binary indicator on the availability of the variable if the variable had missing values. We used this strategy to ensure that the data set fed to the decision tree classifier had no missing values. Altogether, we had the three continuous variables (SJR, SNIP and IPP), two categorical variables (*panel* and *typeOfChannel*), and five binary variables (*inJCR*, *inNOR*, *inDNK*, *hasLanguageAvailable*, and *hasSherpaCodeAvailable*).

With stratified cross-validation (according to the four classes of ranks) and the inverse class frequencies as weights (see Section 3.1), we obtained a classifier that predicted the actual expert-based rank for nearly 88% of all publication channels correctly. Only 1853 (12.09%) of the publication channels were misclassified. In comparison with the trivial classifier, our decision tree was circa 6% more accurate. Fig. 2 shows the pruned decision tree. As can be seen from the figure, the SNIP indicator is the variable with the highest predictive power. However, also the other two Scopus metrics, as well as the panel and the information whether or not the publication channel is covered in the Norwegian and Danish databases, are important variables in the decision tree model.

4.2.1. *Deviations*

In Table 9, the characteristics of misclassifed observations are summarized, characterizing the subset of misclassified publication channels, for which (i) the Finnish expert-based rank was higher than the prediction (second column), and (ii) the subset for which the prediction was higher than the Finnish expert-based rank (third column) separately. For comparison reasons, the subset of correctly classified publication channels was characterized according to the same variables (fourth column in the table).

We see from Table 9 that the group of misclassified publication channels incorporates the most channels in which there has been a recent change in the expert-based rank. Interestingly, those misclassified publication channels with *Actual rank higher than prediction* have the highest percentage (12.5%) of positive change in rank, while those misclassified publication channels with *Actual rank lower than prediction* have the highest percentage (27.2%) of negative change in rank. The group with the highest percentage (86.6%) of publication channels in which the Finnish expert-based rank has not been changed recently indicates the correctly predicted observations. Moreover, we see from Table 9 that similar to the finding from the

Table 9
Characteristics of misclassified and correctly classified publication channels with decision tree.

	Misclassificed publication channels		Correctly classified publication channels
	Actual rank higher than prediction	Actual rank lower than prediction	
total sum	360 (2.43%)	1430 (9.66%)	13,008 (87.9%)
in JCR	154 (42.78%)	587 (41.05%)	7077 (54.4%)
mean number of publications	8.56	4.09	3.19
rank now higher	45 (12.5%)	9 (0.63%)	207 (1.59%)
no rankChange	286 (79.44%)	1032 (72.17%)	11265 (86.6%)
rank now lower	29 (8.06%)	389 (27.2%)	1536 (11.81%)
Language NaN	0 (0%)	0 (0%)	13 (0.1%)
English	309 (85.83%)	1245 (87.06%)	10865 (83.53%)
Finnish or Swedish	2 (0.56%)	1 (0.07%)	10 (0.08%)
other Language	49 (13.61%)	184 (12.87%)	2120 (16.3%)
Journal	360 (100%)	1430 (100%)	12999 (99.93%)
Conference	0 (0%)	0 (0%)	9 (0.07%)
NOR rank NaN	9 (2.5%)	43 (3.01%)	1501 (11.54%)
NOR rank equals FI rank	203 (56.39%)	1210 (84.62%)	10,146 (78%)
NOR rank higher FI rank	0 (0%)	78 (5.45%)	233 (1.79%)
NOR rank lower FI rank	148 (41.11%)	82 (5.73%)	934 (7.18%)
DNK rank NaN	8 (2.22%)	106 (7.41%)	2341 (18%)
DNK rank equals FI rank	237 (65.83%)	1070 (74.83%)	9481 (72.89%)
DNK rank higher FI rank	0 (0%)	194 (13.57%)	516 (3.97%)
DNK rank lower FI rank	115 (31.94%)	55 (3.85%)	669 (5.14%)

deviation study of association rules (Section 4.1.1), those publication channels for which the actual Finnish expert-based rank was higher than the prediction have with an average of 8.56, the most publications per publication channel.

4.3. Confusion matrix using reference indicator

As described in Section 3, we compared the *JuFo*-rank against the reference indicator using confusion matrices. As argued and concluded in Section 3.3.1, the three Scopus metrics met the requirement of fair external quality indicators the best. For interpretation purposes, we analyzed only that set of publication channels that had a highly deviating SJR, SNIP and IPP value (see Section 3.3).

To fractionalize the three Scopus metrics, we divided the available SJR, SNIP and IPP values into categories (0–3) such that the same frequencies of *JuFo*-ranks were present also in the SJR, SNIP and IPP categories. This fractionalization according to reference metrics was also used by Ahlgren and Waltman (2014) for the Norwegian expert-based ranking. With this rule, a publication channel is classified as rank 0 if the SJR value is smaller than 0.1, as rank 1 if SJR is in (0.1, 1.303], as rank 2 if SJR is in (1.303, 2.925], and, finally, as rank 3 if SJR is in (2.925, 45.894]. Similarly, SNIP is rank 1 if in (0, 1.442], rank 2 if in (1.442, 2.513, and rank 3 if in (2.513, 71.662]; and IPP is rank 1 if in (0, 2.419], rank 2 if in (2.419, 4.749], and rank 3 if in (4.7490, 159.283]. The confusion matrix between these sets are provided in Table 10.

We aim to have the same number of observations for each rank of the categorized Scopus metrics and the *JuFo*-ranking. However, the total number of observations of the *JuFo*-ranking and the categorized Scopus metrics do not coincide for each rank level. For example, 328 publication channels have an SJR value smaller than 0.1 and 444 publication channels have an SJR value of exactly 0.1. Therefore, we have 290 fewer publication channels that have SJR-rank 1 compared to the *JuFo*-rank (see *all* column and row for SJR in Table 10). Furthermore, 12,805 publication channels have an SJR value smaller than 1.303, and four publication channels have an SJR value of exactly 1.303, which results in three fewer publication channels that have SJR-rank 2 than *JuFo*-rank 2. Similar observations can be made for SNIP and IPP.

4.3.1. Deviations

As explained in Section 3, we entitle a publication channel to be highly deviating if the *JuFo*-rank is at least two ranks higher (or lower respectively) than the SJR, SNIP and IPP rank. As can be seen in Table 10, 225 publication channels are highly deviating in the sense that they have a higher, and 161 are highly deviating in the sense that they have a lower *JuFo*-rank than the SJR metric indicates. Furthermore, 259 publication channels have a higher *JuFo*-rank and 176 have a lower *JuFo*-rank than the SNIP metric indicates, while 427 publication channels have a higher *JuFo*-rank and 214 have a lower *JuFo*-rank than the IPP metric indicates. If we combine all subsets, 140 publication channels remain that have a higher *JuFo*-rank than all three reference indicators (the list of these publication channels can be found in Table A.16), and 60 have a lower *JuFo*-rank than all three indicators (these are explicitly listed in Table A.17).

Table 10
Confusion Matrices of fractionalized SJR, SNIP, IPP and *JuFo*.

	JuFo 0	JuFo 1	JuFo 2	JuFo 3	All
SJR 0	14	311	3	0	328
SJR 1	21	11080	1158	222	12,481
SJR 2	0	1219	646	191	2056
SJR 3	0	161	252	238	651
All	35	12771	2059	651	15,516
SNIP 0	1	657	108	4	770
SNIP 1	18	10257	994	147	11,416
SNIP 2	0	1076	710	263	2049
SNIP 3	0	176	238	237	651
All	19	12166	2050	651	14,886
IPP 0	0	654	108	4	766
IPP 1	12	9786	1234	315	11347
IPP 2	0	1445	444	151	2040
IPP 3	0	214	256	179	649
All	12	12,099	2042	649	14,802

Table 11 provides a summary of meta information for all publication channels for which the fractionalized SJR, SNIP and IPP are highly deviating. As can be seen from the table, the highly deviating channels combined make up less than 1% of all the publication channels in the system. Interestingly, we see again exactly as for the misclassified publication channels with decision tree in Section 4.2.1 that for the subset of publication channels in which the Finnish expert-based rank is higher than all three reference indicators (second column in the table), a high percentage of ranks has recently been changed to a higher rank, while for the publication channels for which the Finnish expert-based rank is lower than all three reference indicators suggest (third column in the table), a high percentage of ranks (70%) was recently changed to a lower one. Moreover, as already detected with the decision tree, we see that for the group for which the *JuFo*-rank is higher than suggested by all three reference indicators, on average, more publications of Finnish researchers exists. However, compared to the decision tree result, this time the difference is not significant.

The 140 publication channels that have a higher *JuFo*-rank than they should have according to the SJR, SNIP and IPP values can mostly be characterized by their SSH orientation (see Table A.16). This is, as discussed in Section 1, the underlying reason behind the expert-based final rankings according to the Norwegian model followed in Finland. As commented by Hicks (2012), SSH journals might be badly indexed in databases (like Scopus) and the language of the published articles can

Table 11
Characteristics of publication channels for which the expert-based rank is highly deviating from SJR, SNIP and IPP.

	Publication channels for which the *JuFo*-rank is highly deviating from SJR, SNIP and IPP	
	JuFo-rank higher than all three Scopus metrics	*JuFo*-rank lower than all three Scopus metrics
total sum	140 (0.61%)	60 (0.26%)
in JCR	9 (6.43%)	53 (88.33%)
mean number of publications	2.59	2.52
rank now higher	17 (12.14%)	0 (0%)
no rankChange	123 (87.86%)	18 (30%)
rank now lower	0 (0%)	42 (70%)
Language NaN	0 (0%)	0 (0%)
English	118 (84.29%)	59 (98.33%)
Finnish or Swedish	0 (0%)	0 (0%)
other Language	22 (15.71%)	1 (1.67%)
Journal	140 (100%)	60 (100%)
Conference	0 (0%)	0 (0%)
NOR rank NaN	0 (0%)	6 (10%)
NOR rank equals FI rank	125 (89.29%)	45 (75%)
NOR rank higher FI rank	0 (0%)	7 (11.67%)
NOR rank lower FI rank	15 (10.71%)	0 (0%)
DKN rank NaN	0 (0%)	8 (13.33%)
DKN rank equals FI rank	131 (93.57%)	17 (28.33%)
DKN rank higher FI rank	0 (0%)	35 (58.33%)
DKN rank lower FI rank	9 (6.43%)	0 (0%)

be other than English (see Table 8). This, with other disciplinary variations of the publication and citation patters (see Puuska (2014)), effects citation-based indicators. However, the SNIP indicator takes "subject field" into account (see Table A.13).

Moreover, for more than 93% of the 140 publication channels under study, the Danish expert-based rank (and for almost 90% of these publication channels, the Norwegian expert-based rank) coincides with the Finnish expert-based rank (see Table 11). If we combine all lists of publication channels, i.e. those which are evaluated higher in *JuFo* than the fractionalized SJR, SNIP and IPP, and those that have a Norwegian or Danish rank which is also lower than the *JuFo*-rank, only five publication channels remain.[7] Interestingly, again for four out of these five journal, the rank was recently updated to a higher one. Furthermore, according to *JuuliDB*, Finnish researcher have published in three of these journals, and in two cases the publications can again be linked to panel members.

The 60 publication channels that have a lower *JuFo*-rank than SJR, SNIP and IPP suggest can mostly be characterized by their review related orientation (see Table A.17). It is clear that review journals generally accumulate more citations than the original research articles. Therefore, they can be characterized by higher citation-based than expert-based rank. For 75% of these 60 publication channels the *JuFo*-rank coincides with the Norwegian (and for more than 28% with the Danish) expert-based rank (see Table 11). Altogether, only five publication channels were evaluated higher by the three citation-based reference indicators and the Norwegian and Danish expert-based ranks than by the Finnish experts.[8] Interestingly, again according to the pattern, the rank has recently been downgraded for all of these five channels. However, the most likely explanation why these seemingly very prestigious journals have not been ranked higher in *JuFo* is that all five, in fact, are review journals.

Summing up, for more than 99% of all publication channels under study (see the first row, *total sum*, in Table 11) the *JuFo*-rank was not highly deviating from SJR, SNIP and IPP. Moreover, for most of the publication channels for which the *JuFo*-rank was highly deviating from the three Scopus metrics, the *JuFo*-rank was supported by the Norwegian or Danish expert-based rank. Only ten publication channels (five for which the *JuFo*-rank was higher and five for which the *JuFo*-rank was lower) remained for which the *JuFo*-rank could not be explained by another citation- or expert-based metric.

5. Discussion and conclusions

The purpose of this study was to analyze whether or not the assignment of quality ranks to publication channels – which currently is performed by experts – could (at least partially) be replaced by automatic rules. We have provided an analysis of the national expert-based ranking system that used more variables, encodings, and computational methods than are found in the existing, relevant literature. Especially using novel techniques to cope with missing values (e.g., binary indication of whether a citation-based indicator is available or not) allowed us to analyze a much higher portion of the publication channels in *JuFoDB* than could have been analyzed by using other existing methodologies, which always restrict researchers to a subset of publication data and/or indicators that are completely available.

Association rules for the whole *JuFo* data showed that the availability of the three metrics provided by Scopus (SJR, SNIP and IPP), predict the Finnish expert-based rank very well. Furthermore, using decision trees with data for which the three Scopus measures were available, we found that a significant part of the work accomplished by the panels could be automated, or could at least provide a justified reference rank for panel discussion and decision-making. Similar to the study by Ahlgren and Waltman (2014), in which the Norwegian expert-based rank was predicted, our prediction model for the Finnish expert-based rank also showed that the SNIP indicator had the highest predictive power. The third part of our analysis illustrated that for more than 99% of the publication channels under study, the Finnish expert-based decisions did not deviate significantly from SJR, SNIP and IPP.

However, although the citation-based indicators showed the highest predictive power in our analysis, automatic rules using *only* these measures would certainly not be an alternative to the expert-based ranks. Ahlgren et al. (2012) concluded that with regard to coverage, currency, legitimacy, and transparency, the Norwegian model is preferable to automatic ranks constructed using citation-based indicators. Here, we argue that automatic rules could be utilized more under the condition that *all relevant and available* information is used to construct the prediction models. For example, our decision tree (Fig. 2) showed that besides the citation-based indicators, the panel (i.e., the discipline) of the publication channel – as well as the information whether the channel is covered in other relevant databases – are important variables to include in an automatic decision-support model. This fact was especially evident in Table 8, which showed the large disciplinary differences in coverage of both the journals in Scopus and the Finnish publications in them. Consequently, an automatic decision-support model should be based not only on citation-based indicators but also on information such as the discipline, language, and coverage in other databases.

Through our analysis of the publication channels for which the Finnish expert-based rank was higher than the rules suggested, we found multiple signs that the higher-than-predicted rank of a publication channel could be linked to the publication profile of Finnish scholars or even those who can influence the decision-making process. This discovery is

[7] *Etudes Classiques*, *Journal of Agricultural Science*, *Journal of American Folklore*, *Journal of Higher Education Policy and Management*, and *New German Critique*.

[8] *Biological Reviews*, *Natural Product Reports*, *Neuroscience and Biobehavioral Reviews*, *Progress in Neurobiology*, and *Trends in Plant Science*.

interesting when linked to the study by Serenko and Dohan (2011), who found a relationship between the current research interests of scholars and an overranking of publication channels in that particular research field. However, as also discussed by Ahlgren and Waltman (2014), opposite interpretations are possible for high deviations between expert-based ranks and citation-based indicators. Are these deviations a sign that expert-based opinions are truly necessary for avoiding the under- or overrating of certain publication channels? Or do they reveal (deliberate or unintentional) inaccuracies in the judgments of experts? We are not in the position to answer these questions, nor do we have the expertise to do so. However, our analysis of the highest deviating publication channels revealed certain patterns, and we think they should also be presented to the steering committee as part of the panel discussions.

In fact, interestingly, all three analysis methods showed that for the subset of publication channels with a higher-than-predicted rank, a high percentage of the Finnish expert-based rankings had been upgraded during the most recent panel evaluation. Similarly, in each case, the subset of publication channels with a lower-than-predicted rank showed the highest percentage of channels for which the rank had been downgraded during the most recent evaluation round. Basically, this result means that the old ranks coincided better with the other available quality information about the publication channels. However, as discussed in the paragraph above, there are two opposite interpretations of this finding that are possible.

As a whole, a data analysis methodology – expected ranks by a reference technique and the study of deviations – was proposed and demonstrated. This methodology can be applied in other similar instances of sparse data and tens of thousands of observations. From the report by Wilsdon et al. (2015), it is evident that automatization of expert judgment in research evaluation on the basis of advanced methodology and large datasets are currently a broad interest in research policy making. Naturally, this is possible only with open and accessible databases on publication channels and publication activity, according to the Norwegian model. Our analysis and results indicate that using repeatable methods and the detected rules and patterns, even if they are enlarged and improved (e.g. by considering also whether the publication channel publishes original research or reviews), could save money and man-hours in managing one of the three main components of the Norwegian performance-based funding model – the national database – and bring more transparency and objectivity into the second main component: the publication channel rankings.

Authors' contribution

Conceived and designed the analysis: Mirka Saarela, Tommi Kärkkäinen, Tuomo Rossi.
Collected the data: Tommi Lahtonen.
Contributed data or analysis tools:Tommi Lahtonen.
Performed the analysis: Mirka Saarela.
Wrote the paper: Mirka Saarela, Tommi Kärkkäinen.
Other contribution: Tuomo Rossi.

Appendix A. Additional tables

Table A.12
Evaluating Panels: distribution of ranks.

Panel ID and name	Rank 0	Rank 1	Rank 2	Rank 3	Total
–	5329	1127	91	15	6562
1 Mathematics and statistics	5 (0.6%)	678 (82.1%)	106 (12.8%)	37 (4.5%)	826
2 Computer and Information Scis.	122 (8.2%)	1157 (78.0%)	153 (10.3%)	51 (3.4%)	1483
3 Physical Scis., Space Scis. & Astronomy	4 (0.8%)	472 (91.6%)	21 (4.1%)	18 (3.5%)	515
4 Chemical Scis.	1 (0.28%)	413 (92.6%)	25 (5.6%)	7 (1.6%)	446
5 Geosciences & Environmental Scis.	4 (0.68%)	571 (90.6%)	42 (6.7%)	13 (2.1%)	630
6 Biosciences I	5 (0.88%)	570 (91.5%)	36 (5.8%)	12 (2.0%)	623
7 Biosciences II	0 (0%)	568 (91.3183%)	34 (5.5%)	20 (3.2%)	622
8 Civil Engr. and Mechanical Engr.	25 (4.48%)	477 (84.9%)	48 (8.5%)	12 (2.1%)	562
9 Electrical & Electronic Engr., Information Engr.	32 (5.3%)	491 (81.0%)	68 (11.2%)	15 (2.5%)	606
10 Chemical, Materials, & Environmental Engr.	21 (2.8%)	669 (88.0%)	55 (7.2%)	15 (2.0%)	760
11 Medical Engr., Biotechnology & Basic Medicine	2 (0.2%)	1012 (89.8%)	92 (8.2%)	21 (1.9%)	1127
12 Clinical Medicine I	1 (0.1%)	815 (91.2%)	63 (7.1%)	15 (1.7%)	894
13 Clinical Medicine II & Dentistry	2 (0.2%)	1091 (90.9%)	81 (6.7%)	26 (2.2%)	1200
14 Health Scis. and other Medical Scis.	15 (1.7%)	781 (90.0%)	59 (6.8%)	13 (1.5%)	868
15 Agricultural sciences	2 (0.2%)	730 (91.5%)	51 (6.4%)	15 (1.9%)	798
16 Economics and Business	79 (6.2%)	1034 (81.7%)	117 (9.2%)	35 (2.8%)	1265

Table A.12 (*Continued*)

Panel ID and name	Rank 0	Rank 1	Rank 2	Rank 3	Total
17 (Interdisc.) Social Scis., Media & Comm.	26 (1.6%)	1317 (83.0%)	190 (12.0%)	55 (3.5%)	1588
18 Psychology and Educational Scis.	34 (2.7%)	1068 (84.4%)	120 (9.5%)	44 (3.5%)	1266
19 Political Scis., Public Administration & Law	11 (1.0%)	887 (82.0%)	147 (13.6%)	37 (3.4%)	1082
20 Philosophy & Theology	13 (1.1%)	959 (83.5%)	140 (12.2%)	36 (3.1%)	1148
21 Languages	23 (2.3%)	820 (81.0%)	138 (13.6%)	31 (3.1%)	1012
22 Literature, Arts & Architecture	11 (0.6%)	1413 (82.9%)	216 (12.7%)	65 (3.8%)	1705
23 History, Archaeology & Cultural Studies	11 (0.6%)	1507 (82.8%)	248 (13.6%)	53 (2.9%)	1819
24 Multidisciplinary journals	11 (30.6%)	10 (27.8%)	5 (13.9%)	10 (27.8%)	36
Total	5789 (20%)	20,637 (70%)	2346 (8%)	671 (2%)	29,443

Table A.13
Overview of reference quality indicators.

Indicator	Source	Original paper	Journal self-citations	Normalized	Description
Total Cites (ToCi)	Thomson Reuters' JCR	–	included	no	The total number of citations to the journal in the JCR year.
Impact Factor (IF)	Thomson Reuters' JCR	Garfield (1972)	included	yes	The average number of times articles from the journal published in the past two years have been cited in the JCR year. The IF is calculated by dividing the number of citations in the JCR year by the total number of articles published in the two previous years. An IF of 3.5 means that, on average, the articles published one or two year ago have been cited three and a half times. (Note that only citations that are indexed themselves in JCR contribute to the citation count.)
5-Year Impact Factor (5y IF)	Thomson Reuters' JCR	Fundamental idea goes back to Garfield (1972)	included	yes	The average number of times articles from the journal published in the past five years have been cited in the JCR year. It is calculated by dividing the number of citations in the JCR year by the total number of articles published in the five previous years.
Immediacy Index (II)	Thomson Reuters' JCR	Fundamental idea goes back to Garfield (1972)	included	yes	The average number of times an article is cited in the year it is published. The Immediacy Index is calculated by dividing the number of citations to articles published in a given year by the number of articles published in that year.
Articles	Thomson Reuters' JCR	–	not applicable	no	The total number of articles published in the journal in the JCR year.
Eigenfactor Score (EF)	Thomson Reuters' JCR	Bergstrom et al. (2008)	excluded	no	The Eigenfactor Score measures the importance of a citation by the influence of the citing journal divided by the total number of citations appearing in that journal. The calculation is based on the number of times articles from the journal published in the past five years have been cited in the JCR year, but it also considers which journals have contributed these citations so that highly cited journals will influence the network more than lesser cited journals.

Table A.13 (*Continued*)

Indicator	Source	Original paper	Journal self-citations	Normalized	Description
Article Influence Score (AI)	Thomson Reuters' JCR	Bergstrom et al. (2008)	excluded	yes	The journal's average EF score per published article. It is computed by dividing the EF through the number of articles published by the journal over the 5-year period.
IPP (Impact per Publication)	Scopus	Fundamental idea goes back to Garfield (1972)	included	yes	The impact per publication, calculated as the number of citations given in the present year to publications in the past three years divided by the total number of publications in the past three years.
SJR (SCImago Journal Rank)	Scopus	González-Pereira et al. (2010)	limited to max. one third	yes	The SJR is a measure of the scientific prestige of scholarly channels. SJR assigns relative scores to all of the channels in a citation network. Its methodology is inspired by the Google PageRank algorithm, in that not all citations are equal. A publication channel transfers its own 'prestige', or status, to another publication channel through the act of citing it. A citation from a publication channel with a relatively high SJR is worth more than a citation from a publication channel with a lower SJR. A publication channel's prestige for a particular year is shared equally over all the citations that it makes in that year; this is important because it corrects for the fact that typical citation counts vary widely between subject fields. The SJR of a publication channel in a field with a high likelihood of citing is shared over a lot of citations, so each citation is worth relatively little. The SJR of a publication channel in a field with a low likelihood of citing is shared over few citations, so each citation is worth relatively much. The result is to even out the differences in citation practice between subject fields, and facilitate direct comparisons of publication channels.
SNIP (Source Normalized Impact)	Scopus	Moed (2010)	included	yes	The SNIP per paper measures contextual citation impact by weighting citations based on the total number of citations in a subject field.

Table A.14
Availability of quality metrics in Thomson Reuters' JCR and their Spearman correlation to SJR, SNIP and IPP.

Thomson Reuters metric	Unavailable	Correlation		
	(isNaN)	SJR	SNIP	IPP
Total cites	0	0.3638	0.22226	0.34126
Impact factor	45	0.8709	0.80517	0.97411
5-Year impact factor	450	0.9076	0.76697	0.94966
Immediacy index	205	0.7500	0.66563	0.82632
Eigenfactor score	0	0.4123	0.23787	0.36926
Article influence score	450	0.9407	0.71489	0.86817

Table A.15
JuFo-rank 2 but no other reference of quality.

Name	Panel	SJR	IPP	SNIP
		Manually found		
Panel 2: 50				
ACM conference on computer and communications security	2	1.997	1.687	2.286
ACM conference on computer-supported cooperative work and social computing	2		coverage discontinued	
ACM international conference and exhibition on computer graphics and interactive techniques	2	–	–	–
ACM international conference on information and knowledge management	2	0.528	0.461	0.677
ACM international conference on mobile computing and networking	2	1.786	1.059	1.129
ACM international joint conference on pervasive and ubiquitous computing	2		coverage discontinued	
ACM multimedia conference	2		coverage discontinued	
ACM sigact-sigmod-sigart symposium on principles of database systems	2	2.208	1.554	1.518
ACM SIGCHI annual conference on human factors in computing systems	2	0.900	0.931	1.150
ACM sigkdd conference on knowledge discovery and data mining	2	2.879	2.023	2.331
ACM sigmod international conference on management of data	2	3.015	2.107	2.241
ACM sigplan conference on programming language design and implementation	2	3.141	2.099	2.768
ACM sigplan-sigact symposium on principles of programming languages	2	1.495	1.099	2.136
ACM sigsoft international symposium on the foundations of software engineering	2		coverage discontinued	
ACM symposium on computational geometry	2	0.670	0.548	0.770
ACM symposium on principles of distributed computing	2	1.127	0.894	1.165
ACM symposium on user interface software and technology	2		coverage discontinued	
ACM/IEEE international conference on human-robot interaction	2	–	–	–
ACM/siam symposium on discrete algorithms	2	2.247	1.520	1.644
Annual conference of the special interest group on data communication	2	–	–	–
Annual conference on neural information processing systems	2	–	–	–
Annual international acm sigir conference on research &development on information retrieval	2		coverage discontinued	
Computer aided verification	2	–	–	–
Conference on uncertainty in artificial intelligence	2	–	–	–
European conference on computer vision	2	–	–	–
European conference on information retrieval	2	–	–	–
European software engineering conference	2	–	–	–
European symposium on algorithms	2	–	–	–
IEEE annual symposium on foundations of computer science	2	–	–	–
IEEE international conference on data mining	2	–	–	–
IEEE international conference on pervasive computing and communications	2		coverage discontinued	
IEEE international symposium on parallel &distributed processing	2		coverage discontinued	
IEEE/ACM international conference on automated software engineering	2	–	–	–
International colloquium on automata, languages and programming	2	–	–	–
International conference on artificial intelligence and statistics	2	–	–	–
International conference on autonomous agents and multiagent systems	2		coverage discontinued	
International conference on information processing in sensor networks	2		coverage discontinued	
International conference on information systems	2	–	–	–
International conference on intelligent user interfaces	2	0.596	0.544	0.886
International conference on machine learning	2		coverage discontinued	
International conference on network protocols	2	–	–	–
International conference on pervasive computing	2	–	–	–
International conference on principles and practice of constraint programming	2	–	–	–
International conference on the theory and application of cryptographic techniques EUROCRYPT	2	–		

Table A.15 (*Continued*)

Name	Panel	SJR	IPP	SNIP
		Manually found		
International conference on tools and algorithms for the construction and analysis of systems	2	–	–	–
International cryptology conference CRYPTO	2	–	–	–
International semantic web conference	2	–	–	–
International symposium on software testing and analysis	2	–	–	–
Working IEEE/IFIP conference on software architecture	2	–	–	–
Www international conference on world wide web	2	–	–	–
Panel 5: 1				
Journal of geophysical research: oceans	5	2.031	3.108	1.249
Panel 17: 2				
Mir rossii	17	–	–	–
Yhteiskuntapolitiikka	17	–	–	–
Panel 18: 3				
Kasvatus	18	–	–	–
Language, cognition and neuroscience	18	0.0	0.0	0.0
Psykologia	18	–	–	–
Panel 19: 7				
Current legal problems	19	–	–	–
Hallinnon tutkimus	19	–	–	–
Legisprudence	19		coverage discontinued	
Mcgill law journal	19		coverage discontinued	
Oikeus	19	–	–	–
Politiikka	19	–	–	–
Zeitschrift fur europarecht, internationales privatrecht und rechtsvergleichung	19	–	–	–
Panel 22: 4				
Journal of dance education	22	–	–	–
Storyworlds	22	–	–	–
Taidehistoriallisia tutkimuksia	22	–	–	–
Theatre arts journal: studies in scenography and performance	22	–	–	–
Panel 23: 6				
Mitteilungen des Deutschen Archaologischen Instituts: Orient Abteilung: Baghdad	23		coverage discontinued	
Mitteilungen des Deutschen Archaologischen Instituts: Orient Abteilung: Damaskus	23	–	–	–
Studia fennica: anthropologica	23	–	–	–
Studia fennica: historica	23	–	–	–
Studia historica	23	–	–	–
Suomen muinaismuistoyhdistyksen aikakauskirja	23	–	–	–

Table A.16
JuFo-rank at least two ranks higher than SJR, SNIP and IPP.

Name	Panel	JuFo rank	SJR	SNIP	IPP	NOR	DAN
Panel 1: 1							
Journal of mathematical biology	1	3	1.183	1.432	2.017	2	2
Panel 2: 1							
Neural computation	2	3	0.878	1.13	1.572	2	2
Panel 15: 2							
Canadian journal of forest research-revue Canadienne de recherche forestiere	15	3	1.071	1.045	1.862	1	2
Journal of agricultural science	15	3	0.813	1.423	1.959	1	1
Panel 17: 4							
Acta sociologica	17	3	0.752	1.205	1.089	2	2
Communication monographs	17	3	1.024	1.223	1.326	2	2
Differences: a journal of feminist cultural studies	17	3	0.166	1.095	0.265	2	2
Feminist theory	17	3	0.672	1.299	0.782	2	2
Panel 18: 4							
Comparative education	18	3	0.812	0.766	0.747	2	2
Journal of cross-cultural psychology	18	3	0.917	1.228	1.64	2	2
Journal of higher education policy and management	18	3	0.881	1.151	1.008	1	1

Table A.16 (*Continued*)

Name	Panel	JuFo rank	SJR	SNIP	IPP	NOR	DAN
Journal of philosophy of education	18	3	0.687	1.221	0.622	2	2
Panel 19: 11							
Common market law review	19	3	0.645	1.12	0.495	2	2
Crime and delinquency	19	3	1.038	1.035	1.162	2	2
European journal of international law	19	3	0.573	1.36	0.616	2	2
European law journal	19	3	0.706	1.052	0.587	2	2
European law review	19	3	0.618	1.391	0.526	2	2
International and comparative law quarterly	19	3	0.59	1.156	0.484	2	2
Journal of law and society	19	3	0.381	1.16	0.656	2	2
Law and philosophy	19	3	0.352	1.026	0.269	2	2
Oxford journal of legal studies	19	3	0.454	1.121	0.554	2	2
Public management review	19	3	0.815	1.044	1.299	1	2
The modern law review	19	3	0.356	1.308	0.43	2	2
Panel 20: 19							
British journal for the history of science	20	3	0.254	1.391	0.462	2	2
Erkenntnis	20	3	0.621	0.961	0.49	2	2
International journal of systematic theology	20	3	0.139	0.257	0.033	2	2
Journal of biblical literature	20	3	0.332	0.564	0.106	2	2
Journal of contemporary religion	20	3	0.311	1.025	0.588	2	2
Journal of ecclesiastical history	20	3	0.166	0.443	0.106	2	2
Journal of the history of ideas	20	3	0.15	0.831	0.21	2	2
Journal of the history of philosophy	20	3	0.15	0.858	0.161	2	2
Method and theory in the study of religion	20	3	0.236	0.572	0.226	2	2
Neue zeitschrift fur systematische theologie und religionsphilosophie	20	3	0.104	0.075	0.031	2	2
New testament studies	20	3	0.353	1.089	0.224	2	2
Novum testamentum	20	3	0.123	0.282	0.036	2	2
Numen	20	3	0.133	1.015	0.175	2	2
Philosophy of science	20	3	1.086	1.303	0.877	2	2
Phronesis	20	3	0.159	1.44	0.231	2	2
Technology and culture	20	3	0.313	1.327	0.541	2	2
Vetus testamentum	20	3	0.196	0.131	0.014	2	2
Zeitschrift fur die alttestamentliche wissenschaft	20	3	0.28	0.049	0.01	2	2
Zeitschrift fur die neutestamentliche wissenschaft und die kunde der alteren kirche	20	3	0.121	0.209	0.043	2	2
Panel 21: 14							
Cognitive linguistics	21	3	0.718	1.356	0.812	2	2
English language and linguistics	21	3	0.544	1.254	0.686	2	2
Journal of African languages and linguistics	21	3	0.177	0.418	0.182	2	2
Journal of child language	21	3	1.04	1.329	1.475	2	2
Journal of pragmatics	21	3	1.038	1.226	0.909	2	2
Language variation and change	21	3	0.903	1.437	1.067	1	2
Langue francaise	21	3	0.331	1.055	0.222	2	2
Linguistic typology	21	3	0.304	0.445	0.385	2	2
Linguistics	21	3	0.584	1.068	0.642	1	2
Natural language engineering	21	3	0.316	1.126	0.695	2	2
Target: international journal of translation studies	21	3	0.293	1.323	0.39	2	2
Text and talk	21	3	0.433	0.656	0.339	2	2
Transactions of the philological society	21	3	0.339	1.159	0.351	2	2
Voprosy yazykoznaniya	21	3	0.1	0	0	2	2
Panel 22: 54							
Art history	22	3	0.13	0.505	0.067	2	2
Art journal	22	3	0.126	0.659	0.083	2	2
Boundary 2: an international journal of literature and culture	22	3	0.172	0.963	0.2	2	2
British journal of aesthetics	22	3	0.398	1.068	0.296	2	2
Burlington magazine	22	3	0.145	0.152	0.059	2	2
Cambridge opera journal	22	3	0.169	0.53	0.069	2	2
Cinema journal	22	3	0.138	0.916	0.25	2	2
Classical philology	22	3	0.132	0.463	0.05	2	2
Computer music journal	22	3	0.23	0.787	0.433	2	2
Critical quarterly	22	3	0.116	0.249	0.048	2	2
Design issues	22	3	0.274	0.832	0.571	2	2
Deutsche vierteljahrsschrift fr literaturwissenschaft und geistesgeschichte	22	3	0.115	0.098	0.029	2	2
Diacritics: a review of contemporary criticism	22	3	0.101	0	0	2	2
Early music history	22	3	0.169	0.743	0.167	2	2
Elh	22	3	0.148	0.879	0.102	2	2
Essays in criticism	22	3	0.1	0.15	0.025	2	2
Ethnomusicology	22	3	0.183	0.982	0.24	2	2

Table A.16 (*Continued*)

Name	Panel	JuFo rank	SJR	SNIP	IPP	NOR	DAN
Etudes classiques	22	3	0.1	0	0	1	1
History of photography	22	3	0.173	0.902	0.123	2	2
Journal of aesthetics and art criticism	22	3	0.203	0.514	0.161	2	2
Journal of architecture	22	3	0.242	0.372	0.143	2	2
Journal of design history	22	3	0.136	0.42	0.109	2	1
Journal of hellenic studies	22	3	0.179	0.549	0.065	2	2
Journal of musicology	22	3	0.208	0.839	0.105	2	2
Journal of new music research	22	3	0.26	0.857	0.575	2	2
Journal of the American musicological society	22	3	0.361	1.112	0.357	2	2
Journal of the royal musical association	22	3	0.233	0.691	0.184	2	2
Journal of the society of architectural historians	22	3	0.101	1.29	0.153	2	2
Journal of the warburg and courtauld institutes	22	3	0.111	0.895	0.086	2	2
Journal of visual culture	22	3	0.161	0.958	0.333	2	2
Leonardo	22	3	0.253	0.729	0.203	2	2
Mfs: modern fiction studies	22	3	0.179	0.578	0.094	2	2
Modern language quarterly	22	3	0.127	0.952	0.155	2	2
Music analysis	22	3	0.18	0.854	0.314	2	2
Music education research	22	3	0.761	1.075	0.519	2	2
Music theory spectrum	22	3	0.196	0.91	0.186	2	2
Narrative	22	3	0.181	1.138	0.23	2	2
New German critique	22	3	0.106	0.436	0.097	1	1
Nineteenth-century literature	22	3	0.127	0.574	0.111	2	2
October	22	3	0.1	0.508	0.049	2	1
Philologus	22	3	0.13	0.201	0.028	2	2
Popular music	22	3	0.201	1.188	0.348	2	2
Renaissance studies: journal of the society for renaissance studies	22	3	0.16	0.496	0.054	2	2
Representations	22	3	0.124	0.735	0.185	2	2
Screen	22	3	0.117	0.836	0.128	2	2
Scriptorium	22	3	0.1	0.557	0.043	2	2
Slavic and east European journal	22	3	0.126	0.353	0.104	2	2
Tdr	22	3	0.213	1.035	0.126	1	2
Television and new media	22	3	0.329	1.193	0.434	2	2
Textual practice	22	3	0.17	0.686	0.106	2	2
Theatre journal	22	3	0.192	0.985	0.143	2	1
Theatre research international	22	3	0.161	0.556	0.068	2	2
Yearbook for traditional music	22	3	0.168	0.839	0.188	1	2
Zeitschrift fur kunstgeschichte	22	3	0.1	0	0	2	2
Panel 23: 30							
American anthropologist	23	3	0.818	1.147	1.129	2	2
American antiquity	23	3	0.807	1.257	1.038	2	2
American journal of archaeology	23	3	0.376	1.284	0.422	2	2
Annales: histoire, sciences sociales	23	3	0.157	0.951	0.187	2	2
Anthropological theory	23	3	0.758	1.437	0.866	2	2
Antiquity	23	3	0.873	1.167	1.352	2	2
Archaeological dialogues	23	3	0.238	0.886	0.4	2	2
Early medieval Europe	23	3	0.137	1.291	0.261	2	2
Environmental history	23	3	0.28	0.987	0.44	1	2
Geschichte und gesellschaft	23	3	0.148	1.177	0.235	2	2
Historical methods	23	3	0.254	0.306	0.316	2	2
Historische zeitschrift	23	3	0.133	0.632	0.086	2	2
History	23	3	0.125	0.955	0.178	2	2
International history review	23	3	0.152	0.52	0.153	2	2
International review of social history	23	3	0.216	1.18	0.295	2	2
Jahrbucher fur geschichte osteuropas	23	3	0.155	0.91	0.109	1	2
Journal of American folklore	23	3	0.12	0.573	0.167	1	1
Journal of American history	23	3	0.16	1.125	0.267	2	2
Journal of contemporary history	23	3	0.186	1.159	0.33	2	2
Journal of folklore research	23	3	0.135	0.393	0.1	2	1
Journal of material culture	23	3	0.451	1.113	0.641	2	2
Journal of social history	23	3	0.165	0.882	0.212	2	2
Journal of womens history	23	3	0.257	1.389	0.449	2	2
Journal of world prehistory	23	3	0.829	0.885	1.724	2	2
Past and present	23	3	0.315	1.383	0.393	2	2
Rethinking history	23	3	0.227	1.156	0.349	2	2
Russian history	23	3	0.137	0.198	0.056	1	2
Scandinavian journal of history	23	3	0.153	1.041	0.274	1	2
Speculum: a journal of medieval studies	23	3	0.115	1.362	0.191	2	2
Vierteljahrshefte fur zeitgeschichte	23	3	0.145	1.425	0.27	2	2

Table A.17
JuFo-rank at least two ranks below SJR, SNIP and IPP.

Name	Panel	JuFo rank	SJR	SNIP	IPP	NOR	DKN
Panel 1: 1							
Archives of computational methods in engineering	1	1	6.284	5.712	7.175	1	1
Panel 2: 3							
ACM transactions on intelligent systems and technology	2	1	4.966	12.305	10.085	NaN	NaN
Foundations and trends in machine learning	2	1	12.076	17.015	19.5	NaN	1
Journal of statistical software	2	1	6.131	4.372	6.402	1	2
Panel 3: 11							
Advances in optics and photonics	3	1	7.988	9.249	11.28	NaN	NaN
Annual review of condensed matter physics	3	1	13.19	5.928	14.5	NaN	NaN
Astroparticle physics	3	1	3.012	2.776	3.828	1	1
Astrophysical journal letters	3	1	3.914	1.487	4.852	1	NaN
Astrophysical journal supplement series	3	1	6.857	3.125	9.687	2	1
Living reviews in solar physics	3	1	3.382	3.039	5.889	0	NaN
Monthly notices of the royal astronomical society	3	1	3.196	1.494	4.911	1	2
Monthly notices of the royal astronomical society: letters	3	1	3.661	1.503	4.106	NaN	NaN
Nano energy	3	1	3.403	2.379	5.951	NaN	NaN
Progress in quantum electronics	3	1	3.97	5.066	7.24	1	2
Publications of the astronomical society of the pacific	3	1	2.99	1.266	3.147	1	1
Panel 4: 13							
Accounts of chemical research	4	1	11.33	4.865	20.685	1	2
Acs catalysis	4	1	3.47	1.839	6.278	1	NaN
Acta crystallographica section D: biological crystallography	4	1	20.717	5.01	13.344	1	1
Aldrichimica acta	4	1	7.861	2.175	12.353	1	NaN
Annual review of analytical chemistry	4	1	3.082	2.445	7.841	NaN	NaN
Annual review of physical chemistry issn	4	1	7.602	4.836	14.741	1	1
Chemical society reviews	4	1	13.505	6.593	26.899	1	2
Coordination chemistry reviews	4	1	4.624	3.612	11.321	1	1
Journal of applied crystallography	4	1	3.119	6.457	5.829	1	2
Journal of photochemistry and photobiology c: photochemistry reviews	4	1	4.143	4.034	11.133	1	2
Mass spectrometry reviews	4	1	3.08	2.716	7.981	1	1
Natural product reports	4	1	3.116	3.778	9.338	2	2
Progress in solid state chemistry	4	1	3.448	6.624	7.692	1	1
Panel 5: 2							
Journal of the atmospheric sciences	5	1	3.464	1.491	2.992	2	1
Monthly weather review	5	1	4.039	1.692	3.345	1	1
Panel 6: 12							
Annual review of ecology evolution and systematics	6	1	6.226	4.259	13.275	1	2
Annual review of entomology	6	1	6.476	6.562	13.532	1	2
Annual review of phytopathology	6	1	6.037	4.47	12.257	1	2
Biological reviews	6	1	5.651	4.057	10.268	2	2
Current opinion in plant biology	6	1	5.656	2.201	8.833	2	2
Genome biology and evolution	6	1	3.162	1.017	4.314	1	NaN
Methods in ecology and evolution	6	1	2.946	2.384	4.64	1	NaN
Molecular ecology resources	6	1	3.468	2.927	6.913	1	1
Oceanography and marine biology	6	1	3.05	3.084	6	1	2
Quarterly review of biology	6	1	3.556	2.441	5.774	1	2
Studies in mycology	6	1	3.393	4.141	8.625	1	2
Trends in plant science	6	1	7.209	4.218	14.831	2	2
Panel 7: 43							
Advances in genetics	7	1	3.772	1.964	5.273	1	1
Annual review of biochemistry	7	1	27.902	6.978	29.52	1	2
Annual review of cell and developmental biology	7	1	19.686	4.777	20.105	1	2
Annual review of genetics	7	1	18.504	4.183	18.197	1	2
Annual review of microbiology	7	1	10.107	3.888	14.535	1	2
Biochimica et biophysica acta: gene regulatory mechanisms	7	1	3.642	1.309	5.607	1	1
Biochimica et biophysica acta: molecular cell research	7	1	2.999	1.344	4.93	1	1
Bioessays	7	1	3.251	1.139	4.577	2	1
Biotechnology advances	7	1	3.001	3.941	10.365	1	2
Cell reports	7	1	8.134	1.666	6.562	1	NaN
Chromosoma	7	1	2.942	0.756	3.068	1	1
Cold spring harbor perspectives in biology	7	1	4.857	1.276	4.689	1	NaN
Cold spring harbor symposia on quantitative biology	7	1	4.2	0.789	3.424	1	1
Critical reviews in biochemistry and molecular biology	7	1	5.107	1.558	6.436	1	2
Current opinion in biotechnology	7	1	3.382	2.146	7.812	1	2
Current opinion in cell biology	7	1	8.519	2.206	9.514	1	2
Current opinion in genetics and development	7	1	7.581	1.722	7.716	1	2

Table A.17 (*Continued*)

Name	Panel	JuFo rank	SJR	SNIP	IPP	NOR	DKN
Current opinion in microbiology	7	1	5.036	1.906	7.455	1	2
Current opinion in structural biology	7	1	6.88	1.987	8.377	1	2
Current opinion in virology	7	1	3.195	1.588	5.572	NaN	NaN
Current topics in developmental biology	7	1	3.988	1.385	5.457	1	1
Cytokine and growth factor reviews	7	1	3.939	2.488	9.133	1	2
Developmental biology	7	1	3.219	1.059	3.684	1	1
Epigenetics and chromatin	7	1	4.134	0.887	4.344	1	NaN
Fems microbiology reviews	7	1	7.649	4.143	13.299	1	2
Journal of biological chemistry	7	1	3.391	1.219	4.564	2	2
Journal of molecular biology	7	1	3.158	1.091	3.803	1	1
Journal of molecular cell biology	7	1	3.2	1.246	4.919	1	NaN
Microbiology and molecular biology reviews	7	1	10.607	5.107	16.429	1	2
Molecular plant	7	1	3.357	1.676	6.14	NaN	1
Mutation research: reviews in mutation research	7	1	3.285	2.041	6.719	1	2
Nature protocols	7	1	6.328	2.273	8.188	2	1
Nature reviews molecular cell biology	7	1	23.593	5.945	25.446	1	2
Open biology	7	1	4.545	1.25	4.23	NaN	NaN
Progress in lipid research	7	1	4.97	3.573	12.125	1	2
Reviews in medical virology	7	1	3.529	2.129	6.962	1	2
Seminars in cell and developmental biology	7	1	4.939	1.518	6.22	1	2
Trends in biochemical sciences	7	1	11.198	3.072	13.309	1	2
Trends in cell biology	7	1	10.198	2.71	11.754	1	2
Trends in genetics	7	1	9.354	2.263	10.754	1	2
Trends in microbiology	7	1	5.211	2.338	8.865	1	2
Wiley interdisciplinary reviews-computational molecular science	7	1	4.045	4.136	9.248	0	NaN
Wiley interdisciplinary reviews. rna	7	1	5.014	1.251	6.421	NaN	NaN
Panel 10: 2							
Annual review of chemical and biomolecular engineering	10	1	3.774	2.735	8.484	NaN	NaN
Geotechnique	10	1	3.91	3.156	2.372	1	2
Panel 11: 30							
Advances in immunology	11	1	4.303	1.447	5.271	1	2
Aids	11	1	3.701	1.756	5.759	2	1
Biochimica et biophysica acta: reviews on cancer	11	1	3.823	2.143	7.96	1	2
Brain behavior and immunity	11	1	2.967	1.447	5.83	2	1
Brain research reviews	11	1	4.54	2.903	8.682	1	2
Brain structure and function	11	1	3.304	0.942	3.365	2	1
Cancer discovery	11	1	4.676	1.13	5.129	1	NaN
Chemistry and biology	11	1	3.054	1.355	5.187	2	2
Circulation: cardiovascular genetics	11	1	3.337	1.35	5.563	1	NaN
Cold spring harbor perspectives in medicine	11	1	3.353	1.683	5.866	NaN	NaN
Current opinion in chemical biology	11	1	4.491	2.241	9.032	1	2
Current opinion in immunology	11	1	5.988	1.855	7.966	1	2
Current opinion in neurobiology	11	1	6.13	1.826	7.254	1	2
Developmental neurobiology	11	1	2.991	1.102	4.206	1	1
Disease models and mechanisms	11	1	3.06	1.308	4.856	1	NaN
Drug resistance updates	11	1	3.686	2.997	10.364	1	2
Frontiers in neuroendocrinology	11	1	3.632	2.34	8.49	2	2
Glia	11	1	3.15	1.41	5.452	1	2
Hippocampus	11	1	3.402	1.257	4.723	1	1
Immunological reviews	11	1	8.712	2.98	11.808	1	2
Molecular cancer therapeutics	11	1	3.117	1.441	5.926	1	1
Mucosal immunology	11	1	3.99	1.598	6.889	1	NaN
Neurobiology of disease	11	1	3.156	1.399	5.723	1	2
Neuroscience and biobehavioral reviews	11	1	5.666	3.344	10.596	2	2
Neuroscientist	11	1	3.392	1.891	7.075	1	1
Physiology	11	1	3.674	1.644	5.828	1	2
Progress in neurobiology	11	1	5.234	2.801	9.988	2	2
Seminars in immunology	11	1	4.207	1.081	5.262	1	2
Trends in immunology	11	1	7.5	2.412	10.435	1	2
Trends in neurosciences	11	1	10.184	3.393	13.309	1	2
Panel 12: 19							
Advances in cancer research	12	1	3.738	0.927	3.763	1	1
American heart journal	12	1	3.457	1.779	4.807	1	1
Cancer and metastasis reviews	12	1	4.053	2.157	8.21	1	2
Cancer treatment reviews	12	1	2.934	2.241	6.445	1	1
Circulation: arrhythmia and electrophysiology	12	1	3.968	2.081	5.288	1	NaN
Circulation: cardiovascular interventions	12	1	4.193	2.138	5.569	1	NaN
Circulation: cardiovascular quality and outcomes	12	1	4.515	2	4.989	1	NaN
Heart rhythm	12	1	3.335	1.744	4.209	1	1

Table A.17 (*Continued*)

Name	Panel	JuFo rank	SJR	SNIP	IPP	NOR	DKN
JAMA internal medicine	12	1	4.898	3.554	8.101	2	NaN
Journal of investigative dermatology symposium proceedings	12	1	4.223	3.412	7.875	1	1
Journal of mammary gland biology and neoplasia	12	1	3.22	1.783	6.596	1	1
Journal of thoracic oncology	12	1	3.051	1.87	5.394	1	1
Molecular oncology	12	1	3.5	1.392	5.926	1	NaN
Neoplasia	12	1	3.14	1.227	5.392	1	1
Neuro-oncology	12	1	3.023	1.741	6.012	1	NaN
Obesity reviews	12	1	3.638	2.904	8.497	1	2
Oncotarget	12	1	3.053	1.378	5.207	1	NaN
Seminars in cancer biology	12	1	5.117	2.108	8.265	1	2
Seminars in liver disease	12	1	3.471	2.855	8.045	1	1
Panel 13: 6							
Acta psychiatrica scandinavica	13	1	3.14	2.097	5.175	2	1
Alzheimers and dementia	13	1	5.814	4.251	13.075	1	NaN
Human reproduction update	13	1	4.341	4.107	9.89	1	1
Progress in retinal and eye research	13	1	5.174	4.087	10.778	1	2
Schizophrenia research	13	1	3.163	1.453	4.673	2	1
World psychiatry	13	1	3.34	4.073	7.074	1	2
Panel 14: 2							
Health affairs	14	1	4.636	3.001	4.538	1	2
Skeletal muscle	14	1	3.314	1.928	5.717	NaN	NaN
Panel 15: 1							
Renewable and sustainable energy reviews	15	1	3.273	3.644	6.822	1	1
Panel 16: 12							
Academy of management annals	16	1	9.928	4.74	8.225	NaN	1
Annual review of economics	16	1	7.843	2.514	2.849	1	NaN
Annual review of financial economics	16	1	3.706	1.447	1.426	1	NaN
Brookings papers on economic activity	16	1	5.301	2.708	2.308	1	1
Computers and operations research	16	1	2.97	2.942	3.076	2	1
Economic policy	16	1	5.212	4.003	3.875	1	1
Imf economic review	16	1	4.335	2.602	2.563	1	1
Journal of economic perspectives	16	1	8.485	5.176	5.138	1	2
Nber macroeconomics annual	16	1	3.03	1.498	1.182	1	1
Qme: quantitative marketing and economics	16	1	3.976	0.897	1.238	1	2
Review of environmental economics and policy	16	1	3.175	2.58	3.661	1	1
Tax policy and the economy	16	1	3.22	3.012	2.125	1	1
Panel 17: 1							
Foundations and trends in communications and information theory	17	1	6.471	3.324	4.778	1	1
Panel 18: 3							
Neuropsychology review	18	1	3.193	2.432	6.861	1	1
Perspectives on psychological science	18	1	5.179	3.892	7.596	1	1
Psychological science in the public interest	18	1	4.451	9.167	12.75	1	1

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